The preferred design of pedagogical agents by older adults for self-management health programs for chronic conditions

by

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Abstract

This dissertation comprises a study of pedagogical agents and the preferences of older adult learners for specific pedagogical agents. Quantitative data were gathered from participants over the age of 55 concerning their preferences both for pedagogical agents' design characteristics in general and then specifically in a self-management health program for chronic conditions. Critical aspects of pedagogical agent design identified for general learning environments by older adults include the voice and facial expression of the pedagogical agent, level of competence, demeanour and degree of realism. Such findings are not comparable to existing studies, as most have focused on school age (K-12) and post-secondary students (adults under age 55). Respondents indicated for self-management health training environments for chronic conditions that the degree of realism, voice of the agent, role of agent and professional attire are important design attributes of the pedagogical agent in this context. An unexpected finding in the study is a preference by participants for task-orientated learning in both learning in general and self-management health contexts. This finding calls into question the underlying premise of the importance of relational aspects of agents in a healthcare training environment. This aligns more with andragogical principles than the social psychological perspective which is frequently found in the literature. This avenue of research warrants more investigation.

Keywords: pedagogical agents, older adults, embodied conversational agents, virtual health programs

Preface

This thesis is an original work by Donna Feledichuk. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name “The design of pedagogical learning agents in a self-health management program for older adults”, No. Pro00080233, DATE May 9, 2018.

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This work was inspired by my mother, who suffered from COPD. I watched for many years good intended but busy health care professionals who did their best to try to educate us all on my mon's condition especially when she was moved onto the lung transplant list but had limited time in scheduled appointments to provide the level of information needed to help her better manage her own medical condition. It was only when she would be hospitalized that enough time would be carved out to educate my mom on how to better cope with her life changes and provide strategies to minimize more damage to her lungs; no fault of any one individual but a symptom of the systems. I would like to thank Dr. Ronald Damant, my mom's pulmonary specialist for all the care he provided to my mom through the duration of her illness, and the time he spent educating me to better help her. Unbeknownst to him it set much of direction of this work.

Special people have come and in out of my life to help me on this journey. Thank you to Dr. Jennifer Locke, Dr. Heather Kanuka and Dr. Katy Campbell for their guidance early in my

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Chapter 1: Overview of the Study

Introduction

The World Health Organization (2018) predicts that the worldwide population of adults over the age of 60 will be 2.0 billion in the year 2050. This is almost double the number in 2015 and will account for almost a quarter of the world's population, up steeply from the current proportion of 12%. With the aging population comes increased chronic health conditions such as osteoarthritis, chronic obstructive pulmonary disease, diabetes, depression and dementia and numerous complex health problems (World Health Organization, 2018).

The internet and computers have both become increasingly accessible to older adults; as such health care providers have been using programs deliverable either via the internet or computers as a means of providing important health care information to seniors (Bickmore et al., 2010; Bickmore, Gruber, & Picard, 2005). Several studies have investigated the role that computers can play in both health care environments and within educational settings (Bickmore, Caruso, Clough-Gorr, & Heeren, 2005; Lisetti, et al., 2012; Wargnier & Jouvelet, 2014; van Wissen, Vinkers, & van Halterern, 2016).

Computer agents are virtual humans capable of carrying on conversations in which the modalities are the natural modalities of human conversation (i.e. listening, speaking, mannerisms and writing). These agents can take on numerous different types of roles, most common as an assistant, tutor, information provider, or customer service agent (Ruttkay & Pelachaud, 2004). Specifically, in health care, computer agents have been used to provide a means of communicating with patients on a regular basis regarding their own ongoing health maintenance, provide information regarding the patient's condition and provide a supportive environment

(Bickmore, 2003). Many researchers in the health field have studied agents called embodied conversation agent (ECA), these agents are anthropomorphic and designed to match the appearance, language, attitudes and behaviours of humans (Nass, Isbister, & Eun-Ju, 2000). In studies ECAs have assumed the role as coaches, tutors and experts in addition to companions (Laranjo, Dunn, Tong, Kocaballi, & Chen, 2018; Provoost, Lau, Ruwaard, & Riper, 2017; Tsiourti, Joly, Wings, Moussa, & Wac, 2014; van Wissen, Vinkers, & van Halterern, 2016). In education, specific computer agents, called pedagogical agents, have been used as learning companions (learn with the student as a peer), mentors (supportive and encouraging cheerleader of the learner's progress), experts (highly knowledge in the subject area), or tutors (can provide assistance if learner needs help with a concept) to increase learner motivation and understanding of concepts (Baylor & Kim, 2003; Baylor & Kim, 2005). In more recent definitions pedagogical agents are being classified as any type of agent that facilitates learning (Lin, Atkinson, Christopherson, Joseph, & Harrison, 2013).

Pedagogical agents have evolved in the last few decades to incorporate many of the characteristics of ECAs. In the past 10 - 15 years anthropomorphic pedagogical agents have been introduced into health training environments. As the prevalence of use of pedagogical agents as a teaching tool increases it is becoming increasingly more important that there is a solid foundation and understanding of how these agents should be designed to maximize their training potential and produce a positive outcome on learning.

Rationale for the Study

The World Health Organization (2017) reported that non-communicable conditions (NCDs) such as diabetes, cancer, cardiovascular and chronic pulmonary disease accounted for

70% of the worldwide morbidity rate, while in Canada the percentage of deaths from NCDs was 88%. Bauer, Briss, Goodman and Bowman (2014) report that at least half of all adult Americans have at least one chronic condition and this extends to 92% of all older adults (Patrick, et al., 2016). This presents a direct cost and burden to the health care system. Bickmore (2010) states that in 1990 in the United States, 75% of health care expenditures, nearly a half of a trillion dollars, were due to chronic health conditions. In Canada, direct health care spending for people with chronic illness accounts for 42% of all spending which is close to 40 billion dollars annually and 65% of the indirect health care costs in the country (Mirolla, 2004). One in five Canadians live with a chronic condition and in 2014 nearly 40% of adults over the age of 65 had self-reported at least one of the four major chronic illnesses (cancer, diabetes, cardiovascular disease and chronic respiratory diseases) and 90% of all newly diagnosed cancers are in Canadians over the age of 50 (Public Health Agency of Canada, 2016).

Self-management health programs for chronic conditions such as COPD have been found to reduce hospital admissions by 39.8% and reduce emergency room visits by 58.9% (Bourbeau, et al., 2003). These programs however, are mostly delivered in a face-to-face environment, limiting availability for older adults who may have challenges in arranging travel, do not live near large hospitals or urban centers, or have mobility issues. Developing self-management health programs for a computer-based delivery model is important as it can expand the reach and overall benefit of these programs. It is also a viable way to help contain healthcare costs as it provides opportunities to increase patient access to pertinent education and information necessary to manage their health condition. As the population continues to grow and age, NCDs will continue to increase (van Wissen, Vinkers, & van Halterern, 2016) as will corresponding health care costs. This will only further burden an already taxed system and extend wait times

and access to programs. Virtual self-management health programs could decrease this burden as such programs can help address the lack of human power available to meet the demands to care for our aging population (Petrie, Darzentas, & Carmien, 2018).

Bickmore with various colleagues (Bickmore, 2010; Bickmore, 2015; Bickmore & Cassell, 2005; Bickmore & Pickard, 2005; Bickmore, Bukhari, Pfeifer Vardoulakis, Paasche-Orlow, & Shanahan, 2012; Bickmore, Caruso, Clough-Gorr, & Heeren, 2005; Bickmore, Gruber, & Picard, 2005) has conducted numerous studies on the use of agents as a means to both monitor health and also relay necessary one-time health information for a variety of health related conditions. Expansion to researching the roles of agents in healthcare have been reviewed in areas such as clinical psychology (Provoost, Lau, Ruwaard, & Riper, 2017), dementia (Wargnier & Jouvelet, 2014) and chronic illness (van Wissen, Vinkers, & van Halterern, 2016). However, limited research has been conducted on the necessary physical characteristics of agents in healthcare settings that make these agents acceptable to the end user.

> Despite its potential health benefits in terms of ease of use and health outcomes, there is limited evidence about the extent to which chronic patients accept the use of an ECA as health coach, and if they do, what the ECA should look like to engender user acceptance. (van Wissen, Vinkers, & van Halterern, 2016, p. 264)

To create a health care computer-based learning environment for older adults that allows for knowledge building, Scardamalia and Bereiter (2006) contend that social relationships and social dialogue must exist in such an environment. In the creation of pedagogical agents, the ability to develop social relations between learner and agent are critical for learning. In their seminal book *The Media Equation*, Reeves and Nash (1996) demonstrated that human-computer

interactions are consistent with human-human interactions and can evoke human social responses. This human-computer interaction evoking human social responses has been demonstrated with relational agents (a specific type of agent defined by Bickmore (2003) to develop a long term social-emotional relationship with the user) and ECAs, but it has also been demonstrated with pedagogical agents (Baylor & Kim, 2003; Baylor, Ryu, & Shen, 2003; Gulz, 2004; Woo, 2009). In studies regarding pedagogical agents, researchers believe that the resulting human-computer interactions that emulate human-human interactions are attributed to the persona effect (Lester et al., 1997). The persona effect is defined and explained by Lester et. al. (1997) as "the presence of a lifelike character in an interactive learning environment - even one that is not expressive - can have a strong positive effect on student's perception of their learning experience" (p. 22).

By giving pedagogical agents lifelike features such as facial expressions, gestures, and movements, the agents are anthropomorphized and can emulate real people. This anthropomorphism facilitates an emotional connection between the agent and the learner. Baylor et al., (2003) suggest that this is due to the agent bringing familiarity to the learning environment by simulating a teacher-student like classroom environment, minimizing fear and anxiety. User acceptance of an agent is a critical determinant of its effectiveness as particularly "characteristics of the agents can unconsciously affect the human decision making process" (van Wissen, Vinkers, & van Halterern, 2016, p. 264). User acceptance means being perceived as trustworthy, likeable and as having the expertise to be an effective substitute for a human (van Wissen, Vinkers, & van Halterern, 2016).

While research is starting to explore the use of agents in health care for learning, the focus has been primarily on the conversational aspects to develop relationships with patients, with presumptions made regarding the physical attributes necessary for the success of such agents. As such the theoretical framework utilized in the field has come from social perspectives. Consideration has not been given to adult learning theory particularly when considering older adult learners. As we consider the utilization of pedagogical learning agents in training programs for adult learners it is imperative to be cognizant of the research in adult learning theory.

Developing pedagogical agents for health care training targeted at older adults, whom as previously stated are more likely managing a chronic condition, can facilitate deep learning to develop the knowledge necessary to manage one's own condition, increase accessibility to health care programming, and reduce burdens on the health care system. However, it is important to understand the necessary physical attributes of the agents that will make connecting on a social level more probable for the learner and promote a positive learning environment and achieve health outcomes. The purpose of this study is to discern the which attributes of pedagogical agents are preferred by an older adult learner and specifically which attributes are preferred in a self-management health program for chronic conditions.

Research Questions

This study was aimed at answering the following two research questions:

1. What characteristics of a pedagogical agent are preferred by older adult learners?
2. Specifically, what characteristics of a pedagogical agent are preferred by older adult learners in self-management health programs for chronic conditions?

Overview of Proposed Method

A group of older adults reviewed a website explaining what pedagogical agents are and were presented with a few examples of different types of agents in different learning contexts. The website was designed to provide participants an overview of pedagogical agents, the breadth of their use and how they are used in learning environments, but not immerse them in a full experience with an agent. After reviewing the website the participants were asked to complete an online survey to discern preferred characteristics for pedagogical agents in general and then in a self-management health program for chronic conditions, no additional agents were presented in the survey. The survey was aligned with attributes described by Domagk (2010) which is described more in chapter three. Participants responses were analyzed using quantitative methods and the analyses provided in the results section are descriptive. More detail as to the methodology is given in chapter four.

Chapter 2: Theoretical Framework

According to Sawyer (2005), in the field of learning sciences researchers have discovered that deep learning is more likely to occur in complex social and technological environments and knowledge construction is often associated with deep learning. When considering knowledge construction attention must be paid to both the cognitive processes and the social interactions. Since learning can be contended to be primarily cognitive, emotional, and social (Bandura, 1986), it is hypothesized that all of these aspects should be incorporated within pedagogical agents in order for them to be optimally effective (Ebbers, 2007). Social cognitive theory states that the actions, cognitive and affective, as well as the environmental events all interact within a system of triadic reciprocal causation (Bandura, 1989). Research in the area of pedagogical agents has often been conducted from a social cognitive perspective (Kim & Baylor, 2006; Moreno, Mayer, Spires, & Lester, 2001). Since pedagogical agents use an anthropomorphized interface that renders personas to computers they emphasize the social relations between agent and learner (Kim, 2004). This allows pedagogical agents to support social-cognitive aspects of learning, providing learners with a sense of companionship, making the computer-based learning environment meaningful and relevant (Biswas, Schwartz, & Bransford, 2001; Kim & Baylor, 2006).

Social cognitive theory has been proven as a useful theory when investigating technology integration (Compeau, Higgins, & Huff, 1999). Social cognitive theory uses an agentic approach to self-development, suggesting people intentionally contribute to their life circumstances through self-organizing, self-regulating, self-reflecting and being proactive. People do not only produce social systems, but they are a product of them as well (Bandura, 2005). It recognizes

three modes of human agency: personal, proxy and collective which in an educational setting equate to learner control, social modeling and collaboration (Kim & Baylor, 2006). Further within this theory the similarity of social models and the learner is vital because learners are more likely to appraise their competency with those similar to themselves than dissimilar. Therefore, in pedagogical learning agent research it is believed that it is important that the personal characteristics of the model, such as age, gender, ethnicity and competency are like the learners (Kim, 2004).

Compeau et al. (1999) argued that social cognitive theory acknowledges the continuous reciprocal interaction between the environment and the learner's cognitive perceptions, and as such it allows for a richer understanding of how capability and confidence can develop over time. In their study of 394 adults they incorporated a model of social cognitive theory to explain the reaction of participants to computer technology. They described that the learner's outcomes both in performance and meeting their personal goals in using computer technology determine their computer self-efficacy, their affect and their usage of computer technology. The learner's computer self-efficacy will correlate to the learner's anxiety in regards to using the computer technology.

Bandura is not the only researcher to suggest the importance of social interactions in learning. Other theories considering these interactions include distributed cognition, which argues that human cognition is distributed across individuals in a society, Vygotsky's Zone of Proximal Development which emphasized the role of social interaction in advancing the skills of others in higher level development and Piaget's ideas that an individual is a socialized entity and their ideas are influenced by society through cultural transmission (Kim, 2004).

Kim (2004) has conceptualized different theoretical frameworks and their relation to the different learning attributes that are commonly studied with pedagogical agents. As illustrated in Figure 2.1, social cognitive theory can be used as a framework to explore seven constituents of pedagogical agents as learning companions: competency, interaction type, gender, affect, ethnicity, multiplicity, and feedback. In comparison to the other frameworks presented, distributed cognition or social interaction supporting theory, social cognitive theory allows for a broader exploration of more attributes.

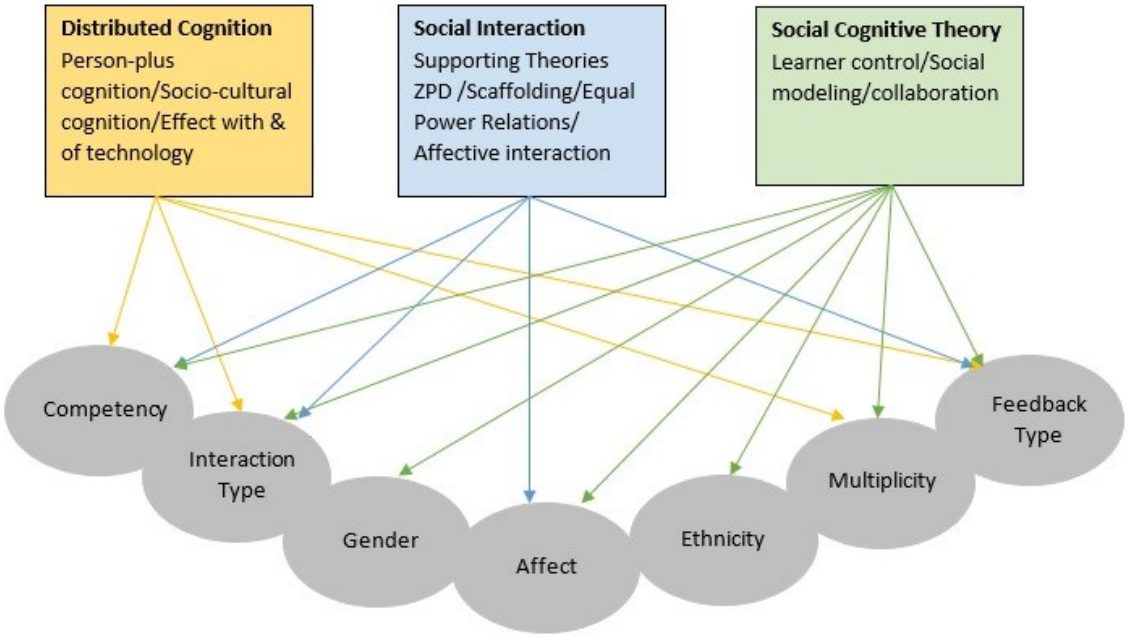

Figure 2.1: Constituents of Pedagogical Agents in Relation to Different Theoretical Framework after Kim, 2004, p. 38.

For this study the social cognitive framework was utilized to allow for a broader exploration of agent attributes, which is important as there is limited research on pedagogical agents and older learners, and as such agent attributes have not been as clearly defined for this age of learner.

Chapter 3: Review of Relevant Literature

This literature review covers an exploration of pedagogical agents, specifically the use of pedagogical agents to build a social learning environment, different characteristics of pedagogical agents and impacts on learners, the use of pedagogical agents with older adult learners and the boarder characteristics of agents used in healthcare environments.

Social Learning Environments and Pedagogical Agents

The social nature of human beings has been the basis of learning theories by Bandura (social learning theory) (1986) and Vygotsky, Cole, John-Steiner, Scribner & Souberman (1978). Work within the area of the learning sciences has expanded these ideas; Greeno's (2006) work on situated cognition is highly dependent on social aspects of learning as is cognitive apprenticeship (Collins, Brown, & Newman, 1989) and Scardamalia and Bereiter's theory of knowledge building (2006). Research in the area of pedagogical agents has spanned more than twenty years, and most findings support the use of agents to promote student motivation, cognition, and self-efficacy due to the agents' social aspects (Atkinson, 2002; Baylor & Kim, 2003; Heidig & Clarebout, 2011; Lester, et al., 1997; Lusk & Atkinson, 2007; Veletsianos, 2007).

Pedagogical agents stem from work on intelligent tutoring systems that were designed to support individualized learning (Kim, Baylor, & PALS-Group, 2006). Unfortunately, cognitive tutors did not provide situated social interaction that could impact learning and motivation. Reeves and Nash (1996) demonstrated that human-computer interactions are consistent with human-human interactions and can evoke human social responses. Building on Reeves and Nash's findings pedagogical agents were explored as a means of provided human-computer

interactions that could emulate a social learning environment. One of the common benefits frequently identified in the literature is that pedagogical agents, due to their social nature, promote learner motivation and engagement (Lester, et al., 2001; Moreno, Mayer, Spires, & Lester, 2001).

However, results on the impact of improving student learning through the use of pedagogical agents have been mixed (Gulz, 2004; Veletsianos, 2012). Kim and Baylor (2006) argue that cognitive functioning of learners is dependent on the social context of the learning environment. In their review of prior work in the area of pedagogical agents, they contend that studies that show little or no impact on learning from use of pedagogical agents suffered in agent design in that the agents lacked empathetic social encouragement. Veletsianos (2012) also argues for the social importance of agent design, contending that previous empirical studies have shown mixed results in improving student learning due to varied agent modalities and a multiplicity of variables (agent role, image, and voice) with no emphasis on social engagement. He stresses instead the importance of the social interaction of the agents on the learner and the need to review this role of the agent in virtual learning environments and its associated impact on learning. These reviews make a strong case that the social psychological aspects of the agent are significant since they can impact cognitive representation.

In terms of pedagogical agents' ability to build social learning environments, Oviatt and Adams (2000) used a descriptive study to observe students ranging in age from six to ten years utilizing pedagogical agents that were designed as animals in a program that teaches elementary children about marine biology. The researchers observed ten students and noticed that the children built friendship type relationships, even using personal pronouns to talk directly to the animal agents, and they viewed the agents as friends. Approximately one-third of all the

interactions between the learner and agent were strictly social, initiated by the child about such things as the agent's name, birthday, friends, and family life. Similar findings were seen in an experimental study by Ryokia, Vaucelle, and Cassell (2003) in which five-year-old girls were separated into two groups. One group worked with a pedagogical agent in the form of a peer named Sam that modeled story telling behavior, the other group followed the classroom instructions of the teacher with no access to the peer agent. The researchers indicated based upon observations that the girls related to Sam as an intellectual and social partner.

These two studies are described here as they specifically investigated social interaction as an outcome of their study. Often studies describe the social interactions observed between learner and pedagogical agent during the study, but the studies themselves frequently were not designed to investigate this phenomenon and its effect is described tangential to the intended research questions.

It is important to note that in conducting the literature review it was observed that the majority of the research in the field of pedagogical agents has involved a population of teens (middle or high school students) or young adults (university students). This was supported by a review of training literature by Behrend and Foster-Thompson (2011) in which it was identified that studies using pedagogical agents primarily involved college or undergraduate students as participants (Behrend & Foster Thompson, 2011). There is little research that specifically addresses older adults and the social learning aspects of pedagogical agents in an educational context.

Characteristics of Pedagogical Agents and Impact on Learners

There are numerous studies in the literature that have investigated a variety of attributes of pedagogical agents and the impact on learners. It is helpful to categorize the attributes as it makes it easier to review the literature. There are two classifications that have been described in the field. In one classification system, ten key attributes of pedagogical agents are identified by Tien and Osman (2010) . The attributes are:

i) Identity: which includes social interaction patterns and personality

ii) Backstory: inclusive of the cultural variation of the agent and any "history" which impacts the agent's life on screen

iii) Appearance: physical and demographic attributes

iv) Content of speech: language and dialect that matches the culture of the agent

v) Manner of speech: pronunciation and intonation of the agent when speaking

vi) Manner of gesturing: use of non-verbal communication such as facial expression and movement of body

vii) Emotional dynamics: which impacts the agent's comments, actions and behavior

viii) Social interaction patterns: how verbal and non-verbal communication support dialogue

ix) Role: role agent plays interaction whether to educate, guide, coach or entertain

x) Role dynamics: how role impacts agent's interactions and communication

The attributes described by Tien and Osman provide considerable overlap to the second classification system developed by Domagk (2008). Domagk's (2008) framework of Pedagogical Agents-Conditions of Use (PACU) model and subordinate Pedagogical Agents – Levels of

Design (PALD) model (Domagk, 2010) are helpful in organizing and framing the research in the field as it is more readily discussed in the literature (Heidig & Clarebout, 2011) versus the Tien and Osman classification. As such Domagk's model will be used as the framework to review the literature in this study.

Agent design framework. Domagk's (2008) PACU model addresses four conditions to consider in the incorporation of pedagogical agents into a learning environment:

1. the learning environment in which the pedagogical agent is implemented and its topic
2. the characteristics of the learner who works with the learning environment
3. functions that the pedagogical agent executes
4. the pedagogical agent design

It is significant to appreciate that these conditions are intertwined and help explain why each agent in different studies have not been designed in the same fashion. Different looking and acting agents may be necessary based on the learning context and the learner's characteristics. For example, an effective pedagogical agent for a child may look very different and act differently compared to one that is used for adults, even if the context is the same.

In specifically addressing the pedagogical agent design a subordinate model to the PACU model, the PALD model is also suggested by (Domagk, 2010). The model, shown in Figure 3.1, has three levels beginning with general features and moving to detailed aspects of the agent design.

1. Global design level: considers whether the agents should be human or non-human

2. Medium design level: takes into account two categories, first technical decisions such the agents' responsiveness to the user in terms of emotions, empathy, expressiveness, degree of realism and role of agent, animation, voice and communication style. The second category, choice of character, considers the agent role, possible role models to base the agent upon and level of competence.
3. Detailed design level: considers visual aspects of agent such as age, gender, ethnicity, clothing, weight etc.

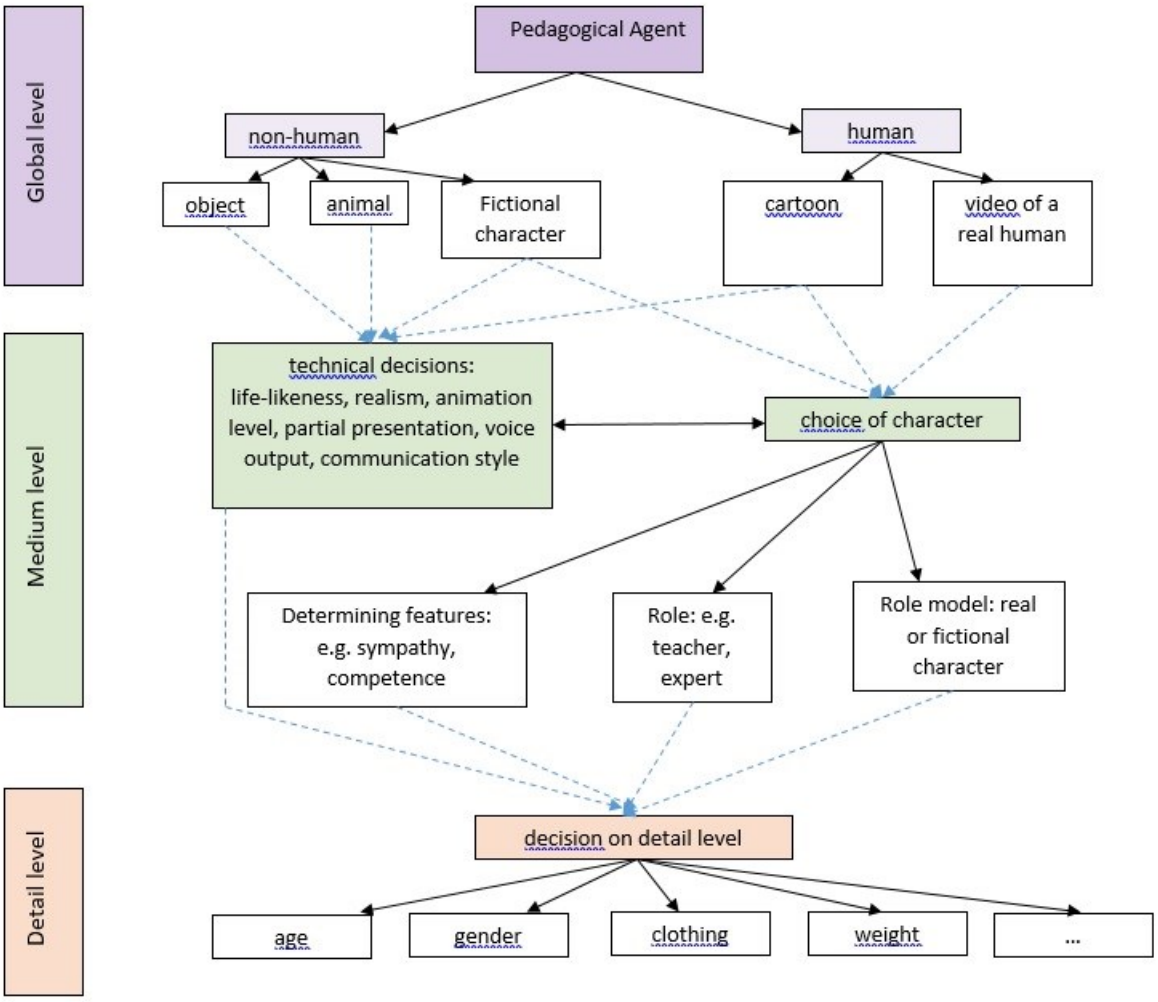

Figure 3.1: Pedagogical Agents – Levels of Design (PALD) after Domagk, 2010, p. 84.

In reviewing the literature, it should be noted that often in studies combinations of attributes were studied as one attribute, for example animation and facial expression may be combined in one study as non-verbal communication. Therefore, some studies may be mentioned under more than one attribute in the review of the literature below.

Global design. Global design considers whether the agents should be human or non-human. After this determination has been made global design is concerned with whether non-

human agents should be an animal or an object and whether a human agent should be a real person (represented through video) or a depiction of a real person (as in an animation, cartoon or computer-generated character). To date very few studies have considered the global design level (Heidig, 2010). Almost the totality of research in pedagogical agents in recent years has focused on non-video generated human agents. At the inception of computer agents some non-human agents were seen in studies, put the propensity of the agent design is human. Only one recent study could be found by Looijie, Neerincx and Cnossen (2010) which utilized a plastic yellow cat for the agent design however, the researchers did not investigate the participants' preference for the design of the agent.

Medium design. Regarding medium level design aspects, the necessity of the degree of realism, the agent's ability to be responsive to express emotion and empathy, level of animation, the role of agent and agent voice are important considerations.

The majority of studies on the design of pedagogical agents have focused on the technical decisions at the medium design level (Domagk, 2010). In particular earlier research focused on the modality principle (effect of voice versus text) (Atkinson, 2002) and then researchers moved to study the impact of human generated voice versus computer generated voice removing the use of text as a way to communicate with the user (Baylor, Ryu, & Shen, 2003; Harrison & Atkinson, 2009). Today text-based agents are all but obsolete from the current literature, which in terms of communication for this literature review the focus will be on studies utilizing voice-based agents. With advances in technology more and more studies have focused on the degree of realism of agents. Fewer studies have investigated the other aspects of technical decisions.

The second aspect of medium design, choice of character has rarely been investigated aside from the extensive work of Baylor and Kim (2003; 2004; 2005; 2016) in regards to agent roles.

Animation. The degree in which agents move and gesture relates to their degree of animation and Domagk's model (2010) indicates two types of agents in relation to animation, static or animated. Pedagogical agents should according to Lester at al. (1997) have socio-emotive abilities and therefore should be visually represented by means of gestures, facial expressions, and have a rich and interesting personality. In other words they should be animated. However, some studies (Baylor, Ryu, & Shen, 2003; Dirkin, Mishra, & Altermatt, 2005; Lusk & Atkinson, 2007) found no difference in learning retention when comparing static to animated agents. Baylor, Ryu and Shen (2003) did find higher levels of engagement with animated agents and Lusk and Atkinson (2007) reported benefits when using animated agents in near and far transfer in comparison to static agents. With a move to embodied conversational agents dominating the research, almost all studies in the last five years has been conducted on animated agents.

Non-verbal communication. Before considering agent voice it is important to discuss other aspects of communications such as non-verbal communication and communication style as these are integral to the expressiveness of the agent. In terms of non-verbal communication, the agent's look which is discussed in more detail in the subsequent sections conveys non-verbal messages that will influence how the learner interacts with the agent (Baylor, Ryu, & Shen, 2003; Veletsianos, 2010). However, things such as body posture, forward lean, facial orientation (towards or away from learner), nodding, and smiling all influence our perception of the agent (Bickmore, 2003) and influence the motivation of the learner (Baylor, 2011).

Gestures and gaze have been shown to guide the learners' attention that may facilitate learning by focusing the learner on the meaning and context of the information (Johnson & Lester, 2016; Rickel, 2001). It is suggested that the presence of animation, a form of non-verbal communication itself, forces the learner to pay more attention to the agent, increasing the cognitive effort of the learner and promotes learning (Baylor, Ryu, & Shen, 2003). Additionally, non-verbal communication in the form of visual cues increase the tendency of the learner to view their interaction with the agent as they would with a human teacher, which it is suggested, increases the students desire to learn (Harrison & Atkinson, 2009; Lusk & Atkinson, 2007).

Much of the non-verbal communication can be convened through agent demeanour as demeanour can encompass gaze and gestures. Literature suggests it is important to appear relaxed, yet confident to persuade the learner that the instructor is in control of the situation (Andre, et al., 2010) and that a positive demeanour relays empathy (Cooper, Brna, & Martins, 2006). It has also been shown that the perception of agent warmth can be correlated to the perception of believability of the agent and that emotional agents are judged as more believable than those showing no emotion (Niewiadomski, Demeure, & Pelachaud, 2010).

Communicative style. Bickmore (2003) describes two types of communicative styles, task oriented and relation oriented (or task condition versus social condition). A task orientated communication style would provide only information directly related to the content in a succinct and objective manner. Relation orientated agents focus on developing social relationships with learners. A combined task-relation orientated agent would focus on the social relationship while contributing to helping the student solve the learning task.

A study conducted by Haake and Gulz (2009) demonstrated that females in particular prefer a certain communicative style dependent on the role of the agent. In their study they found that females felt strongly that a combined task-relation orientated communicative style should be used with relational agents. They attributed this effect to the observation that in the real-world females are reliant upon subjective relational strategies, whereas males rely more on formal, objective strategies for social interaction.

Voice. Earlier studies by Mayer and Moreno (Mayer & Moreno, 1998; Moreno & Mayer, 1999), as well as Atkinson (2002) discuss the significant impact voice has in communication in media rich learning environments, suggesting the most meaningful interaction between learner and agent involves both visual and verbal interaction (Baylor, Ryu, & Shen, 2003).

When considering the type of voice it has been demonstrated that learners prefer a human voice over a computer generated voice and further that learners perceive the agent as being more human like when a human voice versus a computer generated voice is utilized (Baylor, Ryu, & Shen, 2003; Ryu & Ke, 2018). Additionally, Harrison and Atkinson (2009) found significant differences between recall and transfer in learners interacting with agents with human voices as compared to agents with computer-generated voices. This finding is supported in the literature by Mayer, Sobko, and Mautone (2003) and Atkinson, Mayer, and Merrill (2005). Exploring voice further, Harrison and Atkinson (2009) found there was no difference in terms of recall and transfer in regards to whether the human voice used by the agent was male or female, however interestingly participants perceived the male human voice as more competent than the female human voice. Ryu and Ke (2018) in a thorough study conducted on 48 university students on the use of a real instructor's voice and appearance on perceived human-likeness of the agent, engagement, credibility and ability to facilitate learning, found that a real instructor's voice

significantly promoted engagement and persona effect, found that voice had a greater impact on persona perception than appearance and influences the social presence of the agent. In a study relating directly to older adults, Tsiourti. Joly, Wings, Moussa and Wac (2014) observed that adults over the age of sixty-five preferred virtual agents used as companions with a smooth communicative style, using human speech and facial expressions.

With advances in technology, including automated speech recognition and text-to-speech technologies the ability to synthesize computer generated human language has significantly improved pedagogical agents' communication capabilities allowing for highly interactive conversations between agent and learner (Johnson & Lester, 2016). As technology improves the need to research the impact of these improvements is also needed. For example, will the improved communication abilities positively or negatively impact the perceived trustworthiness of the agent? Other important factors when considering speech is that it is best to keep the passages short (Hapeshi, 1993). Speech is also better redundant to gestures (i.e. stating and then point to the appropriate object on the screen) versus complementarity in which the information is split between the speech and gesture (Buisine & Martin, 2007). Lastly Johnson and Lester (2016) found that the impact on achieving learning outcomes was enhanced when the agents' communication was conversationally and polite.

Graphical style. Graphical style or visual style is an interesting aspect of agent design. While many researchers in the field of pedagogical agents (Lester, et al., 1997; Nass, Isbister, & Eun-Ju, 2000; Welch, Blackmon, Liu, Mellers, & Stark, 1996) argue for as much realism as possible in agent design, work especially in the area of animation suggests that learners will more easily get involved with a stylized character. Studies testing pedagogical agents' different graphical styles have indicated mixed results. Haake and Gulz's 2009 study showed that

participants, 12- 15 years in age, preferred stylized agents (simplified and cartoonish learning companions) over realistic ones. In 2004, Baylor and Kim assigned undergraduate students to agents that were either realistic or cartoon. In their study they found that male students demonstrated better transfer of learning with realistic images than with cartoon images, while with female learners there was no significant difference between realistic or cartoon images. A study completed in 2015 on the preferences of appearances of virtual partners for seniors found that none of the 15 seniors in the study preferred a cartoon-like option for an agent (Cereghetti, et al., 2015) and Tsiourti et al. (2014) found in individual interviews of 20 participants over the age of 65 there was also a predilection for a realistic agent appearance. The studies' results are mixed as to the choice of the graphical style of the agent and may even provide an argument for differences in biases related to the age of the learner.

Haake and Gulz (2009) argue that in accordance with McCloud (1993), based upon comic research, characters that are more simplified and cartoonish emphasize socio-emotional expression allowing participants to perceive the agent more as a "friend" with whom they could have a personal relationship rather than a more detailed and naturalistic one. They suggest that more realistic agents promote objectivity and are less likely to facilitate the idea of developing a personal relationship between agent and learner. This difference is further explained by McCloud (1993), who states that a highly detailed and naturalistic character does not allow the user to elaborate on and fill in expectations and ideals in regards to the character, whereas a stylized character invites elaboration by the user, who may project on the character from their own personal and subjective experiences. The more realistic the agent the more expectations the learner holds regarding how the agent responds socially and intellectually (Buisine & Martin, 2007). Further, it is hypothesized that a reduction in detail especially in regards to the

distinctness of its features facilitates a more rapid and a more accurate processing and interpretation of information (Isbister, 2006), while Haake and Gulz (2009) contend that the reason for these findings may be the lower expectation of stylized agents by the user. This is important as the agents needs to be believable to be accepted by the learner, and stylized agents appear to allow the learner to forgive aspects of agent design that might be counterintuitive to the learner's expectation of the agent.

As technology has improved however, designers are able to generate more realistic agents. At times this has become problematic due to the uncanny valley theory (Mori, 1970). The theory explains how human-like replicas (at the time of the study the research was conducted on robots and digital animations) can evoke feelings of uneasiness or eeriness as they approach a high level of realism. Cognitive dissonance is used to explain this reaction as our minds will try to categorize the agent as human or non-human to anticipate its behaviour. If the agent is so realistic that it makes it difficult to easily discern this difference this will cause an emotional response in the form of uneasiness, disgust or fear (Stein & Ohler, 2017).

A 2001 (Moreno et al., 2001) study explored the effect of agents with iconic features in relation to a full expressive video image. They found no significant difference in terms of transfer of learning, interest in learning, or retention and it is noted that in this study the iconic agent had no facial expression or gaze.

These differences in preference for styles in agent research are well encapsulated by van Wissen et al. (2016)

> There are diverging claims in the literature about the impact of realistic versus more stylized appearances in visual rendering, but few empirical studies to back up claims on either side. On the one hand, an ECA's strength is that it emulates a human communicator, with all its social and emotional affordances that such a relationship brings (e.g., support). On the other hand, the 'uncanny valley' demonstrates a thin line between very realistic ECAs and those that look uncomfortably creepy, leading to negative user responses and discontinued system use. Moreover, people expect virtual characters to display behavior that fits their appearance: the more human-like an ECA looks, the less forgiving they are when the ECA does not meet expectations. (p. 265)

Agent role. Baylor and Kim (2004; 2005) and Kim (2007) have conducted numerous studies on pedagogical agents including those on agent role. The researchers undertook a large experimental study in 2004. Part of this study considered the instructional role of the agent in relation to its gender and ethnicity. Agents assumed the role of motivator, mentor, or expert. It was found that agents that were African-American in appearance and expert gave the strongest results in terms of student learning. For Caucasian designed agents the effect on learning was more pronounced if the agent assumed the role of mentor.

In 2005, Baylor and Kim reported the impact of the instructional role of the agent on student motivation and learning transfer. In a study of 149 undergraduate students Baylor and Kim first sought to determine if the different instructional roles of expert, mentor, and motivator could be authentically simulated. This was proven successful as learners were able to perceive the role of the agent. Secondly, they consider the impact of the instructional role of the agent on the learner. It was found that mentor and motivator agents led to improved learner self-efficacy whereas expert agents led to improved learning outcomes. A different study Wang et al. (2008)

found that pedagogical agents in the role of coach or tutor are most effective for novice learners. In a more recent study, Kim and Baylor (2016) discovered that splitting the functionality of the role between different agents, for example incorporating both an expert agent and a motivator agent in a training scenario, is preferable to combining different roles into one agent role, as students learned more and had higher motivation working with two agents in different roles than with one in a combined role.

It is interesting to note that it is difficult to discern the most effect role of an agent in a learning environment. A meta-analysis of pedagogical and conversational agent roles identified predominately that 64% of studies utilized agents as information delivery vehicles and the remainder used agents as coaches, but the authors note that recent advances in the field of artificial intelligence have promoted intelligent tutors (Schroeder & Gotch, 2015). As technology changes it may drive the type of role we see more so than the learner's preference.

Level of competence. While generally not discussed separately as an entity in the research, a few studies were found dealing specifically with agent competency. Kim, Baylor and the PALS Group (2006) in a study of 72 undergraduate students in a computer literacy course concluded that agents should be designed as highly competent for learning contexts in which the outcome is focused on knowledge and skill acquisition and in contexts where learners' self-efficacy beliefs in the task are a major concern, less competent agents acting more as co-learners would be more effective. Niewiadomski, Demeure and Pelachaud (2010) also demonstrated that competent agents are viewed as being more believable.

Addressing characteristics of pedagogical agents from another perspective Kim (2007) asked college students which traits they would want in a pedagogical agent. In long interviews

with six students it was discerned that agent competency, agent personality, and agent control were the most influential traits to students. Incorporating these traits Kim designed an experiment for 46 undergraduate students. Based on previous studies Kim had explored, she decided to make the agent male, in same age range as the students, and with a computer-generated voice. There were two versions of the pedagogical agent a low competency version and a high competency version of which students were randomly assigned. Results indicated that academically strong students demonstrated higher self-efficacy beliefs in the task, as well as strongly valuing the pedagogical agent-controlled environment over the student directed environment. By contrast academically weak students showed higher self-efficacy after working with the low-competency pedagogical agents and tended to value the learner-control environment. In a similar study by Xiao, Stasko and Catrambone (2004), working with undergraduate students the researchers determined that it is important to match a user's preferred interaction style to the way help is provided. While studies such as these suggest that more competent learners may prefer expert agents while less competent learners prefer motivating agents or no agent at all, Bickmore and Cassel (2005) also identified that learner preference may be dependent on whether learners are extroverted or introverted. Extroverted students preferred agents that were forward and took control, while introverted students preferred a learner-controlled agent environment or no agent at all.

Facial expression. Empathy in agents can be expressed into two ways, through the agent behavior or through their emotional expression (Paiva, et al., 2004). Facial expression is particularly important in communicating emotion (Hone, 2006). Baylor and Kim (2009) also identified that facial expressions may be able to facilitate persuasion and add impact to the message.

Hone (2006) demonstrated that facial expression in agents can relay empathy and/or sympathy, and female agents are perceived as more sympathetic than male agents. Walker, Sproull, and Subramani (1994) conducted a study using two different agents one with a stern face and one with a neutral expression. They found that users liked the stern-faced version less, but spent more time, wrote more comments, and made fewer mistakes with the stern-faced version. In a Baylor and Kim's study (2009), they investigated five different types of facial expression: neutral, serious, happy, surprised and sad. They indicated when the expression was correlated to the content participants indicated a greater sense of agent persona. However, Frechette and Moreno (2010) showed in a study of college students in an astronomy course that the presence of an agent regardless of nonverbal communication abilities did not produce an effect and further that students preferred a static version of an agent over one with facial expressions.

Design aspects. The actual visual features of the pedagogical agent are also important and are outlined in the PALD model. Few studies deal directly with one specific visual attribute of the agent in relation to student motivation for learning, self-efficacy, or cognition (Domagk, 2010). There were however, many more studies that looked specifically at ethnicity, which is also an important aspect to the visual design of the agent and which will be considered in this section.

***First impressions*.** Research by Reeves and Nass (1996) has suggested that that first impressions as well as stereotyping behaviour seen in human-human interactions transfer to human-agent interactions. Therefore, first impression in regards to human-agent interactions can have both social and pedagogical implications (Gulz & Haake, 2006; Veletsianos, 2010). Veletsianos (2010) proposes that some of the first things learners notice about an agent is its

gender, facial expression, ethnicity, hairstyle, hair color, and clothing. Schroeder and Adesope (2015) caution that visual appearance of agents can invoke stereotypes which is supported by Veletsianos (2010). This is supported by drama theory, which states that a character's appearance will immediately produce an impression of personality with the audience, which will precipitate a set of expectations and attitudes of the audience to the character (Brahnam, 2001). Baylor (2011) also argues that an effective agent is similar to the learner and represents someone whom the learner aspires to be like. Therefore, it is important to give careful consideration to the specific visual features of pedagogical agents.

Gender. In a 2002 study (Moreno et al.) involving 39 female university students, participants were more likely to apply stereotypic expectations to female agents versus male agents. Hone (2006) found that female agents were more effective than male agents in reducing user frustration. While the female agents alleviated frustration in the Hone study (2006), Baylor and Kim (2003b) found positive results with male agents versus female agents in a study involving 130 pre-service teachers in which almost 73% of the participants were female. Users in this study perceived the male agents as more extraverted and agreeable than the female agents and reported that male agents facilitated self-regulation better. In 2004, Baylor and Kim undertook another study of 312 undergraduate students. Students were assigned to one of eight agents that differed in gender, ethnicity and type of image, either realistic or cartoon. Both self-efficiency and self-regulation were better for learners using male agents than with those using female agents regardless of student's gender. Students in the study perceived the male agents as significantly more interesting and intelligent leading to greater satisfaction with the male agents versus the female agents. The preference for a male agent was demonstrated also by Moreno et al., (2002) in which their study showed male pedagogical agents promoted achievement of

learning outcomes better than female agents. Gender may also be impacted by the learner's assumption of the role, for example Veletsianos (2010) found that agents were stereotyped differently depending upon their discipline (e.g. arts vs sciences).

In a recent study Schroeder and Adesope (2015) conducted research on 77 pre-service teachers investigating whether contextually-relevant female or male pedagogical agents provide a cognitive advantage. 74% of the participants were female and 86% were Caucasian. In this study and there was no significant between the male or female agent in the learner's recall, multiple choice and transfer scores nor did gender impact the learner's perception of the agent.

Body shape. In 1940, Sheldon (as cited by Gulz & Haake, 2006) stated that muscular bodies (mesomorphs) tend to be assigned positive traits, fat bodies (endomorphs) negative traits, and thin bodies (ectomorphs) variously positive and negative traits, thus the body shape of the agent is important to consider. In one of the few studies investigating body shape, Dryer (1999) found that in relation to human-computer interactions, agents that are perceived as agreeable tended to be represented by rounder shapes, while agents perceived as disagreeable were typically represented through bold colour, big bodies, and erect postures.

Ethnicity. There have been mixed results on the impact of ethnicity on student's perception of agents and the impact on different aspects of learning. Nass et al. (2000) premises that upon initially meeting someone for the first time we classify them as "in-group" or "out-group." This categorization is based upon readily observable physical cues with ethnicity being the most salient. In contrast to this suggestion, Baylor and Kim (2004) discovered that European American users demonstrated higher levels of learning with African American agents versus with similar European American agents. The authors attributed this to the novelty effect.

However, the same researchers also state that students working with agents of the same ethnicity perceived the agents to be significantly more engaging and affable (Baylor & Kim, 2003b). Similarly, Pratt, Hauser, Ugray, and Patterson (2007) found in the use of African American agents versus European American agents that learners were more likely to change their actions based on input from an agent whose ethnicity is similar to theirs. Nass et al. (2000) also suggest that learners perceived agents with the same ethnicity as themselves as being more trustworthy than agents of other ethnicities as did Ramachandiran and Jomhari (2015).

Uncanniness. As technology has improved and emerging software programs make it easier for educators to develop agents the uncanny valley theory has become important in agent research due to the ability to produce very lifelike agents. The uncanny valley theory was first described by Japanese robotics engineer Masahiro Mori in 1970 (Stein & Ohler, 2017). Mori recognized that robots exhibiting human characteristics can evoke feelings of eeriness and an inability to accept the robot. This has carried over to agent research and was demonstrated in a study by Stein and Ohler (2017), in which very life like agents were accepted by users if they believed they were being controlled by humans but respondents showed cognitive dissonance if they believed the same agent was computer controlled. Bogdanovych, Trescak and Simoff (2016) likewise caution that is important when interpreting data to understand that incorrect results can occur due to the uncanny valley phenomenon when analyzing appearance and linking it to believability or engagement by the learner.

Contextual relevance. In looking at the design of an agent, it is important to consider the agent in relation to the content the agent will be supporting. An agent that is best suited for a corporate training program may not be best suited for a teen awareness program on cyber

bullying. Therefore, the context for which the agent is being developed will drive the design of the agent and therefore should be considered first.

Contextual relevance is defined by Veletasios (2007) as the conformity of an agent's visual characteristic to the content area in which the agent will function. Veletasios found that alignment of the visible characteristics of the agent in relation to the content area under consideration influenced the learner's perception of the agent. Perception may activate stereotypes in regard to preconceived notions of agent knowledge or intelligence. Just as we, as individuals, stereotype and categorize other individuals, the media equation holds that we will also stereotype pedagogical agents (Reeves & Nass, 1996). This stereotype is driven from the content in which the agent is intended to support. If the agent's visual appearance does not conform to the learner's expectation given the content area under investigation, the pedagogical agents become contextually irrelevant to the learner. These expectations of the agent may influence learner's attention and perceptions of agents' relevance, degree of seriousness, and authenticity and thereby learning (Veletsianos, 2010). The agent in a sense is a social actor, in that it must perform expected social activities as dictated by the content such as talking and reacting to learners' responses in a fashion congruent to the content which determines the effectiveness of the agent in supporting learning (Woo, 2009).

Pedagogical Agents and Adult Learners

Most of the studies on the impact of agent characteristics have been conducted on students ranging from middle school to undergraduate university programs (Baylor & Kim, 2004; Baylor & Kim, 2005; Baylor, Rosenberg-Kima, & Plant, 2006; Ebbers, 2007; Johnson & Lester, 2016; Kim & Baylor, 2016; Ramachandiran & Jomhari, 2015; Ryu & Ke, 2018; Stein &

Ohler, 2017). Very few studies have been done that deal specifically with adults outside of a university setting. One study by Hudlicka (2011), investigated the effectiveness of a virtual coach as a pedagogical agent in mindfulness mediation training. The study ran over seven weeks with 32 participants having a mean age of 38. In this study it was found that the virtual coach provided more effective training than a self-administered program that utilized written and audio materials. Another study by Höök, Perrson, and Sjölinder (2000) sought to determine if a pair of pedagogical agents could encourage more exploration of websites. In a descriptive study using a mother-daughter agent combination that provided a bantering type of dialogue when the participant visited a site, the researchers discovered that the pedagogical agents encouraged exploration, learners perceived them as human like, created a narrative experience, and most users commented on being in a better mood after their encounter with the agents. This study worked with learners ranging in age from 19 – 41 years old. However, the learners did not interact with the agents, the agents simply engaged in a conversation between themselves dependent upon the nature of the site visited by the learner.

Moving outside of pedagogical agents specifically and reviewing computers agents in general, Bickmore et al. (2005) provide a descriptive study involving older adult learners and relational agents. Older adults ranging in age from 63 to 85 years old (mean 74 years old) worked with relational agents to monitor their physical activity. It was reported that most of the participants reported that they formed a social bond with the agent, with many bonds being strong. Those working with a relational agent also demonstrated a much higher physical activity than those in the control group. Vardoulakis, Ring, Barry, Sidner and Bickmore (2012) in a study involving participants over the age of 55 investigated the merit of long-term social companions for older adults living alone. They found very high levels of acceptance of the agents as a means

of providing in-home social support by the participants. Other studies (Bickmore & Cassell, 2005; Bickmore & Gruber, 2010; Bickmore et al., 2010) have demonstrated similar effects, older adults are able to develop social bonds with relational agents and that there tends to be better compliance in relation to the specific health programs when relational agents are utilized.

One study of particular relevance to this study was on the use of persuasive agents for health self-management in older adults (Looije, Neerincs, Cnossen, 2010). The study involved 24 participants ranging in age from 45 to 65 (mean age 55) and tried to discern which interface text-based, virtual, or physical (described as virtual with ability of the agent to follow the participant's movement with its head) would be the most persuasive in a virtual chronic health self-management setting. It should be noted however, that in this study the virtual computer agent and the physical agent were both a yellow plastic cat. The researchers used questionnaires to discern the empathetic abilities, social personality, and trust of the agent in diabetic based scenarios that were presented to the participants. The agents were designed to work on the psychological method of motivational interviewing to persuade participants to take action to undertake healthy behaviour. They found that the agents were perceived as more empathetic and social then a text-based chat like interface and emphasized the importance of social behaviors in agent design. Further they found that almost 90% of participants would use a computer agent if needed.

Outside of Bickmore's work with relational agents and subsequent studies expanding on his initial research with older adults (see Heerink, Krose, Evers & Wielinga, 2010; Fasola & Mataric, 2012 and Looije, Neerincs, Cnossen, 2010 as described above) only a few studies specifically addressing older adult learners and computer agents could be found through the current review of the literature and there were no studies of older adult learners and specifically

pedagogical agents. This could be due to interchangeability of the different agent terms and the overlap of the role of many agents.

One study by Cereghetti, et al. (2015) investigated seniors' preference for the appearance and personality of virtual companions. Fifteen seniors participated in the study and identified as a companion they prefer an agent to have friendly or cheerful disposition to a professional attitude or a dependent personality; who was guiding in their behavior, passively versus proactively; and with a human-like appearance, with no preference for gender; and none preferred a cartoon style agent. Another study simply investigated elderly participants' (ranging in age from 78 to 85 years old) ability to work with an agent (Yaghoubzadeh, Kramer, Pitsch, & Kopp, 2013) and Tsiourti et al. (2014) conducted research in Europe with older adults willingness to accept virtual agents as companions and the desired social skills and appearance of the agent. Tsiourti et al. (2014) identified, like Cereghetti et al. (2015), the preference of a pleasant agent who was also supportive, and passive or non-intrusive that the participant could control. However, instances in which the agent was supporting the user in managing their health, the participants were partial to an agent exhibiting professional behavior. This study also investigated expectations for agent appearance and there were interestingly differences in preferences regarding the appearance of the agent in relation to the geographical region of the participant. Participants in the Netherlands preferred a humanlike agent, while those from Switzerland were partial to a cartoon like appearance. Both groups however, favored a female agent over a male, but the study was investigating the agent in the role of a companion which may have influenced the gender preference. There does not appear to be a bias due to the gender of the participants as half of the participants in the Dutch group were male and approximately a

quarter in the Suisse group. Tsiourti et al. found the older adults wanted an agent who used natural language synchronized with appropriate non-verbal communication.

There are now emerging studies of older adults and their preference for human like game avatars (Carrasco, Baker, Waycott, & Vetere, 2017; Cheong, Jung, & Theng, 2011; Puri, Baker, Hoang, & Zuffi-Carrasco, 2017), some participants even able to build their own avatars int these studies. Avatars were designed by older adults as either similar to themselves or quite different from their own appearance.

Pedagogical Agents in HealthCare Settings

Despite the increasing use of virtual agents especially embodied conversational agents in other domains the use in healthcare is still not widespread. Further the use of agents in a teaching capacity to promote health education is rare. Most agent use within the field has been orientated to supporting patients and with older adults particularly in the role of a companion (Laranjo, et al., 2018). Compounding the limited research within the healthcare field Laranjo et al. (2018) also contend that of the studies completed there are numerous issues with their study design including use of non-validated questionnaires or subjective measures, inconsistency in reporting design methods, poorly reported intervention details and conflicts of interest.

More studies have been conducted on the use of ECAs to provide social and emotional assistance to older adults (Tsiourti, Joly, Wings, Moussa, & Wac, 2014). This can provide some insight into preferences by older adults to agent characteristics in general, but not specific to a healthcare environment.

Within the healthcare field Bickmore has conducted the most research of virtual agents and their impact on health outcomes (Bickmore & Cassell, 2005; Bickmore, 2010; Bickmore, 2015; Bickmore & Pickard, 2005; Bickmore, Bukhari, Pfeifer Vardoulakis, Paasche-Orlow, & Shanahan, 2012; Bickmore, Gruber, & Picard, 2005). Bickmore's work focused on agents as relational agents, a type of conversational agent that emulates face-to-face conservations including the social, emotional and relational aspects. These agents are designed to build long-term socioemotional relationships with user (Bickmore, 2003). Under the framework of social cognitive theory this type of agent is important in a teaching context as it would enable the social-cognitive aspects of learning, providing learners with a sense of companionship. Bickmore's research has tended not to focus on the pedagogical aspects of the agents but more the relational aspects. He has equated the social relational aspects to the impact on health outcomes and lack of a supportive relationship being linked to low levels of motivation to perform appropriate self-care. Bickmore has framed his research from work by Levinson, Gorawara-Bhat and Lamb (2000) who state that "outcomes of care are optimal when physicians address patients' emotional and personal concerns in addition to their biomedical problems" (p. 1022).

Bickmore's (2010) work with relational agents specifically in chronic disease management does utilize the agents in a pedagogical role in that the agents provided patients additional information about their condition but the findings focused on the relational aspects and the agent-learner relation. He discusses the ability of the agents to provide health information in a low-pressure environment allowing patients to freely ask questions and allowing the learner to take the time they needed to understand the information. However, Bickmore was viewing the results from a relational perspective and made no consideration for the design

aspects of the agent and whether that could either negatively or positively impact the relationship of agent and patient or the effect on patient learning.

In a 2017 meta-analysis, 49 studies addressing mental health outcomes through ECA use were reviewed by Provoost, Lau, Ruwaard and Riper. The researchers specifically investigated the role the ECA assumed in the studies. Most ECAs performed the role of social interaction partner, in fewer studies the role of tutor, counsellor, or health care provider was also assumed.

vanVugt, Hoorn, Konjin and Veldhuis (2009) studied the effectiveness of an agent e-health advisor. This study considered four different research questions regarding the outer appearance of the agent, body-shaped similarity and idealness. The study was conducted with 80 university students. In their study, they concluded there was no direct effects on similarity and idealness. A similar (in body shape to the participant) e-health advisor evoked as much intention, involvement and distance as a dissimilar one. As well a non-ideal agent (one that did not conform to the participant's perception of a health advisor's body type) evoked the same level of intention, involvement and distance as an ideal agent. The researchers identify that idealness of an agent was more important than similarity for user acceptance of the agent.

An interesting finding in the vanVugt et al. (2009) study was that e-health advisors depicted as heavier were perceived as more trustworthy, more involving and less distancing than the ones depicted as slim. The heavier the agent, the more trustworthy they were perceived to be. This is because participants believed the heavier the agent was more ethical. The supposed ethics of the agent was the most significant predictor of involvement, distance and use intention. vanVugt et al. suggest that the heavier e-health advisor in the context of food intake and dieting may be perceived as more trustworthy because they know what it is like to be heavy versus a

slender or athletic e-health advisor. This demonstrates the importance of not making presumptions about the preferred appearance of an agent, as the participants' ideal advisor given in prior to the test was not a heavy agent.

Bickmore et al. (2010) consider the use of ECAs to promote walking in older adults with low health literacy. The study involved 88 patients over the age of 65. Although Bickmore does not normally consider the appearance of the agent in most of his studies, he did find in this study that participants with an inadequate health literacy seemed to anthropomorphize the ECA more than those with a higher health literacy.

Finally, Lisetti et al. (2012) conducted a literature review of avatar-based health interventions. Many of the studies they identified were Bickmore's research on relational agents, but additionally they identified other studies in which various agents showed positive outcomes on health behavior but again the studies reviewed assumed the design of the agent and did not research critical design aspects in relation to achieving health outcomes.

Self- Management Health Programs for Chronic Diseases

Chronic disease self-management is an attempt to work with patients to monitor and manage their illness. It places an emphasis on patients working in partnership with health professionals to become "experts" in managing their own illness (Stinson, Wilson, Gill, & Holt, 2009). Self-management is defined as "the individuals' ability to manage the symptoms, treatment, physical and psychosocial consequences, and life style changes inherent in living with a chronic condition" (Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002, p. 178). The intent of a self-management health program is not only to monitor one's own condition but to also

impact one's own cognitive, behavioral, and emotional responses in a dynamic and continuous process to maintain or even improve one's own quality of life (Barlow, 2001).

Chronic disease is the leading cause of poor health, disability and death, but with improvements in technology there is an emergence of more virtual self and social health management programs (Patrick, et al., 2016). There is also a trend in healthcare to become more user-centered, which is changing the role of both practitioner and patient as patients learn more about managing their own health through self-monitoring and self-management (Patrick, et al., 2016). Self-management programs have been shown to provide benefits for participants in terms of knowledge of their condition, performance of self-management behaviors, self-efficacy and in some instances improvement of various health indicators (Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002) when compared to patients receiving only standard care.

In a review of the approaches to self-management in chronic illness, Barlow et al., (2002) identified that self-management approaches utilize social, cognitive, and behavior therapies and many also incorporate self-efficacy theory. They concluded in their review of self-management approaches that the content in self-management programs are based on providing mastery experiences, allowing participation in role modeling, providing practice in interpretation of symptoms, molding cognitive reframing and presenting information from a persuasive and credible source. They also have identified that individual approaches appear to be as effective as group interventions.

Self-management programs usually included information-based material as well as cognitive and behavioral strategies that are designed to increase self-efficacy (Barlow et al., 2002). Self-management programs for COPD have particularly addressed the importance of self-

efficacy (Bourbeau, Nault, & Dang-Tan, 2004). COPD patients need to integrate changes in behavior in everyday life; as such self-efficacy is important so that patients feel capable of performing the necessary skills to manage their COPD. Therefore, self-efficacy will play a part in determining the activities a patient will perform or avoid and as such is an integral component of a self-management health training program. This is why the integration of pedagogical agents in a virtual training program is significant as pedagogical agents have repeatedly been demonstrated to increase user self-efficacy which can improves learner confidence and can have positive impact on learning (Gulz, 2004: Kim & Baylor, 2006; Veletsianos, 2012).

Further, as the ability for patients to access self-management training programs can be limited through rural locations and mobility issues it is important to carefully consider how these programs can be virtualized. For example, Lorig, Ritter, Laurent and Plant, (2006) investigated an Internet based approach to chronic disease self-management. In this study which involved nearly 1 000 participants with chronic heart or lung disease or type II diabetes, the test group received a computer-based training program which included email remainders, discussion forums, weekly activities, posted action plains, self-tests, and check-in with a buddy. The content however, was provided in the format of a weekly reading. In comparison to a face-to-face self-management group the patients did as well if not better at improving their health statuses. Stinson et al. (2009) reviewed internet based self-management programs directed at youth and found that the Internet based self-management programs lead to improvements in symptoms and disease control in four out of five chronic diseases (asthma, recurrent pain, encopresis and obesity, with no improvement seen in traumatic brain injury). Lastly, Bickmore through various studies previously outlined has long contended the major role that relational agents can play in chronic disease management, not only providing emotional support, but through compliance

monitor and also by acting as an additional source of information for the patient. He has found that agents place less pressure on patients, are more receptive to questions, and appear less biased than face-to-face health care providers (Bickmore, 2010). The key to successfully using pedagogical agents in health self-management programs is in the agent development and designing an agent that is perceived as being caring, empathetic, and knowledgeable. However, van Wissen, Vinkers and van Halterern (2016) contend that there is limited research on what an ECA should look like to engender user acceptance by chronic patients.

Gaps in the Literature

Evident from the review of the literature within the area of pedagogical agent research is the paucity of studies of older adult learners in addressing the same design consideration of the pedagogical agent as in similar studies with younger learners and its associated impact on self-efficacy and knowledge creation (Baylor & Kim, 2004; Baylor & Kim, 2005; Kim et al., 2006; Kim , 2007; Kim, Baylor, & Shen, 2007). Work on virtual companions for elderly has provided some basis to preferences for appearances of agents but not in a learning environment and further in one to designed to help manage one's own health (Cereghetti, et al., 2015; Tsiourti, Joly, Wings, Moussa, & Wac, 2014). Bickmore's work with relational agents has demonstrated that computer agents can be effective in building social connections with older adults. Further, he has also demonstrated the effectiveness of computer agents in healthcare settings and the virtualization of self-management health programs have shown some success.

Given our aging population in Canada and the need for more access to health awareness programs it seems important to investigate the characteristics necessary to design pedagogical agents for computer-based self-management health training programs. While consideration has been given to social aspects of learning, researchers when considering adult learners' interactions

with pedagogical learning agents have not considered other aspects of adult learning theory. This is not to state that some adult learning theories do not consider social aspects of learning (Merriam, Caffarella, & Baumgartner, 2007). Social cognitive perspectives have been applied to examine cognition and aging investigating how people come to learn and to make sense of their world (Blanchard-Fields & Kalinauskas, 2009). Other adult learning theories consider prior learning experience, self-direction and orientation to learning (Knowles, 1984), experiential learning (Kolb, 1984) and self-directed learning (Brookfield, 1993; Grow, 1991).

When reviewing research in the field of pedagogical agents even to this date the research has been directed at school aged learners (K-12 or post-secondary) in formal learning environments (Johnson & Lester, 2016). Kim and Baylor (2016) also identify that there are underlying erroneous assumptions in studies that learners will perceive the agent features as the designer intended and that individual features can be investigated separately from the role of the agent and the context of the learning.

Even as the study of agents in healthcare has moved to primary research based on ECAs there is still a lack of studies that consider the appearance of the agent even though the premise of the design is based upon the ability of the agent and patient to develop a social rapport which is heavily dependent on the acceptance of the appearance and actions of the agent (Provoost, Lau, Ruwaard, & Riper, 2017; Wargnier & Jouvelet, 2014).

Chapter 4: Methodology

Type of study

The study used quantitative methods to determine the preferred design attributes of pedagogical agents by older adult, specifically over the age of 55, in general training environments and specifically in a self-management health program for a chronic condition using the PALD model suggested by Domagk (2010). Age 55 as a lower limit is consistent with other studies in healthcare such as Irwin, Cole & Nicassio (2006) and Murrell, Himmelfarb & Wright (1983), who defined older adults as being over the age of 55 and relevant to computer agents Vardoulakis et al. (2012) also defining over age 55 as older adult.

The research questions for this study were:

1. What characteristics of a pedagogical agent are preferred by older adult learners?
2. Specifically, what characteristics of a pedagogical agent are preferred by older adult learners in self-management health programs for chronic conditions?

Sampling Procedures

Ethical approval was obtained from the University of Alberta Ethics Review Board after submission of the research questions, consent letter and description of study and research site, on May 9, 2018 (No. Pro00080233). Participants over the age of 55 years old were invited initially through a posting on a Lifelong Learning Association website and later through posters displayed at the association's spring learning conference to participate in the study. The association is in an urban center and has over 400 members over the age of 50. The Association works in partnership with a post-secondary institution to offer educational courses that are current and relevant with a goal of promoting mental and physical well-being. The percentage of

members over the age of 55 was not made available to the researcher. However, if all members were over the age of 55 the ideal sample size using a+/- precision of 10% and a confidence level of 95% and P=0.5 is 81 using tables presented by the University of Florida (Israel, 1992). This sample can be corrected for a finite population using the formula

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

where n_0 is the sample size obtained from the tables, N is the population size and n is the adjusted sample size (Israel, 1992). Using this finite population correction

$$n = \frac{81}{1 + \frac{(81 - 1)}{400}}$$

the final desired sample size is 68.

On the welcome page (Figure 4.1) of the website the research study was explained, and examples of pedagogical learning agents demonstrated in different roles, styles, demographic characteristics and contextual situations were presented on subsequent webpages (Figure 4.2). Participants could take as much time as they liked exploring the site and then were invited to complete an online survey.

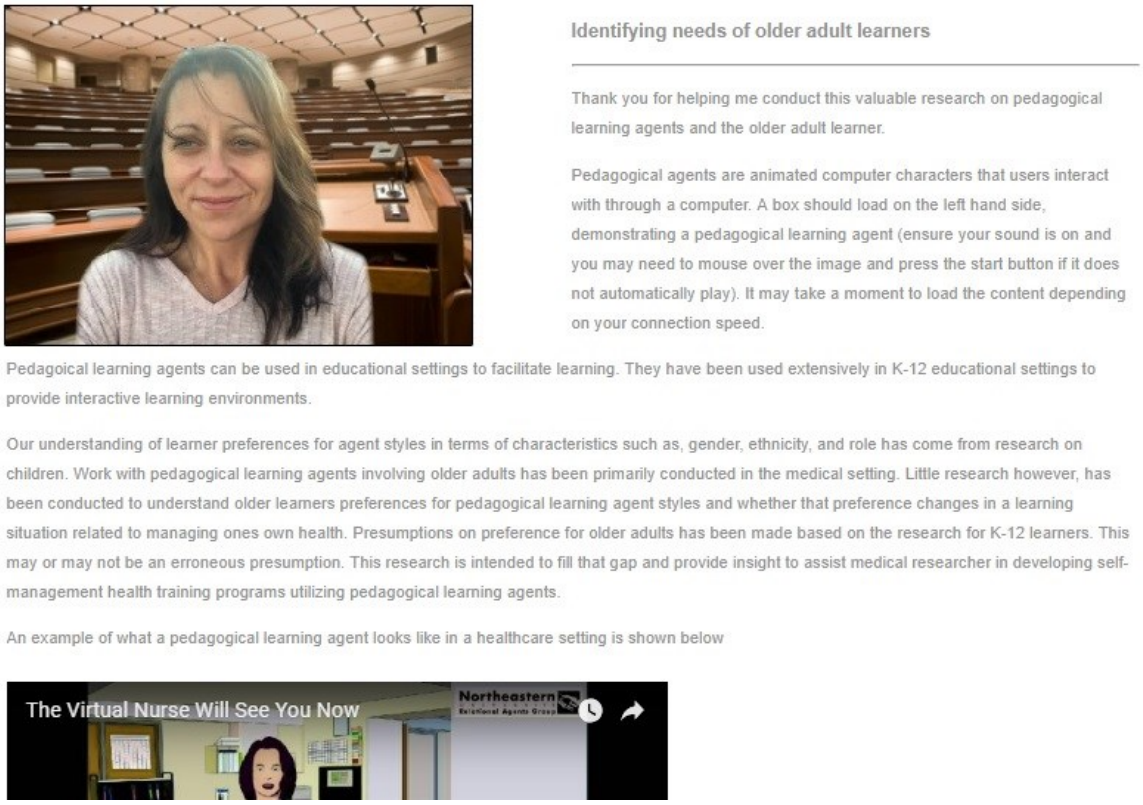

Figure 4.1: Website welcome page from research site.

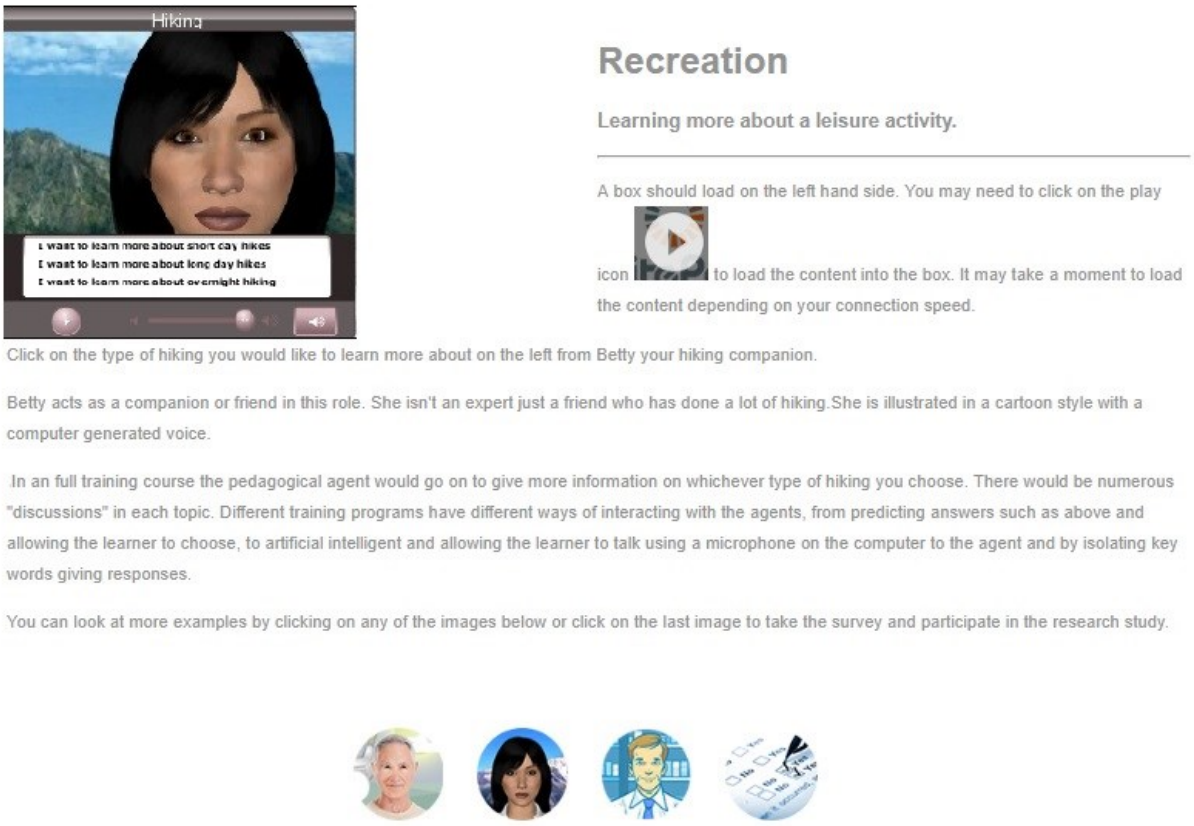

Figure 4.2: Webpage from research website showcasing the different examples participants could explore prior to completing the survey.

Methods

A variety of different styles of agents were introduced to the research participants on the website. This was to allow participants to conceptualize characteristics of an agent. Participants were first welcomed to the site by the researcher, in a realistic agent version of the researcher and were given an overview of the study (Figure 4.3).

Figure 4.3: Researcher's welcoming realistic virtual agent.

They could then explore three different general mock training lessons and one health specific training lesson. In the general training lessons participants could interact with pedagogical agents to enhance their golf swing, discern the type of hiking best suited to their fitness level or learn about tax breaks for seniors (Figure 4.4).

Figure 4.4: A stylized expert pedagogical agent explains tax breaks for seniors.

The health session provided an opportunity to learn about medicine interactions from a pharmacist.

Figure 4.5: A stylized pedagogical agent in role of an expert pharmacist.

Each session was brief and was designed for the participant to interact with the agent for approximately five minutes at a time. Participants interacted with the agent by choosing from a choice of prompts in response to questions the agent asked. Based upon responses to the prompts the agent would provide information unique to the prompt and through more questioning or prompting would provide more specific information to each participant dependent upon their individual responses.

Figure 4.6: Examples of prompts in lesson for participant response. Golf lesson is shown on the left with a realistic teacher agent and hiking lesson on the right with a computer-generated stylized friend agent.

After exploring the different learning examples and engaging with different types of agents, participants were invited to complete an online survey. Survey data were collected anonymously through Survey Monkey, and participants could leave the survey at any time. Participants accessed the survey through a link from the website. On the first page of the survey participants were presented with the informed consent form and were given an option to decline participation. If they declined, they were thanked for their time and the survey ended. If they continued onto the survey, they were presented with 33 questions in three sections. Section A presented 13 questions regarding the participants' preferences for pedagogical agent style for learning in general. These questions aligned with Domagk's (2010) PALD model. The PALD model was used to provide a comprehensive investigation of the design aspects of an agent and to eliminate bias by the researcher as to what attributes should be considered.

The PALD model (Domagk, 2010) has been used to consider the desired attributes of agents in other research studies (Heidig & Clarebout, 2011). To be able to align with the current research and particularly with the move to extensive research regarding ECAs at the global level, participants were not asked whether they preferred their pedagogical agent was human or non-human in the study, as overwhelmingly research is being conducted on human type agents. Therefore, the survey focused on medium and detail level characteristics. The thirteen questions in section A addressed whether participants preferred a cartoon or realistic agent (medium level), whether the agent was static or animated (medium level), communication style (medium level) , type of voice (medium level), role of agent (medium level), facial expression (medium level), level of competence (medium level), demeanour of agent (medium level), gender of agent (detail level), ethnicity of agent (detail level), age of agent (detail level), attire of agent (detail level), and body shape of agent (detail level). Each question had a categorical response that was derived from previous research studies presented in the literature. For example, Gulz & Haake, (2006) describe body shapes as muscular bodies (mesomorphs), fat bodies (endomorphs) or thin bodies (ectomorphs), which were the categories used in this survey. Each question also provided the participant the option of no preference. As each question measured a different it is not possible to measure internal validity of the survey instrument. The survey instrument needs to be evaluated through test-retest situation.

Frequently in research regarding determining the effectiveness of animated pedagogical agents the agent persona instrument was used (Ryu & Baylor, 2005; Baylor & Ryu, 2003). This instrument is designed with two higher level variables: affective interaction and information usefulness, each of which have two subscales. The information usefulness subscales includes a

measure for agent's perceived credibility and the agent's ability to facilitate learning outcomes. The affective interaction subscales measure how human-like the agent is and how engaging the agent is perceived to be.

This instrument was not appropriate for this study as it measures the persona effect of existing agents. This study was for participants to discern preferences without designing agents for participants to evaluate. The agents presented on the research website were to explain what and how pedagogical agents work and allow users an opportunity to interact with different agents especially if they had not been exposed to virtual agents before. The study survey itself did not present any agents as prompts to questions.

Often when discerning the desired visual aspects of agents focus groups and questionnaires are generated by the researchers. No specific instrument has been developed in the field to determine preferred attributes in order to develop an agent and many studies have only focused on a handful of attributes. Hence the use of the PALD as a framework for establishing questions for the survey.

At the end of section A, participants were asked to indicate if they had ever been diagnosed with a significant long-term illness. If participants responded "yes" to this question, they were prompted to complete the same 13 questions from the context of learning about their health condition from a pedagogical agent in section B. If they answered "no" this section did not present to the participant. Lastly, all respondents were all directed to section C and were asked six demographic questions ascertaining age, gender, marital status, ethnicity, level of education, and annual household income (see Appendix A for full questionnaire). Participants were given the option of preferring not to respond to each of the demographic questions. Upon

completion of the study participants were thanked for their time and provided the researcher's contact information if they wanted to receive a copy of the study results.

Different statistical analyzes were performed on the results. Frequencies were used to describe the results in both the general and health context. A one sample non-parametric chi square test for goodness of fit using exact test was run on each attribute in the general and heath context to determine if there were any significant preferences in regard to each agent attribute. To determine if there was a relationship between the demographic aspects of the participants and a particular attribute a Fisher exact test was utilized but only in the general learning context as the health context sample size was too small.

Chapter 5: Results

Participants

The participants consisted of 23 individuals over the age of 55, mean age = 63.25 years, SD=6.482, age range 55 – 78, 14 females, 7 males and 2 preferred not to state gender. Table 5.1 presents the demographic information of respondents.

Research question 1

1. What characteristics of a pedagogical agent are preferred by older adult learners?

Responses from Section A of the survey were used to compile responses to this research question and are displayed in Table 5.2. Frequency of responses was generated for each question. As there were three or more categorical groups within each demographic variable, gender (male, female, prefer not to answer), ethnicity, highest educational level, annual income and marital status, initially Kruskal-Wallis H tests were run using an exact test for significance to determine if there was a significant effect of the independent variable on design aspect of the agents.

Table 5.1

Demographic data of participants

ID	Year of birth	Gender	Ethnicity	Level of education	Annual household income	Marital status
1	1959	male	Caucasian	attended college/technical institute but did not complete	>$150,000	married
2	1957	female	Caucasian	completed a master's degree	>$150,000	married
3	1959	female	Caucasian	completed a master's degree	$100,001-$125,000	married
4	1948	male	Caucasian	completed a master's degree	>$150,000	married
5	1963	male	Caucasian	completed a college or technical institute certificate or diploma	>$150,000	married
6	1959	female	Caucasian	completed a college or technical institute certificate or diploma	>$150,000	married
7	1962	female	Caucasian	completed a bachelor's degree	>$150,000	married
8	1949	female	Caucasian	completed a bachelor's degree	$40,001-$60,000	divorced
9	1957	female	Caucasian	completed a college or technical institute certificate or diploma	<$20,000	divorced
10	1956	prefer not to answer	Caucasian	attended university but did not complete	$80,001-$100,000	married
11	1946	female	Caucasian	completed a bachelor's degree	$40,001-$60,000	married
12	1955	female	Caucasian	completed a college or technical institute certificate or diploma	prefer not to respond	married
13	1940	male	Caucasian	graduated from high school	$80,001-$100,000	widowed
14	1948	prefer not to answer	Caucasian	completed a master's degree	prefer not to respond	married
15	1952	female	prefer not to answer	completed a master's degree	$60,001-$80,000	prefer not to respond
16	1959	male	Asian or Pacific Islander	completed a master's degree	$60,001-$80,000	married
17	1962	female	Caucasian	completed a bachelor's degree	prefer not to respond	married
18	1948	female	Caucasian	completed a bachelor's degree	$40,001-$60,000	divorced
19	1961	female	Caucasian	completed a college or technical institute certificate or diploma	prefer not to respond	single
20	1944	male	Caucasian	completed a doctorate degree	>$150,000	married
21	1959	female	Caucasian	completed a bachelor's degree	>$150,000	married
22	1959	female	Caucasian	completed a college or technical institute certificate or diploma	>$150,000	married
23	1957	male	Caucasian	completed a master's degree	>$150,000	married

Table 5.2

General agent attributes by participants

ID	Style	Gender	Ethnicity	Age	attire	facial expression	body shape	role	competence	demeanour	communication style	voice	animation
1	realistic	male	Caucasian	41-55	casual	friendly	muscular	teacher	high - confident	easy-going	task orientated	human	static
2	realistic	np	np	41-55	casual	friendly	muscular	teacher	low - sympathetic	easy-going	task orientated	human	animated
3	realistic	female	np	>55	np	friendly	np	co-learner	no preference	np	combined	human	static
4	realistic	female	np	np	casual	friendly	thin	expert	low - sympathetic	easy-going	combined	human	animated
5	cartoon	np	Caucasian	41-55	casual	friendly	muscular	teacher	high - confident	easy-going	task orientated	human	np
6	realistic	np	Caucasian	np	professional	friendly	muscular	expert	high - confident	easy-going	combined	human	animated
7	cartoon	np	np	np	np	friendly	np	teacher	low - sympathetic	serious	task orientated	human	np
8	realistic	np	np	41-55	casual	friendly	np	expert	high - confident	np	combined	human	animated
9	realistic	np	np	41-55	professional	friendly	np	expert	high - confident	easy-going	task orientated	human	np
10	realistic	male	np	np	casual	friendly	np	co-learner	no preference	easy-going	combined	human	animated
11	realistic	np	np	np	np	np	np	np	high - confident	serious	combined	human	np
12	realistic	np	np	np	casual	friendly	np	co-learner	low - sympathetic	easy-going	combined	np	static
13	realistic	male	Caucasian	>55	professional	friendly	np	expert	high - confident	easy-going	task orientated	human	static
14	realistic	female	Indigenous	>55	professional	neutral	muscular	teacher	high - confident	np	task orientated	human	np
15	realistic	np	np	np	professional	friendly	np	teacher	high - confident	easy-going	combined	human	np
16	np	np	np	np	np	friendly	np	expert	high - confident	easy-going	task orientated	np	static
17	cartoon	np	np	41-55	professional	friendly	np	expert	low - sympathetic	easy-going	task orientated	human	np
18	realistic	np	np	np	np	friendly	np	expert	high - confident	easy-going	combined	human	np
19	cartoon	np	np	41-55	professional	friendly	np	np	high - confident	easy-going	combined	human	animated
20	np	np	np	41-55	professional	friendly	np	expert	high - confident	serious	combined	human	animated
21	np	np	Other	41-55	professional	friendly	np	teacher	high - confident	easy-going	task orientated	human	static
22	realistic	np	np	26-40	casual	friendly	muscular	teacher	high - confident	easy-going	combined	human	animated
23	cartoon	np	np	np	casual	neutral	np	co-learner	high - confident	easy-going	combined	human	animated

np = no preference

The Kruskal-Wallis H test was used originally as opposed to an ANOVA due to categorical nature of the data (Chan, 2003). An exact test was used to compensate for the small sample as the exact test is accurate even with smaller sample sizes (Raymond & Rousset, 1995). The independent variables were the demographic data collected in Section C of the survey. Upon further review however, it was determined that the Fisher exact test would be a better measure as the data both in terms of participant demographics and preferred characteristics was nominal (Metha & Nitin, 1997). Kruskal-Wallis H test presumes one of the data sets is ordinal. An alpha level of 0.05 was used for all statistical tests. As the Kruskwal-Wallis H test was initially ran both Kruskwal-Wallis H test and Fisher exact results are presented however, only the Fisher- exact test results are used in the discussion. The null hypothesis is there is no relation between a demographic variable and an agent attribute.

To discern which attributes were critical in the design of the agent a one sample nonparametric chi square test for goodness of fit was run using an exact test to determine if there was a significant distribution of results favoring one category over the others within each given attribute. The null hypothesis for this analysis was H_0 = the sample frequencies in each category for an agent attribute will be distributed equally. If results meet the null hypothesis the responses would be distributed somewhat equally amongst the categories meaning that respondents did not demonstrate a strong preference for the design of the given attribute. If the null hypothesis was rejected it indicated that there was preference being demonstrated for one or more categories over the other, suggesting the possibility of a design preference and warranting further investigation. Sample size is 23 in all analyzes in the general learning context.

Medium design. The survey asked questions regarding the degree of realism, an agent's degree of empathy/sympathy through facial expression, agent's competence, level of animation, the role of agent, communication style, non-verbal communication and agent voice.

Animation. Participants were asked if they preferred the pedagogical agent to be animated with lots of movement or static with very minimal movement. Nine participants indicated they preferred an animated agent, six a static agent and eight had no preference.

There was no significant difference between any of the categories in participants' demographic variable in relation to the level of animation of agent: Kruswall – Wallis H test gender χ^2 (2) = 0.743, p = 0.761, ethnicity χ^2 (2) = 1.468, p = 0.727, highest education level χ^2 (6) = 4.909, p = 0.695, annual household income χ^2 (6) = 5.340, p = 0.575 and marital status χ^2 (4) = 3.244, p = 0.668 and Fisher exact test gender p = 0.639, ethnicity p = 0.249, highest education level p = 0.657, annual household income p = 0.583 and marital status p = 0.630.

Non-verbal communication. The agent's demeanour was surveyed to determine preference for some aspects of non-verbal communication. Animation investigated in another question is also an aspect of non-verbal communication. Seventeen respondents liked an easy-going demeanour, three a serious demeanour and three respondents had no preference.

There was no effect seen in preference for agent demeanour based upon the participants' demographic variables: Kruswall – Wallis H test gender χ^2 (2) = 2.357, p = 0.403, ethnicity χ^2 (2) = 0.000, p = 1.000, highest education level χ^2 (6) = 6.373, p = 0.479, annual household income χ^2 (6) = 6.050, p = 0.488 or marital status χ^2 (4) = 1.438, p = 0.835 and Fisher exact test gender p = 0.534, ethnicity p = 1.000, highest education level p = 0.609, annual household income p = 0.444 and marital status p = 0.908.

Communication style. Respondents could choose between a task-orientated (provided only information directly related to the topic), relational orientated (focused on developing a social relation) or combined task orientated (focus on the social relationship while contributing to learning). Ten respondents indicated a preference for task orientated while 13 preferred combined, no respondents indicated a preference for relational orientated.

There was no effect seen in preference for agent communication style based upon the participants' demographic variables: Kruswall – Wallis H test gender χ^2 (2) = 0.870, p = 0.816, ethnicity χ^2 (2) = 1.982, p = 0.692, highest education level χ^2 (6) = 4.299, p = 0.939, annual household income χ^2 (6) = 4.485, p = 0.712 or marital status χ^2 (4) = 2.920, p = 1.000 and Fisher exact test gender p = 0.690, ethnicity p = 0.692, highest education level p = 0.939, annual household income p = 0.732 and marital status p = 1.000.

Voice. Participants were asked to indicate their preference for a computer-generated voice for the agent or a human generated voice. Twenty-one participants indicated a human-generated voice and two had no preference.

There was no effect seen in agent voice based upon the participants' demographic variables: Kruswall – Wallis H test gender χ2 (2) = 0.486, p = 1.000, ethnicity χ^2 (2) = 10.526, p = 0.170, highest education level χ^2 (6) = 1.634, p = 1.000, annual household income χ^2 (6) = 6.940, p = 0.340 or marital status χ^2 (4) = 0.739, p = 1.000 and Fisher exact test gender p = 0.585, ethnicity p = 0.170, highest education level p = 1.000, annual household income p = 0.261 and marital status p = 1.000.

Graphical style. Participants were asked to indicate their preferred graphical style as either stylized (or cartoon) agents or realistic agents. Fifteen participants indicated a preference for realistic, five for stylized and three had no preference.

There was no significant difference between any of the categories in each participants' demographic variable in relation to the graphical style of agent: Kruswall – Wallis H test gender χ^2 (2) = 0.277, p = 0.864, ethnicity χ^2 (2) = 3.262, p = 0.289, highest education level χ^2 (6) = 4.430, p = 0.690, annual household income χ^2 (6) = 4.030, p = 0.734 and marital status χ^2 (4) = 2.657, p = 0.740 and Fisher exact test gender p = 0.477, ethnicity p = 0.289, highest education level p = 0.843, annual household income p = 0.870 and marital status p = 0.683.

Agent role. Research participants could choose their preference for agent role: teacher, expert, co-learner or friend. Nine preferred expert, eight teacher, four co-learner, none for friend and two had no preference.

There was no significant difference between any of the categories in participants' demographic variables in relation to the role of the agent: Kruswall – Wallis H test gender χ^2 (2) = 0.064, p = 0.974, ethnicity χ^2 (2) = 1.441, p = 0.858, highest education level χ^2 (6) = 3.001, p = 0.923, annual household income χ^2 (6) = 7.751, p = 0.236 and marital status χ^2 (4) = 4.217, p = 0.377 and Fisher exact test gender p = 0.436, ethnicity p = 0.829, highest education level p = 0.754, annual household income p = 0.262 and marital status p = 0.217.

Level of competence. Level of competence was divided into two categories an agent that was viewed as less competent but still sympathetic and put the learner at ease or an agent that was more competent and appeared confident and kept the learner focused. Sixteen participants preferred a confident agent, while five indicated a preference for a sympathetic agent and two participants had no preference.

There was no effect seen in preference for agent's level of competence based upon the participants' demographic variables: Kruswall – Wallis H test gender χ^2 (2) = 2.737, p = 0.333, ethnicity χ^2 (2) = 0.164, p = 1.000, highest education level χ^2 (6) = 4.713, p = 0.645, annual household income χ^2 (6) = 9.286, p = 0.139 or marital status χ^2 (4) = 0.607, p = 0.964 and Fisher exact test gender p = 0.346, ethnicity p = 1.000, highest education level p = 0.856, annual household income p = 0.288 and marital status p = 0.908.

Facial expression. In terms of the facial expression and its ability to convey sympathy or empathy 20 respondents preferred a friendly face, two neutral, one indicated no preference and no respondents chose stern.

Using Kruswall – Wallis H test there was no significant preference for the facial expression of the agent in relation to the participants' demographic variables of gender χ^2 (2) = 5.074, p = 0.083, ethnicity χ^2 (2) = 0.035, p = 1.000, highest level of education χ^2 (6) = 5.192, p = 0.574, annual household income χ^2 (6) = 4.657, p = 0.636 or marital status χ^2 (4) = 0.129, p = 0.974 and Fisher exact test gender p = 0.186, ethnicity p = 1.000, highest education level p = 1.000, annual household income p = 0.448 and marital status p = 1.000.

Design aspects. The visual features of the pedagogical agent considered in this study included gender, age, ethnicity, body shape and attire.

Gender. Three participants indicated a preference for a male agent, three for a female and 17 had no preference.

There was a significant preference for the gender of the agent based upon the gender of the participant using Kruswall – Wallis H test χ^2 (2) = 9.159, p = 0.008, as well as the participants' highest education level χ^2 (6) = 15.17, p = 0.001 and annual household income χ^2

(6) = 11.326, $p = 0.047$ and with the Fisher exact test significance was found with gender $p = 0.011$, and highest education level $p = 0.001$.

There was no effect seen in preference for agent gender based upon the participants' ethnicity using the Kruswall – Wallis H test χ^2 (2) = 0.723, $p = 1.000$ or marital status χ^2 (4) = 5.371, $p = 0.271$ and with the Fisher exact test for ethnicity $p = 1.000$, annual household income $p = 0.121$ and marital status $p = 0.651$.

. ***Body shape.*** Six respondents indicated they liked a muscular agent, one a thin agent, none for a heavy agent and 16 had no preference regarding this characteristic.

Using Kruswall – Wallis H test there was no significant preference for the body shape of the agent in relation to the participants' demographic variables of gender χ^2 (2) = 1.133, $p = 0.675$, ethnicity χ^2 (2) = 0.902, $p = 1.000$, highest level of education χ^2 (6) = 7.702, $p = 0.226$, annual household income χ^2 (6) = 7.512, $p = 0.252$ or marital status χ^2 (4) = 3.343, $p = 0.524$ and Fisher exact test gender $p = 0.231$, ethnicity $p = 1.000$, highest education level $p = 0.175$, annual household income $p = 0.809$ and marital status $p = 0.755$.

. ***Ethnicity.*** Seventeen individuals had no preference for ethnicity of their agent. Four however preferred a Caucasian agent, and one an Indigenous agent and one individual indicated other but did not elaborate on what ethnicity they preferred. None listed a preference for an Asian, Hispanic (Latino) or African American agent.

Using Kruswall – Wallis H test there was no significant preference for ethnicity of the agent in relation to the participants' demographic variables of gender χ^2 (2) = 4.973, $p = 0.095$, ethnicity χ^2 (2) = 0.332, $p = 1.000$, highest level of education χ^2 (6) = 8.802, $p = 0.188$, annual household income χ^2 (6) = 2.057, $p = 0.924$ or marital status χ^2 (4) = 3.393, $p = 0.568$ and Fisher

exact test gender $p = 0.091$, ethnicity $p = 1.000$, highest education level $p = 0.175$, annual household income $p = 0.809$ and marital status $p = 0.755$.

. ***Age.*** Ten participants had no preference for the age of agent, nine indicated they would like their agent to be between 41-55 years of age, three wanted an agent over 55 years of age and one preferred an agent between the age of 26 – 40. None preferred an agent younger than 26 years of age.

There was no effect seen in preference for agent age based upon the participants' demographic variables: Kruskal - Wallis H test gender χ^2 (2) = 0.660, $p = 0.711$, ethnicity χ^2 (2) = 2.347, $p = 0.265$, highest education level χ^2 (6) = 5.438, $p = 0.528$, annual household income χ^2 (6) = 4.768, $p = 0.659$ or marital status χ^2 (4) = 2.277, $p = 0.939$ and Fisher exact test gender $p = 0.712$, ethnicity $p = 1.000$, highest education level $p = 0.388$, annual household income $p = 0.429$ and marital status $p = 0.613$.

Attire. Nine individuals indicated they liked their agent to be casual in attire, and nine individuals indicated they were partial to an agent in professional in attire, while six had no preference.

There was no effect seen in preference for agent attire based upon the participants' demographic variables: Kruskal - Wallis H test gender χ^2 (2) = 1.826, $p = 0.454$, ethnicity χ^2 (2) = 2.264, $p = 0.538$, highest education level χ^2 (6) = 5.977, $p = 0.467$, annual household income χ^2 (6) = 6.772, $p = 0.352$ or marital status χ^2 (4) = 0.579, $p = 0.987$ and Fisher exact test gender $p = 0.759$, ethnicity $p = 0.529$, highest education level $p = 0.796$, annual household income $p = 0.415$ and marital status $p = 1.000$.

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Critical attributes

In terms of determining critical aspects for design of the agents a nonparametric one sample chi-square test for goodness of fit using an exact test to compensate for the small sample size was run. The results of this analysis are shown in table 5.3.

Table 5.3

General agent characteristics analyzed through a one sample nonparametric chi-square test for goodness of fit n=23

Characteristic	Results
Gender	χ^2 (2) = 17.043, p = 0.000
Ethnicity	χ^2 (3) = 30.391, p = 0.000
Age	χ^2 (3) = 10.217, p = 0.017
Attire	χ^2 (2) = 17.043, p = 0.499
Facial Expression	χ^2 (2) = 29.826, p = 0.000
Body Shape	χ^2 (2) = 15.217, p = 0.000
Role	χ^2 (3) = 10.217, p =*0.127*
Competence	χ^2 (2) = 14.174, p = 0.001
Demeanour	χ^2 (2) = 17.043, p = 0.000
Communication style	χ^2 (1) = 0.391, p = 0.532
Voice	χ^2 (1) = 15.696, p = 0.000
Animation	χ^2 (2) = 0.609, p = 0.738
Graphical Style	χ^2 (2) = 10.783, p = 0.005

Research question 2

1. Specifically, what characteristics of a pedagogical agent are preferred by older adult learners in self-management health programs for chronic conditions?

Of the 23 participants who completed the study, nine indicated that they had been diagnosed with a chronic illness. Table 5.4 shows the demographic data for this subset.

Table 5.4

Demographic data of participants with a chronic condition

ID	Year of birth	Gender	Ethnicity	Level of education	Annual household income	Marital status
1	1959	male	Caucasian	attended college/technical institute but did not complete	>$150,000	married
2	1957	female	Caucasian	completed a master's degree	>$150,000	married
5	1963	male	Caucasian	completed a college or technical institute certificate or diploma	>$150,000	married
9	1957	female	Caucasian	completed a college or technical institute certificate or diploma	<$20,000	divorced
10	1956	prefer not to answer	Caucasian	attended university but did not complete	$80,001-$100,000	married
13	1940	male	Caucasian	graduated from high school	$80,001-$100,000	widowed
15	1952	female	prefer not to answer	completed a master's degree	$60,001-$80,000	prefer not to respond
22	1959	female	Caucasian	completed a college or technical institute certificate or diploma	>$150,000	married
23	1957	male	Caucasian	completed a master's degree	>$150,000	married

Table 5.5

Health related agent attributes by participants

ID	Style	Gender	Ethnicity	Age	attire	facial expression	body shape	role	competence	demeanour	communication style	voice	animation
1	realistic	male	Caucasian	41-55	professional	friendly	muscular	expert	high - confident	easy-going	task orientated	human	static
2	realistic	male	Caucasian	41-55	professional	friendly	no	expert	low - sympathetic	serious	task orientated	human	animated
5	realistic	np	Indigenous	41-55	professional	friendly	muscular	expert	high - confident	serious	task orientated	human	static
9	realistic	np	np	41-55	professional	np	np	expert	high - confident	np	task orientated	human	np
10	realistic	male	np	np	casual	friendly	np	co-learner	high - confident	easy-going	combined	human	animated
13	realistic	male	Caucasian	>55	professional	friendly	np	expert	high - confident	serious	task orientated	human	static
15	realistic	np	np	np	professional	friendly	np	teacher	high - confident	easy-going	combined	human	np
22	realistic	np	np	26-40	professional	neutral	np	expert	low - sympathetic	serious	relational orientated	human	animated
23	realistic	male	np	np	professional	neutral	np	expert	high - confident	serious	combined	human	static

np = no preference

In this subset the mean age of respondents was 62.44 years of age (SD=6.521) with a range in age from 55 to 78, four of whom were male, four of whom were female and one preferred not state their gender.

Responses to Section B of the survey were used to compile the data and are displayed in Table 5.5. As the sample size is small only descriptive statistics describing frequency of responses were conducted for questions in Section B and an analysis of independent demographic data of the respondents (Section C) to determine significant effect of the independent variable on design aspect of the agents was not considered.

Medium design. The same medium design aspects covered in the larger group of pedagogical agents in general were analyzed. These included the degree of realism, an agent's ability to express sympathy through facial expression, competence of agent, level of animation, the role of agent, communication style, non-verbal communication, and agent voice all in relation to an agent providing instruction and information related to a chronic health condition.

Animation. Three participants preferred the pedagogical agent to be animated with lots of movement and four static with very minimal movement. Two respondents had no preference.

Non-verbal communication. The agent's demeanour was surveyed to determine preference for some aspects of non-verbal communication. Three respondents liked an easy-going demeanour, five preferred a serious demeanour and one respondent had no preference.

Communication style. Five participants choose a task-orientated (provided only information directly related to the topic) agent, one participant indicated preference for a relational orientated (focused on developing a social relation) agent and three participants liked a combined task oriented (focus on the social relationship while contributing to learning) agent.

Voice. Participants were asked to indicate their preference for a computer-generated voice for the agent or a human generated voice. All respondents indicated preference for a human-generated voice.

Graphical style. Participants were asked to indicate their preferred graphical style as either stylized (or cartoon) agents or realistic agents. All participants preferred a realistic style for the agent.

Agent role. With respect to a health-related pedagogical agent, respondents had a preference for the expert role (seven), followed by teacher (one) and co-learner (one).

Level of competence. Seven participants preferred a confident agent who kept them focused, while two participants indicated a preference for a sympathetic agent who could put them at ease.

Facial expression. In terms of the facial expression respondents, six respondents wanted a friendly face, two neutral and one had no preference.

Design aspects. The visual features of the pedagogical agent considered in this part of the study were the same as research question 1 and included gender, age, ethnicity, body shape and attire.

Gender. Five participants indicated a preference for a male agent, none for a female and four had no preference.

Body shape. Seven individuals indicated no preference for the body shape of the agent and two indicated they liked a muscular agent.

Ethnicity. Five individuals had no preference for ethnicity of their agent but three indicated a preference for a Caucasian agent, and one an Asian agent. None listed a preference for an Indigenous, Hispanic (Latino) or African American agent.

Age. Four respondents answered that they would like their agent in this environment to be between 41-55 years of age, three had no preference regarding age, while one respondent wanted an agent over 55 years of age and one preferred an agent between the age of 26 – 40.

Attire. Eight individuals indicated they liked their agent to be professional in attire while one individual preferred casual attire for their agent.

Critical attributes

In terms of determining critical aspects for design of the agents in a health setting a nonparametric one sample chi-square test for goodness of fit using an exact test to compensate for the small sample size was run as it was for the general setting. The results of this analysis are shown in table 5.6.

Table 5.6

Agent characteristics in a self-management health setting analyzed through a one sample nonparametric chi-square test for goodness of fit n=9

Characteristic	Results
Gender	χ^2 (1) = 0.111, p =.739
Ethnicity	χ^2 (2) = 2.667, p = 0.264
Age	χ^2 (3) = 3.000, p = 0.392
Attire	χ^2 (2) = 5.444, p = 0.020
Facial Expression	χ^2 (2) = 4.667, p = 0.097
Body Shape	χ^2 (1) = 2.778, p = 0.096
Role	χ^2 (2) = 8.000, p = 0.018
Competence	χ^2 (2) = 2.778, p = 0.096
Demeanour	χ^2 (2) = 2.667, p = 0.264
Communication style	χ^2 (2) = 2.667, p = 0.264
Voice	Not reported *
Animation	χ^2 (2) = 0.667, p = 0.717
Graphical Style	Not reported *

* all respondents selected the same desired attribute as such the results is constant Chi-square test cannot be performed

Table 5.7 represents the responses to the Section A and Section B questions by participants who indicated they had a chronic condition. A letter “G” after their identification numbers indicates the participants’ response in the general context and an “H” indicates the health context. When participants changed their response in relation to the context it has been highlighted by an asterisk.

Table 5.7

Participants preferences for agent characteristics in a general setting versus a self-management health context

ID	Style	Gender	Ethnicity	Age	attire	facial expression	body shape	role	competence	demeanour	communication style	voice	animation
1G	realistic	male	Caucasian	41-55	casual*	friendly	muscular	teacher*	high - confident	easy-going	task orientated	human	static
1H	realistic	male	Caucasian	41-55	professional*	friendly	muscular	expert*	high - confident	easy-going	task orientated	human	static
2G	realistic	np*	np	41-55	casual*	friendly	muscular*	teacher*	low - sympathetic	easy-going*	task orientated	human	animated
2H	realistic	male*	Caucasian	41-55	professional*	friendly	np*	expert*	low - sympathetic	serious*	task orientated	human	animated
5G	cartoon*	np	Caucasian*	41-55	casual*	friendly	muscular	teacher*	high - confident	easy-going*	task orientated	human	np*
5H	realistic*	np	Indigenous*	41-55	professional*	friendly	muscular	expert*	high - confident	serious*	task orientated	human	static*
9G	realistic	np	np	41-55	professional	friendly*	np	expert	high - confident	easy-going*	task orientated	human	np
9H	realistic	np	np	41-55	professional	np*	np	expert	high - confident	np*	task orientated	human	np
10G	realistic	male	np	np	casual	friendly	np	co-learner	no preference*	easy-going	combined	human	animated
10H	realistic	male	np	np	casual	friendly	np	co-learner	high – confident*	easy-going	combined	human	animated
13G	realistic	male	Caucasian	>55	professional	friendly	np	expert	high - confident	easy-going*	task orientated	human	static
13H	realistic	male	Caucasian	>55	professional	friendly	np	expert	high - confident	serious*	task orientated	human	static
15G	realistic	np	np	np	professional	friendly	np	teacher*	high - confident	easy-going	combined	human	np
15H	realistic	np	np	np	professional	friendly	np	expert*	high - confident	easy-going	combined	human	np
22G	realistic	np	np	26-40	casual*	friendly*	muscular*	teacher*	high – confident*	easy-going*	combined*	human	animated
22H	realistic	np	np	26-40	professional*	neutral*	np*	expert*	low – sympathetic*c	serious*	relational orientated*	human	animated
23G	cartoon*	np*	np	np	casual*	neutral	np	co-learner*	high - confident	easy-going*	combined	human	animated
23H	realistic*	male*	np	np	professional*	neutral	np	expert*	high - confident	serious*	combined	human	animated

np = no preference.

* Indicates a different preference between contexts

Chapter 6: Discussion

There has been little research conducted to understand the attributes that pedagogical agents should have when implemented into a health training program for older adults. Moreover, little is known about older adult learners' preferences for a pedagogical agent in general. It was, therefore, important to understand what design attributes older adults desired in a pedagogical agent as it is necessary in accordance with social cognitive theory for the learner to connect on a social level with their instructor (even a virtual one) to be able to facilitate deeper levels of learning. Therefore, there needs to be acceptance of the agent by the learner. This becomes even more critical when moved into the realm of health care and learning about one's own chronic medical condition. With these considerations this study was conducted to answer two research questions:

1. What characteristics of a pedagogical agent are preferred by older adult learners?
2. Specifically, what characteristics of a pedagogical agent are preferred by older adult learners in self-management health programs for chronic conditions?

The sample size for this study was 23. Although this is relatively small for a quantitative study the size is consistent with other samples in the field of computer agents when working with older adults as indicated in table 6.1.

Table 6.1

Sample sizes of research studies investigating computer agents and older adults

Study Name	N	Citation
A virtual assistive companion for older adults: Qualitative field study and design implications	20	Tsiorurti et al. (2014)
To be (me) or not to be? Photorealistic avatars and older adults	6	Puri, Baker, Hoang & Carrasco-Zuffi (2017)
Virtual partners for seniors: Analysis of the users' preferences and expectations on personality and appearance	15	Cereghetti et al. (2015)
Creating new technologies for companionable agents to support isolated older adults	44	Sidner at al. (2018)
It's just like you are talking to a friend: Relational agents for older adults	21	Bickmore, Caruso, Clough-Gorr & Keeren (2005)
Negotiating stereotypes of older adults through avatars	23	Carrasco, Baker, Waycott & Vetere (2017)
Avatar: A virtual face for the elderly	24	Cheong, Jung & Theng (2011)
Designing relational agents as long term social companions for older adults	12	Pfeifer-Vardoulakis, Ring, Barry, Sidner & Bickmore (2012)
Virtual agents as daily assistants for elderly or cognitively impaired people: Studies on acceptance and interaction feasibility	6	Yaghoubzadeh, Kramer, Pitsch & Kopp (2013)

Finding participants in the age range that were comfortable in an online learning environment limited the participant pool. The research site was selected specifically as a convenience site as their members are engaged in continued learning activities and would presumably have a higher percentage of members participating in learning activities in comparison to the general population. Convenience sampling has been shown to provide estimates of causal effects comparable to those found on population-based samples. Yet caution must be taken as the convenience sample's relationship to population is unknown and therefore there exists the possibility that features of the sample skew it from the population of interest (Mullinix, Leeper, Druckman, & Freese, 2015).

In 2007, (the last Statistic Canada data available regarding internet use by demographic) 45% of seniors were online and 70% of individuals between the age of 55 to 64. 15% of seniors used the internet for education or training and 36% of the population from 45 to 64 years of age (Statistics Canada, 2007). Averaging these numbers to cover the target age range for this study roughly 58% of individuals at the research site would be Internet users and of those 25% would be using the internet for training purposes. Given the research site has 400 members this equates to 58 potential participants for the study if all were over the age of 55. A 50% response rate is an ideal target for health survey studies but is difficult to obtain and even with incentives most survey participation rates are around 40% - 50%. (Tolonen, Ahonen, Jentoft, Kuulasmaa, & Heldal, 2015). This study had a 40% response rate based on the assumption that all members were over the age of 55 and eligible to participate.

An important consideration regarding sample size is that age has been correlated to survey response rate. Older individuals are less likely to participate, and the non-response rate increases over one half of a percentage for each year increase of respondents' age (Porter &

Whitcomb, 2005). This can negatively impact response rates and may provide some explanation to the lower response rates with seniors in the other studies listed. Finding a research site for this age group usually requires identifying associations or in the case of many other studies utilizing living communities such as assisted living centers or lodges. This limits access to this pool of participants as they tend to be clustered in small groups across numerous regions versus large groups in centralized regions and frequently results in convenience sampling with this population.

It is noted that all but one respondent in this study had some level of post-secondary education. This is not consistent with the demographics of this age group. Statistics Canada (2016) reports that 54% of Canadians aged 25 – 64 have a post-secondary qualifications, no data for the age group 55 and over could be obtained from the available Statistics Canada data reports, but it can be presumed that the percentage of Canadians over the age of 55 with a post-secondary credential would be at most equal if not less than the 25 – 64 age group. This is most probably due to the sampling context; the research site was a lifelong learning association. Longitudinal studies indicate that individuals who have participated in post-secondary education are significantly more likely to undertake lifelong learning compared to those without post-secondary education which could explain the above average rate of post-secondary qualifications of this sample (Jenkins, Vignoles, Wolf, & Galindo-Rueda, 2003).

As Domagk's (2010) PALD model was used to structure the survey questions and organize the data, the results are first discussed within the framework of this model with both the general and health related agent results per each attribute evaluated in each section. It is followed by a discussion regarding the differences in the two contexts and an analysis of older adults and pedagogical agents.

Table 6.2 provides a summary of results found in this study regarding preference for the attribute design compared to the literature.

Table 6.2

Summary of preferred attributes based on frequencies in comparison to the literature

	Literature Review			Study	
Attribute	General	Older Adults	Healthcare	General	Health
Animation	Mostly animated	Not studied	Not studies	Mixed results	Mixed results
Non-verbal communication	Easy-going	Easy-going	Easy-going	Easy-going	Easy-going
Communication Style	Dependent on role of agent	Not studied	Relational	Task or combined	Task or combined
Graphical Style	Results vary	Realistic	Realistic	Realistic	Realistic
Agent Role	Dependent on outcome	Not studied	Mostly companion	Mixed results	Expert
Level of Competence	High with high achieving students Low with low achieving students	Not studied	Not studied	Mostly competent	Mostly competent
Voice	Human voice	Not studied	Not studied	Human voice	Human voice
Facial Expression	Preferred friendly but better outcomes with stern	Friendly	Friendly	Friendly	Friendly
Body Shape	Mesomorph	Not studied	endomorph	Mostly no preference	Caucasian or no preference
Ethnicity	Most studies same as learner	Not studied	Not studied	No preference	No preference
Age	Not studied	Not studied	Not studied	Split 41-55 or no preference	Split 41-55 or no preference
Attire	Not studied	Professional	Not studied	Mixed results	Professional
Gender	Some studies indicate male or no preference	Some studies indicate female otherwise no preference	Not studied	No preference	Male or no preference

Specific Attributes of Pedagogical Agent Design

Medium design. In this section the medium level design aspects results are discussed.

Animation. In the review of the literature it was noted with a move to embodied conversational agents, most studies in the last five years have been conducted on animated agents. The underlying assumption has stemmed from a social cognitive framework and align with Lester at al. (1997) premises that pedagogical agents should have socio-emotive abilities and therefore should be animated. Also, extensive work by Mayer (2014) on multimedia design on cognitive load contends that deeper learning occurs using social cues, in other words animation to enhance non-verbal communication.

In the results of this study in terms of general learning environments 39% of respondents indicated a preference for an animated agent, with 35% indicating no preference and 26% preferring a static agent. There was no significant difference for level of animation based upon the respondents' demographic information. In the health-related learning environment only 33% of respondents who indicated they had been diagnosed with a chronic or life-threatening condition wanted an animated agent, 44% preferred a static agent and 22% of respondents had no preference. These findings differ from the assumption that learners prefer an animated agent but are not necessarily contradicted by the research regarding the impact on learning based on animation of the agent. Mixed results in the literature have been found with more results demonstrating animation increases motivation but this does not necessarily mean an improvement in meeting learning outcomes (Baylor, Ryu, & Shen, 2003; Park, 2015). Kim and Baylor (2016) demonstrated this with an expert agent with only deictic animation (limited to

gestures only when emphasizing content), whom was emotionally detached from learners and functioned only to provide accurate information lead to improved learning outcomes over a motivator agent who was more animated and encouraging in their approach to teaching the learner. The motivator agent however, improved learner self-efficacy. It is therefore cautioned against presuming that animation will improve learning outcomes and further research would need to be conducted to discern whether it would impact motivation for older adults with special consideration regarding our understanding of how adults learn.

Non-verbal communication. Non-verbal communication in addition to animation already discussed can impact the learner's perception of the agent. Especially under the context of social-cognitive theory which positions the social interactions important to promote learning. While there are many aspects to non-verbal communication, this study considered the agents' demeanour which encompasses many aspects of the agent design such as body posture and facial orientation. In the general learning context 74% of respondents preferred an easy-going demeanour. This correlates with the literature in which a relaxed agent that demonstrates warmth was perceived as important in believability of the agent (Andre, et al., 2010; Niewiadomski, Demeure, & Pelachaud, 2010). In contrast in the health setting in which the majority of respondents, almost 60% indicated a preference for a serious demeanour suggesting that the context of the learning is important in some design aspects of the agent.

Communicative style. Bickmore (2003) describes two types of communicative styles, task oriented and relation oriented (or task condition versus social condition). As stated previously a task orientated communication style would provide only information directly related to the content in a succinct and objective manner. In the health-related context more than half of the participants indicated a preference for a task-orientated communication style and a third

preferred a combined task-relational style and only one a relational orientated style. In a general learning context 13 out 23 respondents preferred the combined communication style, while 10 preferred a task-orientated style and none the relational orientated state. This is in stark contrast to the basic premise of Bickmore's work and the use of relational agents. Bickmore conducted a large proportion of the studies on agent use in health care. However, much of the research by Bickmore has not been specific to a pedagogic agent, although some of his agents have worked in the role of a teacher, the majority have been in relationship building for companionship or health monitoring. The results found in terms of communication style might be better explained by the principles of andragogy. Specifically, within andragogy, Knowles (1984) states that for adult learners' instruction should be task-orientated. His theory of andragogy is multifaceted and contends that adults learn differently than children. Knowles (1984) makes six assumptions related to adult learner:

1. Adults need to know why they are learning new knowledge before they learn it.
2. Prior experience of the learner provides is a rich resource for learning.
3. Adults need to be responsible for their learning, has an independent self-concept and can direct his or her own learning.
4. Adults want to apply their learning immediately.
5. Adult learning is problem centered or task related rather than content orientated.
6. Adults are intrinsically motivated to learn.

Task-related learning is supported by Boulton-Lewis, Tam, Buys & Chui (2016) who investigated seniors and reasons for learning in Hong Kong and Australia. Most of the impetus for learning had little do with social interaction (only 10% in the Hong Kong and 2.5% in Australia) and more to do with purposeful driven learning. Leigh, Whitted and Hamilton (2015)

demonstrated that learners were goal-orientated and purposeful in seeking learning experiences in their investigation of healthcare training. As few studies have researched attribute preferences specifically for adult learners, the andragogical principles of Knowles have not been considered in agent design. It should be cautioned however, that there are criticisms of Knowles' work, specifically that it is more assumptions about adult learners than it is a theory of adult learning. Secondly, that while Knowles initially positioned andragogy as adult learning different than pedagogy which he positioned as child learning which was widely criticized, he has since positioned andragogy on a continuum with pedagogy (Merriam, Caffarella & Baumgartner, 2007).

Voice. Research in pedagogical learning agents has consistently demonstrated learner preference for a human voice over a computer generated voice (Baylor, Ryu, & Shen, 2003; Ryu & Ke, 2018; Tsiourti, Joly, Wings, Moussa, & Wac, 2014) with a positive impact on recall and transfer (Atkinson, Mayer, & Merrill, 2005; Harrison & Atkinson, 2009; Mayer, Sobko, & Mautone, 2003). Results in this study were consistent with the literature in that in both contexts participants overwhelming preferred a human generated voice.

Graphical style. Graphical style as discussed in the literature review is an interesting aspect of agent design. As technology is improving the ability to develop more realistic agents, agent appearance is approaching levels of realism often undiscernible from an actual person. This however, has reintroduced the question of the uncanny valley theory and may move agent design away from high levels of realism. The uncanny valley theory postulates that human-like replicas can evoke feelings of uneasiness or eeriness as they approach a high level of realism as our minds to categorize the agent as human or non-human (Mori, 1970). The idea of realism stems from the underlying philosophies of what characteristics an embodied conversational agent

should possess. Researchers in this area discuss the benefits of embodying human characteristics. This however, is in opposition to research by Buisine and Martin (2007) and McCloud (1993) wherein they argue a stylized character invites elaboration by the user and that the learner holds less expectations regarding how the agent responds socially and intellectually.

In this study, most respondents preferred a realistic agent (65% for the general agent design and 100% in the health agent design). Specific to research with older adults this is aligned with both a 2015 study by Cereghettei at al. and a 2014 by Tsiourti et al. of older adults in which in both these studies the preference was for a realistic agent appearance. The 100% preference for a realistic agent in a health setting is congruent with a study by Robertson et al. (2015). Based upon presumptions made from a literature review and focus group results Robertson et al. (2015) choose the cartoon version of an agent to provide health information to a group of mostly Caucasian men diagnosed with prostate cancer. The participants in the study uniformly had a negative reaction to this agent, some even expressing anger with comments inferring that a cartoon agent makes light of a very serious situation. vanWissen, Vinkers and van Halteren (2016) also found a preference by users for a realistic agent in a health setting over a stylized one as did Ring, Utami and Bickmore (2014). This again strongly suggests the importance of contextual relevance. Health, especially when one is ill, can be a stress factor for individuals. A cartoon version of an agent although preferred by the focus group respondents and identified as appropriate in the literature undermined the significance of the situation in the Robertson at al. (2015) study. This effect is demonstrated in this research study with a difference noted between the general learning context and the health-related context in which the preference for a realistic agent were 65% and 100% respectively.

Agent role. In this study there was no clearly defined preference for agent role in the general learner context, as all four roles (expert, teacher, friend, co-learner) were selected by respondents with no clear preference for any one role. However, in the health context there was a predominant preference for the agent to assume the role of expert (78% of respondents) compared to the other possible roles.

Previous studies in the area of competence indicate that more competent learners may prefer expert agents while less competent learners prefer motivating agents or no agent at all. These findings from the literature contradict the results seen in this study. These competency studies are applicable in this context as the role of expert would be perceived as highly competent. In a general learning context, there will be varying levels of competency of the learners, but in the health context presumably, a lower level of participant competence is expected unless coming from a medical background. Therefore, most learners in a health situation would be less competent in the content compared to the agent and one could predict from the Kim (2007) study that they would prefer a motivating style of agent like a friend that was also less competent. These assumptions do not hold true in this study and may be strongly impacted by the health context in which the norm appears to be to want a competent physician or impacted by the age of the learners in this study.

Also, contradictory to findings in this study, is the previous meta-analysis by Provoost et al. (2017) which investigated the role ECAs performed in studies addressing mental-health outcomes. In most of the studies reviewed, the agent assumed the role of social interaction partner, like Bickmore's relational agents which assumed roles more conducive to building relationships in health care situations (i.e. care-giver). The difference could well be explained however in the difference of the agent's goal. An agent designed to deliver information and to

"teach" about a specific health condition may very well not be suited to a long term socially engaging agent and may be better determined by the contextual relevance of the agent (Veletsianos, 2007). It may also stem from adult learner theory and the idea of task-orientated learning described earlier which would influence the learner's preference for the role of the agent.

Level of competence. For this study level of competence was categorized as sympathetic and put the learner at ease or confident and kept the learner focused, discerning whether participants preferred an agent that may have lower competency but displayed sympathetic qualities, or a higher competency but less sympathetic. In both contexts, general and self-management health programs, the predominant agent preference was for a confident agent. This differs from the idea of relational agents that encompass empathetic qualities but aligns with the work by Kim, Baylor and the PALS Group (2006) which identified the need of an agent that is perceived as highly competent when the outcome of the learning is on knowledge and skill acquisition. It also again is congruent with adult learning theories and the idea of task-orientated learning and self-direction which aligns more with a confident agent vs a sympathetic agent.

Facial expression. Walker, Sproull, and Subramani (1994) found that users liked a version of agent with a stern face the least. This is consistent with the results of this study in which respondents overwhelming preferred a friendly face in both the general learning context and the healthcare context, which can be perceived as relaying empathy (Hone, 2006). While learners still indicated preferences for expert, task-orientated, and serious agents in a health context a friendly face was still important. This could be that a friendly face is often interpreted that the individual has compassion (Sinclair, et al., 2016).

Design aspects. The results of the preference for visual features of the pedagogical agent are outlined in this section.

Gender. In this study there was a significant preference for the gender of the agent based upon the gender of the participant and their highest education level. It was noticed that individuals with a lower educational level preferred a male agent, while those at a higher educational level mostly indicated no preference for the gender of the agent. Only male respondents demonstrated a preference for a male agent, with female participants generally indicating no preference for agent gender (13 out of 14 females). In several studies however, the research generally indicated a preference for male agents in learning environment (Baylor & Kim, 2003; Baylor & Kim, 2004; Moreno, et al., 2002).

The results in this study may be explained by different theories, first that gender equality is more readily accepted in groups with higher education levels (which was demonstrated by the number of respondents indicating no preference for agent gender who had a higher level of education) as they have been exposed to egalitarian ideas which can inhibit acceptances of gender stereotypes (Bolzendahl & Myers, 2004; Ingelhart, Norris, & Welzel, 2002). Contrary however, to the findings demonstrated in this study is that prior research suggests that different age cohorts have been socialized differently about women's roles and that older individuals may have more conservative ideas about a women's role, suggesting a male agent would be preferred more readily by this age group which was not the case (Bolzendahl & Myers, 2004).

While the predominance was to indicate no preference for agent gender in a general learning context within the healthcare context five respondents indicated a preference for a male agent and four indicated no preference. In the general learning category there were only three

respondents out of 23 indicating a preference for a male. This may be explained by stereotypes. If we consider responses related to healthcare environment, most respondents in regard to role of agent chose expert. As these learners are older, their frame of reference frequently for physicians and more so for specialist would be a male physician as the number of female physicians is still not on par with male physicians although it has improved over the years. The Canadian Medical Association reported in 2015 that 56.7% of all physicians were male, increasing to 61.9% as medical specialist and 73.8% of surgical specialists (Canadian Medical Association, 2015). Additionally, Veletsianos (2010) found that agents were stereotyped differently depending upon their discipline (e.g. arts vs sciences) supporting the premise that preference for males in a healthcare context with an expert agent may also be impacted by the learner's stereotypes of the role.

Body shape. Very little modern research has been conducted on the preferred body shape of agents. In both the general learning context and the health-related context there was no preference for agent body shape. In the one study in the literature in a health-related context vanVugt et al. (2009) discerned that endomorphic agents were perceived as more trustworthy, although endomorphic agents were not indicated as being the ideal agent prior to using the agents in the experiment. While in theory the respondents indicated mostly no preference, in practice when actually working with an agent that response may change as was seen in the vanVugt et al. (2009) study.

Ethnicity. There was no discernable preference for the ethnicity of the agent in the general learning context or in the health-related context, nor was there any significant preference for the ethnicity of the agent based upon participants' demographic variables. Although there have been mixed results on the impact of ethnicity on student's perception of agents and the

impact on different aspects of learning in the research, such things as the novelty effect and stereotypes did not seem to hold true in this study. This may be related to the higher educational level of the respondents in this study in which all but one participant had some level of post-secondary education. Similar to the results seen with gender preference these results may be due the participants having exposure to egalitarian ideas which may inhibit acceptances of ethnic stereotypes (Bolzendahl & Myers, 2004; Ingelhart, Norris, & Welzel, 2002).

Age and Attire. Studies in the field have not focused on the desired age of the agent or their attire. One study addressed agent age with older adults and found no preferential difference for a younger versus an older agent (van Wissen, Vinkers, & van Halterern, 2016). In the current study the majority of respondents in both learning contexts preferred the agent age to be between 41-55. This is congruent with middle career and when most people are perceived as being at the top of their field.

In terms of attire in the general learning context there was no discernable preference for casual or professional attire, while in the health-related environment there was an overwhelming preference for professional attire. The health-related agent attire relates to research by Cereghetti et al. (2015) in which participants indicated they preferred an agent who was professional in appearance when the agent was supporting them in managing their health. Also, in studies within the field of medicine, patients perceive professionally dressed physicians as being more trustworthy and competent (Chung, et al., 2012).

Differences in Health Related and General Context Agents for Older Adults

The research questions posed in this study intended to discern the characteristics of a pedagogical agent that are preferred by older adult learners and then further specifically in self-

management health programs for chronic conditions. A single sample nonparametric chi square test for goodness of fit using an exact test was used to identify key attributes for design by identifying a significant asymmetrical distribution of responses amongst categories in the given attribute.

Using a significance of $p<0.05$ nine attributes were identified as having a significant distribution in the general learning context. These attributes were gender, ethnicity, facial expression, body shape, competence, demeanour, voice, age and graphical style. Some of these attributes can be ruled out as being critical in the design of an agent as the asymmetrical distribution was due to high response rate in the no preference option, which negates the significance of that attribute since a defined category did not dominate. Attributes falling under this condition are gender, ethnicity and body shape. The remaining attributes are explored in more detail.

In terms of voice, a human voice was strongly preferred by respondents (21 of 23 respondents with the other two respondents indicating no preference). A friendly facial expression was indicated by (20 out of 23 respondents). Regarding the demeanour of the agent the respondents chose primarily an easy-going agent (17 respondents), with competence a confident agent being highly preferred (16 out of 23 respondents) and with graphical style a realistic agent (15 respondents) was indicated. The age of the agent showed high frequency in two categories (nine respondents for 41 -55 age category) and 10 respondents indicated no preference) and low response rates in the other three categories (<26, 26-40, >55) giving the significant probability with the chi square test. However, there is no predominant predilection for any age group, so this attribute is not considered important by the learner in a general learning context. It should be noted that in reviewing communication style although the single sample

nonparametric chi square test did not demonstrate any significance, all respondents preferred a style that was totally or partially task-orientated and none preferred a solely relation orientated style. Caution should be taken when presuming an older adult would prefer an animated agent as suggested in the literature (Baylor, Ryu, & Shen, 2003; Lester, et al., 1997; Lusk & Atkinson, 2007) as this was not demonstrated in the study.

There were four identified critical design aspects in the health-related agent and some of these differed compared to an agent in a general learning context. Important in the design of an agent in a self-management health environment focused on learning about a chronic condition is an agent that is realistic in style (all respondents), with a human voice (all respondents) professional in attire (eight out of nine respondents) and in role of expert (seven out of nine respondents). There were also strong tendencies towards a very task orientated communicative style and an agent confident in abilities and highly competent. Seven out of nine respondents preferred a competent agent and eight out of nine respondents indicated partiality towards an agent that had some component of a task-orientated communication style. A more serious rather than friendly agent was preferred as was a male agent, but not statistically significantly to state these are critical aspects of the agent design. Ethnicity of the agent in this context was not important.

When comparing responses by participants who had indicated they had a chronic condition between the two contexts we see the most variation between answers in the critical attributes that differed between the contexts. Attire and role were two critical attributes of an agent in a self-management health program, but these attributes were not deemed critical in the general context. Five out of nine participants stated a different preference for attire in a general

text as compared to the health context. In regard to agent role six out of nine participants stated a difference preference, all switching to an expert preference in the health context.

Facial expression and demeanour were deemed critical in the general context but not the health-related context. Two out of nine respondents changed from a preference of a friendly facial expression in the general context to no preference or neutral, indicating the more serious nature of the health context. A similar pattern was seen with demeanour, in which five out of nine respondents switched their response from an easy-going demeanour in the general context to a serious demeanour in a health context, and one changed from easy-going to no preference, again highlighting the seriousness of the different context.

The results are most probably explained by contextual relevance. Veletasios (2007) states that alignment of the visible characteristics of the agent in relation to the context of the use of the agent influences the learner's perception of the agent and that perception may activate stereotypes. Therefore, it can be conceived that the agent's visual appearance conforms to the learner's expectation given the content area. Health care education is a very important and serious endeavor especially when one is dealing with a chronic condition. Acceptance of an agent in this context will most probably be influenced by the learner's perception of a healthcare professional and what they perceive as the critical characteristics of that professional. This concept is further discussed by Ring, Utami and Bickmore (2014) in *The Right Agent for the Job.* In considering the visual design of an agent the researchers concluded that there may not be universal design rules for agents but instead the design may be dependent on the context. In this study the general learning question (research question 1) did not describe a specific learning situation. Therefore, it was open to interpretation as to the learning context. The second research

question was specific in its context and engendered some different critical aspects than research question 1.

Another factor is the small sample size particularly in the health-related group. While preferences can be stated from the health-related context, it is not a large enough sample size to generalize to the larger population.

Other Considerations of Older Adults and Pedagogical Agents

One of the patterns that become evident when analyzing the data was the assumptions made based upon the social-cognitive framework. Underlying this framework is the ideology that social acceptance of the agent and social interactions are important for learning. When looking at a large number of the studies throughout the literature review many of the social aspects of agent design impacted learner self-efficacy or motivation, but usually no direct correlation to learning outcomes was identified. Relationships were inferred between motivation or self-efficacy and achieving learning outcomes, which then supported the social cognitive framework. When reviewing the results of this study, the one characteristic that strongly brought this premise into question was the communication style of the agent. If indeed the social cognitive framework was the best perspective to analysis the data, then it would follow in both the general and the health-related context a relational orientated style of communication would have been identified as an important factor by respondents. However, in the general context over half of the respondents preferred a combined (task/relational) communication style and nearly the other half a task-orientated style, with none having a predilection for the relational style. Further in the health-related context more than half of the participants indicated a preference for a task-orientated communication style and a third preferred a combined task-relational style and only one a

relational orientated style. In the scope of the field of research this is troubling as much of the work of agents in health environments has been premised on the use of relational agents and the presumed preference of users to want to build a socio-emotional relationship with the agent.

Bickmore's design of relation agents was based on his understanding of the social psychology of personal relationships (2003). His research stemmed from trying to discern if agents could provide emotional and social support to individuals to help them lead healthy, happy and productive lives, driven by concerns of the fractionation of our population. He was interested in studying if computer agents could assist in what were critical human-human relationships specifically in situations in which a person was attempting to undergo significant cognitive, emotional or behavioral change. Although Bickmore's (2003) initial work in relational agents was in regards to an exercise training agent, the positive outcome of the study led to extending the use of relational agents to chronic disease self-health management (Bickmore, 2010), virtual museum guide (Bickmore et al., 2008), medication adherence (Bickmore & Pfeifer, 2008), clinical psychiatry (Bickmore & Gruber, 2010), intervention strategies for underserved populations (Bickmore, Schulman, Pfeifer, & Yin, 2011), schizopherenia treatment (Puskar, Schlenk, Callan, Bickmore, & Sereika, 2001), social long term companions for older adults (Bickmore, Caruso, Clough-Gorr, & Heeren, 2005; Pfeifer-Vardoulakis, Ring, Barry, Sidner, & Bickmore, 2012), and exercise and sun protection (Sillice, et al., 2018).

The unanticipated result of a preference for task-orientated versus relational orientated agents suggests that possibly the principles of andragogy have not fully been investigated when considering an adult learner's interaction with a computer agent, particularly older adults or with adults in a health related learning environment. Knowles (1984) suggests that adults perfer learning that is task-orientated. Their orienatation for learning is for immediate application and to

solve a problem but the adult learner is still building self-efficacy to perform a task similar to the self-efficacy focus in social cognitive theory. Further, this does not necessarily dismiss the need to build relationships between agent and learner to develop trust, but the type of interactions, role of the agent and purpose of the agent and possibly the framework used to study these types of relationship in a research environment may need to be reconsidered in instances where the agent has a role in providing instruction or teaching to adults.

Limitations

It should be noted that the small sample size is a limitation to the study, and it is important to not overly generalize the results from this study to the large population of older adults as the small sample size can impact the statistical significance. Further research should be conducted using a larger sample size.

As an educator as well as a practitioner of instructional design, my main goal is to design effective learning environments that promote knowledge construction and transference of learning. This required numerous assumptions that were used to establish the design of this research. Some of these assumptions are based on theories of how learning occurs, how knowledge is built, the role of learner's prior knowledge, the choice of instructional strategies, the role of media, and the importance of learner motivation.

It is recognized that not all variables that impact learning can be controlled in this study and interpretation of some results may be influenced as the result of these unstudied variables. The lack of prior learner experience within an online learning environment or with virtual agents may work as an uncontrolled variable that can negatively impact measurable outcomes. Presumably without having interacted with an agent in a meaningful context it may have been

difficult for participants to have discerned the desirable attributes of such agent. Further as the design process it is a reiterative process, starting with a concept and making changes as necessary to meet the desired outcome, what the researcher interprets as the desired attribute and what the participants envision may not be the same. Additionally, what the learner may think they want as an attribute may not in practice be what they need as was demonstrated by vanVugt et al. (2009) with their study of e-health advisors.

It is presumed in this study that individual characteristics can be reviewed independently of each other. Kim and Baylor (2016) questioned whether this is possible in agent design. The reality is the dynamics of how individuals react to each other and what qualities develop relationships is complex. As such attributes cannot be generalized, we cannot assume that everyone will have the same preferences, nor that one individual will respond the same way to one agent as the next. Therefore, like human-human interactions the same consideration must be given to human-computer interactions, in that it may not be possible to review attributes independent of one another and preferences for attributes will differ dependent on the individual. Therefore, it would be wrong to presume that one single agent can be designed that would meet every learners need, but research has indicated certain critical characteristics that need to be considered and have the most impact on learning. These critical characteristics need to be implemented into agent design to engender user acceptance (van Wissen, Vinkers, and van Halteren, 2016) while non-critical aspects can have more flexibility in design.

Chapter 7: Conclusion

Implications for Practice

In this study key attributes for pedagogical agents for older adult learners were identified and also attributes for agents in self-management health programs for chronic conditions. Important attributes for older adult learners in a general included a realistic agent in appearance, a human voice, a friendly face, easy-going demeanour, and competent in abilities. There were four critical design aspects in the health-related agent: realistic in style, a human voice, role of expert and professional in attire. It was interesting that there were more key attributes in the general learning context versus the health related one, but this may be due to the smaller participant size in the health-related context. Not all attributes deemed critical in this study have been identified as critical in other studies, however the context and population of other studies were frequently different. It should be cautioned that most respondents in this study had some degree of post-secondary education (22 out of 23 respondents). This is not aligned with the demographics for this age population, and broad generalizations are not warranted.

One of the most surprising results was the preference for a task-orientated or combined task/relation orientated agent over a relation orientated agent especially in a health context. This could have implications for practice as the majority of studies have been framed for a relational orientation. However, this most also be carefully considered as the earlier studies in the field were premised upon Bickmore's initial investigation as to the ability of agents to form relations (2003). Further, early research was focused on exploring the computer-human relation the

context however, was frequently in the healthcare domain stemming from Bickmore's initial study in health promotion. As early studies showed positive results this grew to more research in the area of healthcare but creeped into other aspects besides exploring just the computer-human relationship. For example, the relationships continued to be explored but also researchers started to examine the impact on a health outcome at the same time. This morphed to the presumption that because a relationship existed that relationship could then be used effectively to educate participants. Similarly, work in pedagogical agents was first developed with school aged children in which andragogical considerations would understandable not have been made. The initial premises made regarding the necessary characteristics of agents to work in a teaching role and the impact of the agents in such roles were then expanded to other populations such as university students, then adults and seniors without the consideration of the underlying theoretical framework and its application to a different population. Consideration of andragogical principles is not evident in any studies with pedagogical agents and older adults. To look now at a specific context, which in this study was the design of pedagogical agents for older adults in a self-management health program, related studies in the field have been built from other contexts and populations and make it difficult to correlate outcomes to earlier research.

This study is significant as it discerned what specific attributes older adults desire in a pedagogical agent and further in a health context. Older adult learners are a segment of the population that have been largely neglected in studies concerning the design of pedagogical agents. Presumptions in previous research have been from proximal contexts which did not always hold in the context of this study. Given the small sample size though it is essential that additional studies are conducted with larger samples to see if the results found in this study are also found in a larger sample. It is also important to revisit the appropriateness of the socio-

cognitive perspective used with pedagogical agents and social psychology ideas applied to relational agents in the context of older adults use of pedagogical agents for learning in a healthcare context. Qualitive research methods such as focus groups or interviews could help further explore this perspective. Additionally, observation of participants interacting with an agent once designed would provide much insight into the dynamics, interactions and relationship with the agent and assist with design considerations.

Future Directions

Based on the outcomes of this study future research should consider: (a) replicating this study with a larger sample size and a more representative demographic population (b) conducting research on older adult use of pedagogical agent from an andragogic framework to discern if it shifts our understanding of agent use with this demographic (c) conduct further analysis on the impact of the communication style on learning with older adults to discern if there is a difference in a task-orientated communication style vs a relation-orientated communication style on learner outcomes.

Conclusion

As technology is continuing to make enormous gains in the ability to develop agents that move toward near human capabilities it is important that we understand what we need to be designing for the most effective training, especially in matters of one's health. Software programs are also making agent development much more accessible to educators as pricing is more affordable with minimal knowledge of coding or graphic design needed. Agents can be made in minutes whereas before a team of programmers and designers would have been required. This makes the availability of agents in education easily accessible.

There is no indication that the use of agents will do anything but grow within the educational setting. Pressures on the health care system also make agent use highly desirable as accessibility to health care professionals is often a bottleneck in the system. With an aging population, younger generations raised on technology that will become an older generation who will be computer savvy, the use of technology by older adults will continue to grow. It is therefore appropriate to presume the use of agents for healthcare education of older adults will also expand. It is thus critical that we understand the underlying premises made in our design choices of agents, ensuring their continued relevance and we understand what the learner requires in an agent's characteristics, so it can be the most effective in a learning context.

An important consideration is the advancement of technology. Already the ability to build one's own avatar is an option in the gaming industry and may be the better approach and more probable move in the future, allowing users to design their own agents. This may alleviate the need to try to generalize preference of attributes by a group to the needs of each individual and ensure the user has an agent with all their desired characteristics. Ultimately the ability to simply project a real healthcare professional (even your own physician) as an agent may not be too far in the future. Ryu and Ke (2018) have already demonstrated significant gains in learning outcomes when an actual instructor is designed as the agent with the instructor's voice and appearance who the user is familiar with represented in the agent. Designing an entire agent as a realistic virtual agent projection of one's own healthcare professional is not outside the realm of possibility in the near future.

The outcome of this study demonstrated that there needs to be further research in order to gain more understanding regarding the design of agents, especially those for use with older adults. This study revealed that older adults may not necessarily desire the same characteristics

of an agent as in other age ranges. Moreover, the preferred characteristics of agent design with older adults differ from a general context to a health context. This magnifies that caution needs to be taken when applying outcomes from one context to another and generalizing desired attributes from one population to another.

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Appendices

Appendix A: Participant Survey

Based on your understanding of Pedagogical Agents (PA) please take the time to complete the following survey. The survey will take you approximately 20 minutes to complete with most questions requiring a single choice by you.

Section A

If you wanted to learn more on a topic of interest (i.e. golfing, art history, baking, woodworking, politics, travel etc.). Please indicate what your preferences would be in terms of the design of a PA that you would like to interact with in your learning.

Appearance of agent

1. I would prefer that my PA was
    a. Cartoon b. realistic c. no preference
2. I would prefer that my PA was
    a. Male b. female c. no preference
3. I would prefer the racial or ethnic identity of my PA to be:
    a. Indigenous b. Asian or Pacific Islander c. African American d. Caucasian e. Hispanic, Latino or Puerto Rican f. Other please specify _____ g. no preference
4. I would prefer the age of my PA to be
    a. <25 b. 26 -40 c. 41 -55 d. over 55 e. no preference
5. I would prefer the attire of my PA to be
    a. Casual b. professional c. no preference

6. I would prefer the face of my PA to be
    a. Stern b. neutral c. friendly d. no preference
7. I would prefer the body shape of my PA to be
    a. Muscular b. plump c. thin d. no preference

Traits of Agent

8. I would prefer my PA assume the role of
    a. Teacher b. expert c. friend d. co-learner e. no preference
9. I would prefer if my PA was
    a. Sympathetic and puts me at ease b. Confident and keeps my focused c. no preference
10. I would prefer it if the demeanour of my PA was
    a. Serious b. easy-going c. no preference
11. I would prefer that my PA communication style was
    a. Task orientated (provide only information directly related to the topic) b. relational orientated (focused on developing a social relation) c. combined task orientated (focus on the social relationship while contributing to my learning) c. no preference
12. I would prefer if the voice of my PA to be
    a. Computer generated b. human generated c. no preference
13. I would prefer if my PA was
    a. Animated with lots of movement b. static or very minimal movement c. no preference

Section B

14. Have you ever been diagnosed with a significant long term chronic illness (i.e. COPD, emphysema, congestive heart failure, diabetes, etc.)

    a. Yes b. no c. prefer not to respond

    If yes, please specify your diagnosis _____ (you can opt to leave this blank if you prefer not to respond)

If you answered "yes" to question 14 please complete questions 15 – 27. If you answered no please continue to Section C, question 28.

There are numerous training programs, medical websites and social media opportunities to learn more about your illness. There are even a few training programs that have specifically utilized PAs to facilitate learning. Consider if you were provided the opportunity to learn more about your illness in an online training program that used a PA as the instructor. Please answer the following questions in terms of the design of the PA from the perspective of learning more about your illness so you could manage it.

Appearance of agent

15. I would prefer that my PA was

    a. Cartoon b. realistic c. no preference

16. I would prefer that my PA was

    a. Male b. female c. no preference

17. I would prefer the racial or ethnic identity of my PA to be:

a. Indigenous b. Asian or Pacific Islander c. African American d. Caucasian e. Hispanic, Latino or Puerto Rican f. Other please specify _____ g. no preference

18. I would prefer the age of my PA to be

a. <25 b. 26 -40 c. 41 -55 d. over 55 e. no preference

19. I would prefer the attire of my PA to be

a. Casual b. professional c. no preference

20. I would prefer the face of my PA to be

a. Stern b. neutral c. friendly d. no preference

21. I would prefer the body shape of my PA to be

a. Muscular b. plump c. thin d. no preference

Traits of Agent

22. I would prefer my PA assume the role of

a. mentor b. expert c. co-learner d. motivator e. no preference

23. I would prefer if my PA was

a. Sympathetic and puts me at ease b. Confident and keeps my focused c. no preference

24. I would prefer that my PA communication style was

b. Task orientated (provide only information directly related to the topic) b. relational orientated (focused on developing a social relation) c. combined task orientated (focus on the social relationship while contributing to my learning) c. no preference

25. I would prefer if the voice of my PA to be

    a. Computer generated b. human generated c. no preference

26. I would prefer if my PA was

    a. Animated with lots of movement b. static or very minimal movement c. no preference

Section C

General demographic information

27. Please indicate your year of birth _____

28. Please indicate your gender

    a. Male b. female c. other d. I prefer not to respond

29. Please indicate your racial or ethnic identification

    a. Indigenous b. Asian or Pacific Islander c. African American d. Caucasian e. Hispanic, Latino or Puerto Rican f. Other please specify _____ g. prefer not to respond

30. Please indicate the highest level of education obtained

    a. Did not finish high school b. Graduated from high school c. attended college/technical institute but did not complete d. completed a college or technical institute certificate or diploma e. attended university but did not complete f. completed a bachelor's degree f. Completed a master's degree g. completed a doctorate degree h. prefer not to respond

31. Please indicate your annual household income

a. <$20,000 b. $20,001 – $40,000 c. $40,0001 – $60,000 d. $60,001 –$ 80,000 e. $80,001 –$100,000 f. $100,001 – $125,000 g. $125,000 – $150,000 h. $>150,000 i. prefer not to respond

32. Please indicate your marital status

a. Married b. widowed c. divorced d. single e. prefer not to respond