Older Adults' Informal Learning Using Mobile Devices: A Review of the Literature

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Abstract: Despite the increasing popularity of mobile devices and the advantages for learning purposes, studies on older adults' informal learning have been minimal as well as many studies on learning using mobile devices have often been associated with younger people but not older people. Thus, this integrative review aims to review the existing literature on older adults (age 65 or older) to examine how older adults use mobile devices in their informal learning and then to identify theoretical perspectives that were employed in the existing literature. Total 28 empirical studies were selected for this review paper. Six major themes emerged as major features of older adults' informal learning using mobile devices. They are ambivalent attitudes towards the use of technology, practical uses, interpersonal and intergenerational communication, collaborative learning experience, self-learning of health or medical knowledge, and affective and emotional dimensions. Implications for older adult informal learning via mobile devices practice and research are discussed.

Keywords: mobile devices, older adults, informal learning

Introduction

The number of Americans ages 65 and older is projected to more than double from 46 million 2017 to over 98 million by 2060, and the 65-and-older age group's share of the total population will rise to nearly 24 percent from 15 percent by 2060 (Mather, Jacobsen, & Pollard, 2015). Average U.S. life expectancy increased from 68 years in 1950 to 79 years in 2013, in large part due to the reduction in mortality at older ages (Mather et al., 2015). This means that older adults aged 65 and over are likely to be healthier and have more opportunities for education than previous generations. The majority of Americans (77%)own smartphones (Pew Research Center, 2017) and older adults are the fastest growing demographic on the internet use (Kisekka, Bagchi-Sen, & Raghav Rao, 2013).

Then, why is it important to highlight informal learning for older adults? Due to a higher propensity for self-directedness, autonomy and a wide range of learning needs in older adulthood (Findsen, & Formosa, 2011; Sipe, 2008), informal and learner-directed style of learning would give a distinctive advantage to older adults. Even though self-directedness and

autonomy occur in any age group when learning, more discretionary time of older adults from the responsibility of the occupation or child rearing may strongly encourage them to involve in informal learning. With this potential benefits of informal learning for older adults, in the context of informal learning via mobile devices, the heterogeneous group of older adult learners are able to choose their learning medium and communication tools (Leen & Lang, 2013) since mobile devices allow learners to access, interact, research, and perform various tasks depending on their preferences on time and place of learning, so that informal learning via mobile devices can meet the multiple demands of older adult learners. With the increasing numbers of older people in the country and growing numbers of people owning mobile devices, there is more interest in understanding how older individuals use mobile technology for learning.

Purpose of The Study

The purpose of this literature review, therefore, is two-fold: First, to review the existing literature on older adults (age 65 or older) to examine how older adults use mobile devices in their informal learning; and second, to identify theoretical perspectives that were employed in the existing literature.

Methods

Search Strategy

For the purpose of this literature review, a literature search was conducted in the following international online databases: EBSCOhost, ScienceDirect, ProQuest, SAGE, and Taylor and Francis. I searched titles, keywords, and abstracts using combinations of several key terms related to the following four search categories: (a) older adult (b) mobile device (c) learning. Specifically, I used the following keywords: “older adult*”, “elderly”, "older people” “mobile device", "hand-held device", “smartphone”, or “tablet”; “social media”, “social network*”, “SNS”, “user-generated*”, “user-created*”, or “smartphone app*”; and “learning”, “informal learning”, or “self-directed learning”. The initial search yielded 287 publications.

Inclusion/Exclusion Criteria

To be included, a publication must have met the following criteria: peer-reviewed journal publications, English-language, and published between 2005 to 2017—the start date of 2005 was chosen because along with the expansion of the third generation of wireless mobile telecommunications technology (3G), data carrying ability and speeds were increased and that jump-started mobile devices as tools for teaching and learning (Demirbilek, 2010; Reagle, 2012).

Through the initial screening, I identified 118 out of the 287 articles to be highly relevant to this research topic. Then, I read the titles, keywords, and the abstracts and screened the 118 articles based on three screening questions: (1) Is this study an empirical study including the population of people aged 65 and older; (2) do these studies have a focus on the informal or self-directed learning; and (3) does the learning occur in digital environmental contexts? I operationalized these criteria by reading the title, abstract, keywords, research purpose of each article. I also included studies that focused on self-learning of health or medical knowledge using mobile devices among older adults. Through a wide range of older adults' health-related daily activities using mobile devices, they attempt to achieve self-determined health-related goals along with self-studying medical knowledge, cultivating social contacts, or taking time for themselves (Steinert, Haesner, Tetley & Steinhagen-Thiessen, 2016). In this way, the studies focusing on mobile devices or Smartphone applications for users' self-monitoring of their health condition also would allow older adults for an in-depth understating of their informal learning as knowledge acquiring through self-directed contexts. I then excluded articles mainly focusing on elderly patients monitoring tools and policyholders managing tools by insurance carriers. In total, 28 articles were selected for inclusion. A part of the matrix of 28 reviewed studies can be found in Table 1(attached).

Literature Analysis and Coding Process

The 28 publications were coded and tabulated regarding the use of mobile devices in support of older adults' informal learning, using the techniques of inductive thematic analysis that is "a process of coding the data without fitting into a preexisting coding frame, or the researcher's analytic preconceptions" to identify salient themes which seemed more appropriate for this literature review (Braun & Clarke, 2006, p. 83). The early round of coding was largely guided by the explicit definitions or descriptions of informal learning via mobile devices such as publication year, journal, and methodology. Other than coding the 28 publications for general information, I also coded them for the following: key themes, the purpose of the study, guiding theory, learning types via mobile devices and findings. To code guiding theories of the articles, I recorded any theory the researchers had employed to describe the phenomenon of informal learning via mobile devices. That is the explicitly stated features of learning via mobile devices were compiled. Also, the coding sheet recorded research methods that comprised reference number, each study's participants' characteristics, data collection method including interview, focus group, focus ethnography, open-ended survey, open-ended discussion, observation, and field study. As presented in Table 1, I labeled each selected article with a certain number (Ref#) using RefWorks system to avoid replication of selected articles and organize them. Finally, I summarized the key findings of each article.

Findings

Overview of the Articles

Of the 28 empirical studies, 14 were qualitative, 11 were quantitative, and 3 used mixed methods as shown in Table 2 (attached). The articles were published in 20 different journals, representing multidisciplinary research. Nearly half the articles (n = 11) were published in technology, computers, social media, or cyberpsychology focused publications. Eight were found in educational gerontology, technological education, and educational psychology journals, 5 were published in the field of gerontology and aging publications, and 4 were published in health education, health promotion, medical, or nursing research publications.

Main Findings

Table 3 listed reviewed articles' findings according to the six emerged themes that characterize older adults' informal learning using mobile devices. They are (a) ambivalent attitudes towards the use of technology, (b) practical uses, (c) interpersonal and intergenerational communication, (d) collaborative learning experience, (e) self-learning of health or medical knowledge, and (f) affective and emotional dimensions. Below, I presented each theme with reference to those articles that examined them.

Ambivalent attitudes. Both qualitative and quantitative findings agreed that older individuals did not highly resistance to adopt mobile devices for informal learning or were willing to use or expand the usage of mobile devices for informal learning (Ahmad, Zainal, Kahar, Hassan, & Setik, 2016; Hernandez-Encuentra, Pousada, & Gomez-Zuniga, 2009; Ryu, Kim, & Lee, 2009). However, many older adults expressed that the certain conditions were met their needs. For example, certainty of improving independence and autonomy in their everyday life, reducing their technology anxiety, assurance of the cybersecurity and privacy, helping for initial set up of devices, and easy access to continuous tutoring and instructional manual (Nguyen, Irizarry, Garrett, & Downing, 2015; Ryu, Kim, & Lee, 2009; Kisekka, Bagchi-Sen, & Raghav Rao, 2013).

Practical use. Five studies highlighted practical usage of mobile devices among older adults, for example, practical use as financial resources, language learning, and cognitive memory enhancement (Ryu, Kim, & Lee, 2009; Gatti, Brivio, & Galimberti, 2017; Myhre, Mehl, & Glisky, 2017; Ginsburg, Cameron, Mendez, & Westhoff, 2016; Tsai, Shillair, & Cotten, 2017). Quantitative research on the practical use of mobile devices has been likely to investigate a memory function or a language practice (Lindsay, Smith, Bell, & Bellaby 2007; Tsai, Shillair, &

Cotten, 2017). However, very few of qualitative researchers have considered much about cognitive functions associated with age and its relation to older adults' informal learning. Examining older adults' practical usage of mobile devices, particularly relating to enhancement or retainment of their memory may seem to be less amenable topic in qualitative research. Few studies highlighted that electronic game on mobile devices was considered more suitable for language learning, computer literacy, and improving communication skills (Demirbilek, 2010).

Interpersonal and intergenerational communication. Both qualitative and quantitative findings agreed on the value of mobile device use for the social aspects of learning. For example, using mobile devices and accessing social networking services made older adults feel informed socially (Amaro, Oliveira, & Veloso, 2016; Delello, & McWhorter, 2017). Older adults were able to build a sense of connectedness and further improved the friendships of their pre-existing social connections (Hayes, van Stolk-Cooke, & Muench, 2015; Heo, & Lee, 2013; Lindsay, Smith, Bell, & Bellaby, 2007). However, a few studies also showed the negative effects of social connection such as experiencing negative feelings by social comparison since in the web space, the superficial domains of intelligence, wealth, and success often outstand (Heo, & Lee, 2013; Kisekka, Bagchi- Sen, & Raghav Rao, 2013). Findings from the qualitative studies emphasized that not only for understanding the social aspects of learning via mobile devices for older adults, but also understanding why mobile devices come to be meaningful within the social context of older adults' lives is important (Harley, & Fitzpatrick, 2009).

Findings from the qualitative studies with regard to intergenerational communication through mobile devices showed how an older content-creator on YouTube contribute to intergenerational communication (Amaro, Oliveira, & Veloso, 2016; Harley, & Fitzpatrick, 2009). The older adult users were able to open their position as an older person in a predominantly youth-oriented medium. While several qualitative studies mentioned that using mobile devices increased the sense of connectedness for older adults, none of the quantitative studies further mentioned about intergenerational communication via mobile devices. Also, several studies that examined the effects of social networking sites on older adults' usage for learning purpose further found the connection between the use of mobile devices and their online privacy concerns. Both older adults who currently use mobile devices for their informal learning purpose and who do not use mobile devices concerned about disclosing their private information and were confused about operating privacy setting on the social network sites (Ginsburg, Cameron, Mendez, & Westhoff, 2016; Kisekka, Bagchi-Sen, & Raghav Rao, 2013; Xie, Watkins, Golbeck, & Huang, 2012).

Collaborative learning. One of the emergent themes in the reviewed articles was a great potential for collaborative learning. Both qualitative and quantitative findings emphasized that

use of mobile devices would provide not only intergenerational or social communication but also offer collaborative learning experiences for older adult learners. Findings showed that older adults who use mobile devices were able to share information and their feelings, develop their knowledge, and expand their social relationships by engaging in collaborative activities such as participating in discussion form posts, friending and commenting to other users' video content, and collaborating with other online content creators such as bloggers or YouTubers (Hayes, van Stolk-Cooke, & Muench, 2015; Harley, & Fitzpatrick, 2009). In this way, qualitative findings elaborated more on the quantitative findings with giving a profound understanding of the older adults' learning needs using mobile devices.

Health-related self-learning. Common findings across quantitative studies were consistent in supporting mobile device use for health-related self-learning or acquiring medical knowledge (Lee, Han, & Jo, 2017; Steinert, Haesner, Tetley, & Steinhagen-Thiessen, 2016). Qualitative findings supplemented quantitative findings on the great potential of mobile device use for health-related informal or self-directed learning (Lindsay, Smith, Bell & Bellaby, 2007; Nahm, Resnick, DeGrezia, & Brotemarkle, 2009; Østensen, Gjevjon, Øderud, & Moen, 2017). In particular, sharing health-related personal experiences on specific discussion board or Q & A posting, older people who retain medical issues were able to acquire lived medical tips from people who went through (Deng, Mo, & Liu, 2014; Hernandez-Encuentra, Pousada, & Gomez-Zuniga, 2009). By participating in discussion form posts and sharing their medical information, older adults appeared to experience self-directed learning with strong learning motivation.

Affective and emotional dimensions. Findings from the qualitative studies emphasized that affective and emotional dimensions were largely associated with facilitating older adults' learning process using mobile devices (Ahmad, Zainal, Kahar, Hassan, & Setik, 2016). Examples of affective and emotional dimensions on learning process included spiritual experience, meditation, religious ritual, and self-motivation by adopting mobile devices (Hernandez-Encuentra, Pousada, & Gomez-Zuniga, 2009; Steinert, Haesner, Tetley, & Steinhagen-Thiessen, 2016).

Theoretical Frameworks

Theoretical frameworks that were employed in the articles were identified as follows: Social Cognitive Theory (SCT), Activity Theory, Experiential learning theory, and Technology Acceptance Model (TAM) or Unified Theory of Acceptance and Use of Technology(UTAUT).

Social cognitive theory (SCT). Bandura's (2001) Social Cognitive Theory that emphasizes the interaction among personal factors, environmental factors, and behavior (Bandura, 1994, 2001), has been employed in three qualitative studies (Gatti, Brivio, & Galimberti, 2017; Nahm, Resnick, DeGrezia, & Brotemarkle, 2009; Tsai, Shillair, Cotten, Winstead, & Yost, 2015). Environmental factors including support of family, friends; personal factors including the individual's technology confidence, self-efficacy, desire to learn new technology, adventurousness using and learning them; and the behavior of actual use of the mobile devices were adopted to analyze the theme relating to older adults' social connection using the mobile devices.

Activity theory. Activity theory is a psychological and multidisciplinary framework for examining human practice by interaction with the individual and social levels (Engeström, 1987, 1999; Leont'ev, 1978). In particular, this theory shaped few qualitative studies in terms of age and role satisfaction and saw if older adults could remain involved in their social roles they are most satisfied (Engeström, 1987, 1999; Leont'ev, 1978; Whitbourne, & Whitbourne, 2010).

Experiential learning theory. Experiential learning theory describes learning as "the process whereby knowledge is created through the transformation of experience. (Kolb, 1984). Several qualitative studies employed this theory to describe older adults' particular learning experiences in which from adopting mobile devices to further utilizing mobile devices as their informal learning medium (Lindsay, Smith, Bell & Bellaby, 2007; Zhang, 2017).

Technology acceptance theory. The types of technology acceptance models used as theoretical frameworks include: Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989), Senior Technology Acceptance and Adoption Model (STAM) (Renaud & Van Biljon, 2008), and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003) have been used to examine older adults' technology acceptance in the quantitative studies. Five of the quantitative studies were employed technology acceptance model to shape their overall research (Barnard, Bradley, Hodgson, & Lloyd, 2013; Ryu, Kim, & Lee, 2009; Ginsburg, Cameron, Mendez, & Westhoff, 2016; Ma, Chan, & Chen, 2016; Tsai, Shillair, & Cotten, 2017). Based on the elements of technology acceptance—perceived ease of use and usefulness, facilitating conditions, self-satisfaction and cost tolerance—older adults decided to adopt and further use mobile devices for their informal learning.

This review showed some theoretical framework on both qualitative and quantitative studies concerning older adults' informal learning using mobile devices. However, quantitative studies with solid theoretical framework have been minimal or less variety of theory was employed. While using various theories in qualitative studies, quantitative research mainly

adapted technology acceptance theories or relevant theories of that. Almost all quantitative studies that used technology acceptance models as the base theory of planned behavior focusing on predicting learners' intention to use and accept of technologies.

Discussion and Recommendations

Need for Future Research

Although the increasing numbers of studies both educational use of technology and educational gerontology along with the increasing older population around the world, only a few reviewed works of literature have concrete theoretical rigor. Thus, this literature review revealed a need for empirical studies with stronger theoretical rigor from fields of adult education and gerontology. For example, theories in adult education such as andragogy, experiential learning, and self-directed learning well acknowledge the importance of adults' learning in all aspects of their daily lives. Specifically, due to a greater propensity for self-directedness, autonomy and a wide range of learning needs in older adulthood (Findsen, & Formosa, 2011; Sipe, 2008), informal learning that goes on daily life using various mobile devices will be likely to give many advantages to older adults.

More than half of the studies considered in this review focused on the older adults' attitude or feelings towards mobile devices or their purpose of informal learning via mobile devices in sporadic use or until entry level of usage. For example, older adults' intention to use of smartphone applications, social networking services (SNS), or video user-generated contents (UGC) and some barriers that should be dealt with for frequent use were discussed. However, there seems to be more room for future qualitative research to examine specific stories or cases of older adults use technology on their regular basis. For example, qualitative adult scholars should look at how older adults use smartphone applications, SNS, and UGC in different cultural contexts for their informal learning on a regular basis. In this way, qualitative research can make a clear contribution to resolving the criticism of informal learning using mobile devices for older adults.

Age-specified Curriculum

Older population encompass all adults from silent generation (born 1925-1945) to the baby boomer (born 1946-1964). With the internet-savvy baby boomer reaching older age, future research will have to differentiate the baby boomer learners' characteristics from the silent generation. As growing numbers of online community members among the baby boomer

generation (Leist & Leist, 2013), considering older population dividing age-subgroups into young-old (65 to 74), middle-old (75 to 84), and old-old (85 years and older) groups who may have considerably different habit of technology use is certainly worth investigating. For the different characteristics of age-subgroups such as old-old adults who less likely to have knowledge about an initial setting of mobile devices or opening SNS account and more likely to concern about technology anxiety and privacy disclosure should be taken into account when curriculum designing.

Mobile Health Education in Practice

More than half of the studies considered in this review mentioned older adults' interests in using mobile devices as their health-related learning. One prominent learning goal using mobile device among older adults was to diagnosis, prevention or treatment their condition or disorder from smartphone applications, blogs, and SNS. In this regard, the adult educators in health education, health promotion, medical, or nursing areas need to consider how mobile devices promote older adults' health-related informal learning in various ways. For example, using online discussion boards that may be facilitated by doctors, nurses, health professionals and many older adults participate in would provide expertized medical information as well as give lived medical tips from people who went through the certain health issues.

References

Ahmad, N. A., Zainal, A., Kahar, S., Hassan, M. A. A., & Setik, R. (2016). Exploring the needs of older adult users for spiritual mobile applications. *Journal of Theoretical & Applied Information Technology, 88*(1), 154-160.

Alexander, B. (2004). Going nomadic: Mobile learning in higher education. *Educause Review, 39*(5), 28-34.

Amaro, A. C., Oliveira, L., & Veloso, A. I. (2016). "Let's build our family tree!": Grandparents and grandchildren using tablets together. *Procedia Computer Science, 100*, 619-625. https://doi.org/10.1016/j.procs.2016.09.203

Bandura, A. (1994). Social cognitive theory of mass communication. In J. Bryant & D. Zillman (Eds.), *Media effects: Advances in theory and research* (pp. 61-89). Hillsdale, NJ: Lawrence Erlbaum.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*, 1-26.

Barnard, Y., Bradley, M. D., Hodgson, F., & Lloyd, A. D. (2013). Learning to use new technologies by older adults: Perceived difficulties, experimentation behavior and usability. *Computers in Human Behavior, 29*(4), 1715-1724.

Black, R. W., & Reich, S. M. (2013). Affordances and constraints of scaffolded learning in a virtual world for young children. In P. Flicia (Ed.) *Developments in Current Game-Based Learning Design and Deployment* (pp. 61-73). Hershey, PA: IGI Global.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3,* 77–101.

Curran, V., Matthews, L., Fleet, L., Simmons, K., Gustafson, D. L., & Wetsch, L. (2017). A Review of Digital, Social, and Mobile Technologies in Health Professional Education. *Journal Of Continuing Education In The Health Professions*, *37*(3), 195-206. doi:10.1097/CEH.0000000000000168

Cheon, J., Lee, S., Crooks, S. M., & Song, J. (2012). An investigation of mobile learning readiness in higher education based on the theory of planned behavior. *Computers & Education, 59*(3), 1054-1064.

Delello, J. A., & McWhorter, R. R. (2017). Reducing the digital divide. *Journal of Applied Gerontology, 36*(1), 3-28. 10.1177/0733464815589985 Retrieved from https://doi.org/10.1177/0733464815589985

Demirbilek, M. (2010). Investigating attitudes of adult educators towards educational mobile media and games in eight european countries. *Journal of Information Technology Education, 9*, 235-247.

Deng, Z., Mo, X., & Liu, S. (2014). Comparison of the middle-aged and older users' adoption of mobile health services in china. *International Journal of Medical Informatics, 83*(3), 210-224. doi: https://doi.org/10.1016/j.ijmedinf.2013.12.002

Díaz-Bossini, J., & Moreno, L. (2014). Accessibility to mobile interfaces for older people. *Procedia Computer Science, 27*, 57-66. doi:https://doi.org/10.1016/j.procs.2014.02.008

El-Hussein, M. O. M., & Cronje, J. C. (2010). Defining mobile learning in the higher education landscape. *Journal of Educational Technology & Society, 13*(3), 12.

Engeström, Y. (1987). Learning by expanding: An activity-theoretical approach to developmental research. Helsinki, Finland: Orienta-Konsultit.

Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen, & R. Punamaki (Eds.), Perspectives on activity theory (pp. 19–38). Cambridge, MA: Cambridge University Press.

Findsen, B. & Formosa, M. (2011). *Lifelong learning in later life: a handbook on older adult learning.* Rotterdam, Netherlands: SensePublishers.

Garrard, J. (2017). *Health sciences literature review made easy: the matrix method*. Burlington, MA: Jones & Bartlett Learning.

Gatti, F. M., Brivio, E., & Galimberti, C. (2017). "The future is ours too": A training process to enable the learning perception and increase self-efficacy in the use of tablets in the elderly. *Educational Gerontology, 43*(4), 209-224. doi:10.1080/03601277.2017.1279952

Ginsburg, H. J., Cameron, R., Mendez, R. V., & Westhoff, M. (2016). Helping others use social media: Age stereotypes when estimating learner's success. *Psychology, Society & Education, 8*(1), 1-12.

Githens, R. P. (2007). Older adults and e-learning: Opportunities and barriers. *Quarterly Review of Distance Education, 8*(4), 329-338. Retrieved from http://lib-ezproxy.tamu.edu:2048/login?url

Harley, D., & Fitzpatrick, G. (2009). YouTube and intergenerational communication: The case of Geriatric1927. *Universal Access in the Information Society, 8*(1), 5-20.

Hayes, M., van Stolk-Cooke, K., & Muench, F. (2015). Understanding facebook use and the psychological effects of use across generations. *Computers in Human Behavior, 49*, 507-511. doi: 10.1016/j.chb.2015.03.040

Heo, G. M., & Romee Lee, a. (2013). Blogs and social network sites as activity systems: Exploring adult informal learning process through activity theory framework. *Journal of Educational Technology & Society,* (4), 133.

Habermas, J. (1971). *Knowledge and human interests*. Boston, MA: Beacon Press.

Harley, D., & Fitzpatrick, G. (2009). YouTube and intergenerational communication: The case of Geriatric1927. *Universal Access in the Information Society, 8*(1), 5-20. doi:http://dx.doi.org/10.1007/s10209-008-0127-y

Hernandez-Encuentra, E., Pousada, M., & Gomez-Zuniga, B. (2009). ICT and older people: Beyond usability. *Educational Gerontology, 35*(3), 226-245. Retrieved from http://www.informaworld.com/openurl?genre=article&id=doi:10.1080/03601270802466934

Igual, R., Plaza, I., Medrano, C., & Rubio, M. A. (2014). *Personalizable smartphone-based system adapted to assist dependent people* doi:10.3233/AIS-140285

Kisekka, V., Bagchi-Sen, S., & Raghav Rao, H. (2013). Extent of private information disclosure on online social networks: An exploration of facebook mobile phone users. *Computers in Human Behavior, 29*(6), 2722-2729. doi: https://doi.org/10.1016/j.chb.2013.07.023

Kuoppamäki, S., Taipale, S., & Wilska, T. (2017). The use of mobile technology for online shopping and entertainment among older adults in finland. *Telematics and Informatics, 34*(4), 110-117. doi: https://doi.org/10.1016/j.tele.2017.01.005

Lee, E., Han, S., & Jo, S. H. (2017). Consumer choice of on-demand mHealth app services: Context and contents values using structural equation modeling. *International Journal of Medical Informatics, 97*, 229-238. doi: https://doi.org/10.1016/j.ijmedinf.2016.10.016

Leen, E., & Lang, F. R. (2013). *Motivation of computer based learning across adulthood.* Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=edswss&AN=000316769300053&site=eds-live

Leist, A., & Leist, A. K. (2013). Social Media Use of Older Adults: A Mini-Review. *Gerontology*, *59*(4), 378-384.

Lindsay, S., Smith, S., Bell, F., & Bellaby, P. (2007). Tackling the digital divide: Exploring the impact of ICT on managing heart conditions in a deprived area. *Information, Communication & Society, 10*(1), 95-114. doi:http://dx.doi.org/10.1080/13691180701193127

Ma, Q., Chan, A. H. S., & Chen, K. (2016). Personal and other factors affecting acceptance of smartphone technology by older chinese adults. *Applied Ergonomics, 54*, 62-71.

Mather, M., Jacobsen, L., & Pollard, K. (December, 2015). *Population Bulletin.* Retrieved from population Reference Bureau website: http://www.prb.org

Myhre, J. W., Mehl, M. R., & Glisky, E. L. (2017). Cognitive benefits of online social networking for healthy older adults. *Journals of Gerontology Series B: Psychological Sciences & Social Sciences, 72*(5), 752-760. 10.1093/geronb/gbw025 Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=a2h&AN=124650363&site=ehost-live

Nahm, E., Resnick, B., DeGrezia, M., & Brotemarkle, R. (2009). Use of discussion boards in a theory-based health web site for older adults. *Nursing Research, 58*(6), 419-426.

Neuendorf, K. A. (2017). *The content analysis guidebook* (2nd ed.). Los Angeles, CA: SAGE.

Ng, W. (2013). Conceptualising mLearning literacy. *International Journal of Mobile and Blended Learning (IJMBL), 5*(1), 1-20.

Nguyen, T., Irizarry, C., Garrett, R., & Downing, A. (2015). Access to mobile communications by older people. *Australasian Journal on Ageing, 34*(2), E7-E12. 10.1111/ajag.12149 Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2015-25172-007&site=ehost-live

Østensen, E., Gjevjon, E. R., Ødegård, T., & Moen, A. (2017). Introducing technology for thriving in residential long-term care. *Journal of Nursing Scholarship: An Official Publication of Sigma Theta Tau International Honor Society of Nursing, 49*(1), 44-53. doi:http://dx.doi.org/10.1111/jnu.12268

Park, Y. (2011). A pedagogical framework for mobile learning: Categorizing educational applications of mobile technologies into four types. *International Review of Research in Open and Distance Learning, 12*(2), 78-102. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ920735&site=eds-live

Pew Research Center (January 12, 2017). *Mobile fact sheet*. Retrieved from http://www.pewinternet.org/fact-sheet/mobile/#

Reagle, D. (November 30, 2012). *10 years of mobile industry history in 10 minutes.* Retrieved from https://www.sitepoint.com/the-advancements-in-mobile-design-and-how-it-has-developed-into-a-strong-industry/

Rosenthal, R. L. (2008). Older computer-literate women: Their motivations, obstacles, and paths to success. *Educational Gerontology, 34*(7), 610-626. Retrieved from http://lib-ezproxy.tamu.edu:2048/login?url

Rogers, E. M. (1995). *The diffusion of innovation* (4th ed.). New York, NY: Free Press.

Ryu, M., Kim, S., & Lee, E. (2009). Understanding the factors affecting online elderly user's participation in video UCC services. *Computers in Human Behavior, 25*, 619-632. doi:10.1016/j.chb.2008.08.013

Selwyn, N. (2004). The information aged: A qualitative study of older adults' use of information and communications technology. *Journal of Aging Studies, 18*(4), 369-384. doi: 10.1016/j.jaging.2004.06.008

Steinert, A., Haesner, M., Tetley, A., & Steinhagen-Thiessen, E. (2016). Self-monitoring of health-related goals in older adults with use of a smartphone application. *Activities, Adaptation & Aging, 40*(2), 81-92. doi:10.1080/01924788.2016.1158569

Sipe, C. (2008). Online learning for the 50-plus adult. *Journal on Active Aging, 7*(1), 34-40. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=31221731&site=eds-live

Swan, K. (2003). Learning effectiveness online: What the research tells us. *Elements of quality online education, practice and direction*, *4*, 13-47.

Trentin, G. (2004). E-learning and the third age. *Journal of Computer Assisted Learning, 20*(1), 21-30. Retrieved from http://dx.doi.org/10.1111/j.1365-2729.2004.00061.x

Tsai, H. S., Shillair, R., & Cotten, S. R. (2017). Social support and "playing around". *Journal of Applied Gerontology, 36*(1), 29-55. doi:http://dx.doi.org/10.1177/0733464815609440

Tsai, H. S., Shillair, R., Cotten, S. R., Winstead, V., & Yost, E. (2015). Getting grandma online: Are tablets the answer for increasing digital inclusion for older adults in the U.S.? *Educational Gerontology, 41*(10), 695-709. Retrieved from http://ezproxy.library.tamu.edu/login?url=https://search.proquest.com/docview/1826652797?accountid=7082

Turner, P., Turner, S., & Walle, V. D. (2007). How older people account for their experiences with interactive technology. *Behaviour & Information Technology, 26*(4), 287-296. doi:10.1080/01449290601173499

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*(3), 425-478.

Vygotskiĭ, L. S., & Cole, M. (1978). *Mind in society: the development of higher psychological processes.* Cambridge, MA: Harvard University Press, 1978.

Whitbourne, S. K., & Whitbourne, S. B. (2010). *Adult development and aging: Biopsychosocial perspectives*. John Wiley & Sons.

Xie, B., Watkins, I., Golbeck, J., & Huang, M. (2012). Understanding and changing older adults' perceptions and learning of social media. *Educational Gerontology, 38*(4), 282-296. doi:10.1080/03601277.2010.544580

Zhang, F., Kaufman, D., Schell, R., Salgado, G., Seah, E., & Jeremic, J (2017). Situated learning through intergenerational play between older adults and undergraduates. *International Journal of Educational Technology in Higher Education, 14*(1), 1-16. doi:10.1186/s41239-017-0055-0

Appendix

Table 1. Example of Matrix of the reviewed studies and their methods, findings, and methodological quality indicators

Ref #	Lead Author (year)	Key themes	Purpose of study / Research questions	Methodology (research methods)	Numbers and description of participants	Theoretical Framework	Key findings	Learning types via MD
486	Kisekka, Bagchi-Sen, & Raghav Rao (2013)	Online social networks	to investigate the factors that influence the extent of private information disclosure of Facebook mobile phone users	Quantitative (Survey questionnaire)	448 cases from national sample of 2277 mobile phone users; 100 (aged 55 and above, 348 (aged 54 and below)	Communication Privacy Management theory	cybersecurity concerns hinder by use mobile devices	Informal technology learning
500	Ma, Chan, & Chen (2016)	Technology acceptance	to explore and confirm, for older adults in China, the key influential factors of smartphone acceptance, and to describe the personal circumstances of Chinese older adults who use smartphone	Mixed method (structured questionnaire and face to face individual interviews)	120 Chinese older adults	Technology Acceptance Model (TAM), and the Unified Theory of Acceptance and Use of Technology (UTAUT)	self-satisfaction and facilitating conditions were proved to be important factors influencing perceived usefulness and perceived ease of use.	Informal technology learning
560	Delello& McWhorter (2017)	community of practice, metaliteracy	to explore whether information and communication technologies specifically iPads, improved the lives of older adults	Mixed-methods (Surveys and Case study	135 residents in retirement community aged from 61 to 99	Metaliteracy and a community of practice (CoP)	the use of technology increased knowledge, elicited closer family ties, and led to a greater overall connection to society	Informal learning and social connection

632	Chiu (2016)	attitudes, impact, and learning needs of older adults using apps on touchscreen mobile devices	to examine the learning needs and changes in attitude and psychological well-being following the training course in a sample of older adults with or without previous Internet experience and with a heterogeneous sociodemographic background	Mixed-method (pre-test and the post-test and 16 attended the focus group interviews)	39 older adults who were recruited from a community center in a low Internet usage area in southern Taiwan	Technology acceptance model (TAM), Diffusion of innovation theory	- the participants' lower depressive symptom scores compared to baseline - the participants' learning needs related to extended practice, usefulness, and compatibility in adopting touch-screen apps	informal learning using apps on touch screen mobile device
634	Deng, Mo, & Liu (2014)	technology adoption	to explore a research model based on the value attitude behavior model, theory of planned behavior, and four aging characteristic constructs to investigate how older and middle-aged citizens adopted mobile health services.	Quantitative (survey)	424 people older than 40 years in China	Value attitude behavior model, Theory of planned behavior	perceived value, attitude, perceived behavior control, technology anxiety, and self-actualization need positively affected the behavior intention of older users	Informal technology learning
640	Tsai, Shillair & Cotton (2017)	Digital literacy and mobile device learning	to examine how older adults, engage with tablet devices and increase their digital literacy	Qualitative (in-depth interviews)	21 individuals aged 65 and older who reported owning tablet computers	Not applicable	two kinds of social support are important in older adults' technology acquisition and learning, including the support for initial set up of devices and the support for learning to use the devices	Informal technology learning

647	Tsai, Shillair, Cotten, Winstea & Yost (2015)	Influences on decision to use the technology / overcoming barrier of self-efficacy / impacts of using the technology	to examine: how older adults decide to use a new technology, tablet computers; how they conquer the barrier of technological self-efficacy through using tablets; the impacts of using this new technology in their lives	Qualitative (Semi-structured interview)	21 older adults in independent living communities in a medium-sized city in the southeastern U.S.	Social cognitive theory	- observational and enactive learning for older adults in using tablets - using tablets helped increase a sense of connectedness - tablet computers may be one way to increase digital inclusion among older adults	Informal technology learning
651	Barnard, Bradley, Hodgson, & Lloyd (2013)	learning and adoption of technology among older adults	to examines the factors and theoretical frameworks for the adoption of technology for older adults	Qualitative case study (mixture of semi-structure d interviews and open discussion)	13older people over 65	Technology acceptance model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT)	- the powerful role that facilitating conditions have for learning how to use digital technologies for this user group - a lack of facilitating conditions during initial use, and highlights potential for appropriate design in helping to avoid some user errors during this phase	Informal technology learning

656	Nahm, Resnick, DeGrezia & Brotemarkle (2009)	Online community activities by older adults	to explore the impact of the social cognitive theory-based structured hip fracture prevention Web site (TSW) on health behaviors through analysis of discussion board postings and to assess participants' experiences with the discussion board.	Exploratory qualitative study (earning modules and open-ended question discussion)	20 participants	social cognitive theory	- participants shared their current health behaviors and discussed specific health problems and concerns - many recognized opportunities for improvement and identified motivators to improve health behaviors	Social connection and informal learning using mobile device

Table 2. Overview of the reviewed articles

Ref#	Research Methods	Journals	Field of Study
130	Qualitative (focus group, online questionnaire)	Educational Gerontology	Specific field in Education
142	Quantitative (survey, questionnaire)	Computers in Human Behavior Comput.Hum.Behav.,	Technology, computer, social media, cyber psychology
276	Qualitative (interview)	Journal of Theoretical & Applied Information Technology	Technology, computer, social media, cyber psychology
486	Quantitative (survey, questionnaire)	Comput.Hum.Behav.,	Technology, computer, social media, cyber psychology
493	Qualitative and mixed analysis (multiple case study and interviews)	Procedia Computer Science	Technology, computer, social media, cyber psychology
500	Mixed method (questionnaire, individual interviews)	Applied Ergonomics	Technology, computer, social media, cyber psychology
505	Qualitative-dominant con-occurrent mixed methods (survey, focused ethnography)	Educational Gerontology	Specific field in Education
509	Quantitative (survey Questionnaire)	Australasian Journal on Ageing	Gerontology and Aging
531	Quantitative (intervention)	Activities, Adaptation & Aging	Gerontology and Aging
560	Mixed-methods (surveys, case study	Journal of Applied Gerontology	Gerontology and Aging
562	Qualitative (focus group, individual interview)	Mobile Media & Communication	Technology, computer, social media, cyber psychology
588	Quantitative (cognitive function test, self-report questionnaires)	Journals of Gerontology Series B: Psychological Sciences & Social Sciences	Gerontology and Aging
628	Quantitative (survey)	Psychology, Society & Education	Specific field in Education
633	Qualitative (open-ended discussions)	Educational Gerontology	Specific field in Education
634	Quantitative (survey)	International journal of medical informatics	Health, medical, nursing
636	Quantitative (survey)	International journal of medical informatics	Health, medical, nursing
640	Qualitative (in-depth interviews)	Journal of Applied Gerontology	Gerontology and Aging
643	Qualitative, exploratory study (observations, interviews)	Journal of nursing scholarship	Health, medical, nursing
647	Qualitative (semi-structured interview)	Educational gerontology	Specific field in Education
651	Qualitative case study (semi-structure interviews, open discussion)	Comput.Hum.Behav.,	Technology, computer, social media, cyber psychology
652	Mixed method (survey, field study)	ACM Transactions on Accessible Computing	Technology, computer, social media, cyber psychology

655	Quantitative (questionnaire)	Journal of Information Technology Education	Specific field in Education
656	Exploratory qualitative study (learning modules, open-ended question discussion)	Nursing research	Health, medical, nursing
657	Quantitative (case study)	Universal Access in the Information Society	Technology, computer, social media, cyber psychology
659	Qualitative (interview)	Information, Communication & Society	Technology, computer, social media, cyber psychology
664	Qualitative (2 Case study, online survey questionnaire)	Journal of Educational Technology & Society	Specific field in Education
665	Quantitative (survey)	Comput.Hum.Behav.,	Technology, computer, social media, cyber psychology
734	Qualitative (conversation analysis)	International Journal of Educational Technology in Higher Education	Specific field in Education

Table 3. Summary of the six identified themes of older adults' informal learning features

Positive attitudes towards use of technology, but along with the certain conditions • Willingness to use or expand the usage of mobile devices for informal learning • Not high resistance to adopt mobile devices for informal learning • Agreeing on the benefits of use mobile educational applications • Recognizing potential opportunities of smartphone's educational applications Conditions • Certainty of improving independence and autonomy • Reducing technology anxiety • Assurance of cyber security and privacy • Helping for initial set up of devices • Easy access to continuous tutoring and instructional manual
Practical uses • Financial resources • Scheduling or reminders • Improving cognitive abilities (memory)
Interpersonal and intergenerational communication • Wishes of staying engaged with social life • Tying with younger family members • Sharing feelings with family and friends • Expand to social relationships beyond geographical limits
Collaborative learning experience • Posting collaborative content generating between grandparents and grandchildren • Participating in online group forum, discussion, chat groups
Health or medical knowledge • Self-monitoring of nutrition, water, physical activity, weight control using mobile applications • Self-diagnosis • Sharing medical and health knowledge with same age group • Decrease and prevention of depressive symptoms
Affective and emotional dimensions • Religious purpose (prayer reminder, religious food scanner) • Meditation (sounds, timer, inspirational video lecture or radio)