

Toward a Model for Collaborative Gerontechnology: Connecting Elders and their Caregivers

Benay Dara-Abrams, Ph.D.

Kinnexus, Inc.

benay@kinnexus.com

Abstract

Gerontechnology is a new field which combines gerontology with technology to support elders in five ways: prevention, enhancement, compensation, care support, and research. Using a four layer model of a human, we examine theories, approaches, and technologies that can be used to address the needs of elders on each of these layers. Current gerontechnology applications primarily focus on the model's lower layers: the elder's physiological functioning and his/her physical skills and activities. We address the cognitive (third) layer through the Theory of Multiple Intelligences, offering ways for elders to compensate for declining cognitive faculties. To address the social interaction (fourth) layer of the human model, we apply social network theory. Coupling collaborative technology with gerontechnology, we construct collaborative social networks to offer elders both care support and enhancement. These networks connect elders and their caregivers, thereby improving communication and offering increased social support to both elders and caregivers.

1. Introduction

The field of gerontechnology was developed in the late 1980s in order to systematically apply technology to address problems associated with aging so that elders would be able to live healthy, independent, socially engaged lives as long as possible [1]. Combining the word “gerontology” (the study of aging) with the word “technology,” the term “gerontechnology” was coined by Jan Graafmans at Eindhoven University of Technology in 1989 [1] to encompass the design and development of techniques, products, and services to support not only the physiological and medical aspects of aging but also the psychological and social issues faced by an aging population [2, 3]. As a new field, the terminology is not yet totally consistent, and in some cases, “gerotechnology” is the term used to refer to the field instead of gerontechnology [4].

The basic tenet of gerontechnology is that technological development drives society, supporting human communication through advances in information and communication technology. Therefore, to ensure that elders continue to remain included in society, technology must be specifically targeted at fulfilling the needs of elders. The second central concept in gerontechnology is that the technological environment can be enhanced to compensate for age-related differences in goals and functioning of elders. Lastly, gerontechnology offers elders control of their technological environment, choosing the tasks which can be accomplished through or with the assistance of technology, and controlling the user interface to their technological environment [2, 3].

2. Domains of application

Gerontechnology is the first international scientific journal to focus on technology to support the aging population in the five domains that constitute the field: health and self-esteem, housing and daily living, mobility and transport, communication and governance, and work and leisure [5, 6]. Founded by the International Society for Gerontechnology, the journal views the technological environment as a mechanism to improve the quality of life for elders, enabling them to continue to live independently and participate socially in healthy, comfortable, and safe environments [6]. The five domains listed in Table 1 categorize human activities that are increasingly supported by technology in the lives of elders [5].

Table 1. Gerontechnology support

Domain of Application	Aim of gerontechnology
Health and Self-esteem	Support physical, cognitive, emotional functions. Maintain independence.
Housing and Daily Living	Accomplish routine tasks independently, safely, conveniently.
Mobility and Transport	Provide ways to move, go places, get around via car or public transportation.
Communication and Governance	Connect with others. Remotely monitor health.
Work and Leisure	Continue work. Engage in learning, creative, and recreational activities.

3. Five Ways of Gerontechnology

Known as Gerontechnology's Five Ways, gerontechnology offers five key approaches to assist elders in continuing to lead healthy, active lives: prevention, enhancement, compensation, care, and research [1]. Prevention includes monitoring an elder's health and well-being, and preventing problems from occurring through interventions, such as those that improve nutrition, increase physical strength, and encourage healthy habits. Enhancement of opportunities might be addressed through communication technology to connect people remotely and provide lifelong learning opportunities. The third way, which is the most developed thus far, is to apply technology to compensate for declining physical, perceptual and cognitive faculties through the use of assistive devices. Gerontechnology offers a fourth way of applying technology to support aging through the development of products to facilitate the care of elders who need caregivers to lift, move, or transfer them. The fifth way of gerontechnology is to support research on aging through such advances as medical imaging of organs and tissues, analysis of neurological events through signal processing, and other non-invasive measurements to better understand the physiological changes that occur in the aging process [2]. Some authors list only the first four ways and do not include research as a fifth approach [3, 5].

Table 2 provides examples of gerontechnology applications designed to accomplish each of the ways that gerontechnology addresses aging challenges in the areas of health and self-esteem, housing and daily living, mobility and transport, communication and

governance, and work and leisure. Compensation and assistance currently constitute by far the most common approach used in gerontechnology [5].

Table 2. Gerontechnology's Five Ways

Way	Tasks	Applications
Prevention & Engagement	Monitor, intervene, teach healthy habits.	Fall prevention, nutrition, strength training.
Enhancement & Satisfaction	Support work & hobbies, expand opportunities.	Virtual reality, enhanced communication.
Compensation & Assistance	Make up for weakness, loss. Support motor activities.	Mobility aids, robotic equipment, assistive tech.
Care Support & Organization	Help move & lift. Administer, monitor meds.	Ergonomically-designed equipment.
Research	Analyze, measure physiological changes.	Medical imaging, non-invasive techniques.

4. Activity theory

Earlier gerontological research was based on the premise that declining capabilities and increasing dependence are the hallmarks of old age. Based on this belief, elders who gradually disengaged and withdrew from social activities and their surrounding environments were considered to be successfully adapting to old age [7]. However, starting in the early 1960s, there was a major transformation in the attitudes and beliefs of psychologists regarding human development and old age. In the field of developmental psychology, a theory of life span development was developed, proposing that people continue to develop throughout their lives as long they are active. Disengagement approaches favored by earlier gerontologists were replaced by activity theory, focusing on providing stimulation and activity to support healthy aging. Suitable activities were encouraged to engage elders and help them maintain their health and connections. [7].

5. Competence and environmental press

At the same time that activity is encouraged on the part of the elder, it is important to consider the elder's competence in conducting such activities. An

understanding of current competence level is necessary in order to establish congruence between a person and his/her environment. The earliest framework for establishing congruence between an individual and the environment was proposed by Murray in 1938. According to personology (Murray's theory of personality), humans are able to experience well-being when their needs are in a state of equilibrium with the demands and features of their environment. Another factor in achieving such equilibrium is the individual's competence at a particular point in time. As the competence model indicates, a person's current level of capabilities and needs serve to mediate the impact of environmental characteristics. Environmental press signifies the potential impact of a specific environmental feature on a person's behavior. In the case of elders, it is important to modify the environment so that environmental press is slightly higher than their adaptation level to provide stimulation but not so high as to challenge their individual competence [8].

Gerontechnology can reduce environmental press through products that offer compensation and assistance. In addition, gerontechnology can make the environment more stimulating through the approach of enhancement and satisfaction, thereby increasing environmental press in a positive way, offering such applications as educational activities, interactive games, and communication technology to support increased social interaction [5].

6. Human model

In order to develop useful technology to support people as they age, it is helpful to construct models of human behavior. These models can be used to better understand the aging process and changes that occur in behavior over time. In addition, models can be used to simulate human behavior and functioning in order to test the efficacy of assistive technology and interventions. As depicted in Figure 1, a comprehensive model of a human constructed for gerontechnology integrates other models into a four-layer model, moving from the inside of the human body to the external interactions of an individual person [2].

Layer 4: An individual's interactions with others, situations, sequences of actions, performance, and requirements.
Layer 3: A person's cognitive performance, measured through standard psychological tests.
Layer 2: A human being's physical performance, observed in his/her physical skills, activities, and exercises.
Layer 1: A human body's internal physiological functioning.

Figure 1. Four Layer Model of Human

This model can be used to assess the state of an individual at any point in time, determining the person's overall well-being and deciding whether there is a need for treatment, intervention, or environmental modification [2]. Through the five ways of gerontechnology, technology can be used to prevent problems, enhance experiences, compensate for declining capabilities, assist caregivers, and conduct research to improve the lives of elders, whose current status can be assessed on each of the four layers of the model at any point in time [1].

7. Person-Environment perspective

The prevalent model in gerontology is based on Kurt Lewin's equation in social psychology: $B=f(P,E)$. This formula states that Behavior (B) is a function of the Person (P) and his/her Environment (E). Implying that a person's behavior is affected by his/her current environment and may change based on environmental factors, this theory was a major departure from earlier psychological theories that stated that a person's behavior was based solely on his/her past. Lewin's inclusion of the environment as an influence on behavior and his understanding that temporal changes in either the person or the environment may be reflected in behavioral changes at any given time are important in considering the changing situation of a person as he/she ages. Viewing the aging population through a person-environment perspective, the environment is recognized as continually changing as the elder obtains what he/she requires from the environment, controls aspects that he/she can manage,

and adjusts to conditions that he/she is unable to change [8].

8. Gerontechnology model

In gerontechnology, the person-environment model is used to delineate aspects of the natural or physical environment, the built or man-made environment, and the social environment. The technological environment in which the elder functions is considered to be part of the built or man-made environment. Engineering and ergonomics follow systems theory, considering both the person and the environment to be part of an overall system [5]. Therefore, interaction between the person and the environment results in a system output measure. Age-related changes in the person's physiological characteristics and behavioral functioning bring about change in the quality of the person-environment interface over the course of time. In addition, aspects of the environment change over time, thereby bringing about other changes in the person-environment interface [5].

9. Theory of Multiple Intelligences

While the person-environment model mentions the person's interaction with the natural, built, and social environments, most of the focus in gerontechnology has been on developing products to address challenges on the first two layers of the human model: the physiological functioning and the physical performance of activities. In order to address challenges on layer three, the cognitive level, it is helpful to consider a theoretical approach from cognitive psychology, the Theory of Multiple Intelligences.

In 1983, Howard Gardner proposed the cognitive theory that each individual possesses multiple intelligences rather than one unitary intelligence [9]. According to Gardner, an intelligence can be defined as both a biological and psychological capacity that can be activated in order to process information, solve problems, and develop products that are valued within a particular cultural setting [10].

At this time, Gardner suggests that humans possess at least eight separate human intelligences. These human capacities include the following:

- Linguistic intelligence: the capacity to speak, write, and comprehend oral and written language as well as the ability to employ language in order to achieve specific goals.

- Logical-mathematical intelligence: the ability to analyze problems systematically and use mathematical operations and scientific methods for investigation.
- Musical intelligence: the skill in performing, composing, and appreciating sounds and patterns of music.
- Bodily-kinesthetic intelligence: the potential to use parts of the body or the entire body for manipulating or constructing products or solving problems.
- Spatial intelligence: the capacity to recognize and manipulate patterns in both wide and confined spaces.
- Interpersonal intelligence: the potential to understand another person's desires, intentions, and motivation, and to be able to interact and work effectively with others.
- Intrapersonal intelligence: the capacity to understand oneself and to construct an effective working model of one's inner workings, including desires, fears, and abilities, and to use this self-knowledge to manage one's life.
- Naturalist intelligence: the ability to recognize and classify the different categories or species in the environment [10].

According to Gardner's Theory of Multiple Intelligences, humans not only possess these intelligences at birth but also they learn and develop their capacities during their lifetimes. While each person possesses all eight intelligences, individuals differ in terms of which of their intelligences are stronger and more developed [10]. As people age and experience physiological changes, elders are able to couple their stronger intelligences with weaker ones to compensate for difficulties in processing information. To compensate for memory problems with their name look-up table, spatial intelligence can be coupled with linguistic intelligence, offering a person's picture along with his/her name. Musical intelligence often remains very strong till the end of people's lives. Therefore, to enhance an elder's experience, musical intelligence can be used in conjunction with storytelling, which activates an elder's linguistic intelligence, which may no longer be as strong as it once was. Multimedia forms of memoirs and personal stories can be shared via the Web, thereby engaging an elder's linguistic intelligence, intrapersonal intelligence, interpersonal intelligence, and spatial intelligence. Thus, multimedia and Web technologies can be used to activate elders' multiple intelligences in ways that can not only compensate for declining faculties and but also can enhance an elder's experience.

10. Social support networks

With the Theory of Multiple Intelligences, we have a way to address the human on layer three, considering his/her cognitive faculties. The use of interpersonal intelligence provides a way to begin to address some of the issues on layer four, regarding an individual's interactions with others. With support from their social networks, elders are better able to deal with problems, ranging from minor annoyances to major crises in their lives. While early researchers viewed social support as a natural by-product of interactions with friends and acquaintances in the social network, more recent work recognizes the fact that a tie between two individuals does not necessarily result in social support. Therefore, current social network research considers the composition of the network and ways that the network is able to provide social support. In addition, many different types of support are required at different times in one's life across the varying circumstances that people encounter in the course of their lives [11]. An important consideration in the social networks of elders is that friends, relatives, and acquaintances in the elder's social network may move or die as the elder ages. As a result, the elder's social network may be shrinking in size just as the elder reaches a point in life when he/she requires significantly more social support. Moreover, since people require many different types of support, particularly as they age, they need social networks which include a wide range of people so that different members of the social network can provide the different types of support that are needed [11].

Moving to a network-centric perspective, researchers examine the variety and type of resources that flow through the network via a number of individuals, who are involved in the social network. In addition, researchers consider the way in which these resources flow to an individual rather than focusing on either the vague concept of social support or strictly on the transaction between two individuals. Viewing the social network as an entity in its own right, social network researchers can analyze the network's structure, the network's components, and the effect of the structure and components on the delivery of resources and support to the individual [11]. With this understanding, analysts now recognize that social support is the result of more than the sheer number of people in the social network; there are other mechanisms operating in the exchange and delivery of resources that provide needed support to the individual [11].

Until recently, most people used the Internet as a tool to access information. At this point, people

increasingly use the Internet to communicate with others and to engage in and support their social interactions. A wide range of people, from young to old, now actively participate in online communities [12]. Observing interactions in online communities, it can be seen that elders not only receive support but also offer support to others, which is important in maintaining their feelings of self-worth. In a study of social interactions in an online community of elders, six different types of interactions were observed: 1) light support, including jokes, good wishes, and superficial forms of encouragement, 2) deep support, consisting of searching questions to understand the problem and personal advice, 3) information, facts, and access to specific pieces of requested information, 4) community building through appreciation and activities on the part of the individual as well as on the part of others, 5) self-disclosure, ranging from sharing of feelings about similar experiences to sharing personal health and medical information, and 6) tangential conversations about a third person or gossip that was off-topic [12]. These online communities support the elder's social network but at this point such communities tend to be separate from other sources of support, such as family members and others who serve as caregivers.

11. Collaborative Gerontechnology

In social networks, ties vary in terms of the degree to which they are supportive. However, as people age and face repeated losses, they require more support. Rather than a loosely coupled social network, depending on their needs and the state of their health, elders may require the support of a fully engaged network of caregivers, ranging from family members and friends to paid caregivers, including doctors and other medical personnel. In general, each caregiver interacts with the elder on an individual basis, necessitating frequent communication and coordination among caregivers. Mistakes are often made, messages aren't relayed, and the elder suffers from not receiving the social support he/she needs. At the same time, caregivers, particularly family members, continue their efforts to support the elder, often suffering from stress and burn-out themselves. These types of communication problems are frequent when an elder is being taken care of by multiple caregivers. What if instead of focusing on the transactions between the dyad of caregiver and elder, caregivers could engage in a collaborative effort to support the elder? According to behavioral science researchers, true "collaboration occurs when a group of autonomous stakeholders of a problem domain

engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain” [13, p. 146]. In a collaborative situation, individuals are committed to working together to achieve a common goal, in this case, to provide needed support to the elder. Computer-mediated communication can be used to provide social support for elders. Coupling collaborative technology with gerontechnology to connect elders and their caregivers into collaborative social networks, we can provide support for elders and caregivers, situating the communication in the social network rather than between each individual dyad, thereby supporting caregivers and elders through their shared purpose.

12. Summary

We have suggested different technology approaches to address the needs of elders, integrating gerontological, cognitive, and social network theories with the five ways of gerontechnology. Table 3 summarizes the ways in which theories, techniques, and technologies can be applied to address the needs of elders on all four layers of human functioning. Adding support for the third (cognitive) and fourth (social) layers, we employ multimedia and collaborative technologies to improve and enhance communication and social support, resulting in an increase in the well-being of elders. Further work is currently underway to develop multimedia collaborative social networks to support elders on both the third and fourth layers of human functioning.

Table 3. Technology support for elders

Human Layer	Theory	Gerontech Way	Technology
Social (4)	Social Network	Care Support, Enhancement	Collaborative Social Networks
Cognitive (3)	Multiple Intell.	Compensation Enhancement	Multimedia presentation
Physical (2)	Person-Environ.	Prevention	e-learning, automated fitness
Physio. (1)	Activity	Compensation Research	Automated measurement devices, medical imaging

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