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E-Learning Design for Older Adults in the United States

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Abstract: As global populations age, there is an urgent need to address the unique learning requirements of older adults in the context of e-learning. This study builds upon prior work to investigate the connections between older adults' cognitive profiles, learning preferences, and attitudes toward technology in the United States. Through a survey of 203 U.S. adults aged 55 and above, data were collected on participant demographics, learning preferences, and attitudes towards technology. The results reveal a tech-savvy sample that is most comfortable with everyday applications and favors practical, visual learning approaches. Key findings include high levels of internet and smartphone adoption, varying confidence levels across different mobile applications, and strong preferences for step-by-step instructions, examples, and graphics in e-learning modules. This mixed-method study serves as a foundation for future research aimed at increasing the adoption and effectiveness of e-learning among older adults in the U.S. and globally, ultimately contributing to the overall quality of life and support for active-aging initiatives.

Keywords: e-learning; adult learning; instructional design; survey; design-based research; lifelong learning

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1. Introduction

The global population is rapidly aging, with adults 60 years and over expected to more than double from 600 million in 2000 to over 2 billion by 2050 (World Health Organization 2022). This demographic transformation brings with it both opportunities and challenges for lifelong learning.

The increased longevity in our population allows for more years of meaningful education, experiences, engagement, and continued contribution well into late adulthood. However, this societal transformation also brings forward new challenges that limit older adults' access to high-quality continuing education experiences (Zhang et al. 2022). These challenges originate in ageist assumptions and inaccessible learning platforms that show a lack of design that is considerate of the needs and preferences of older adults (Mace et al. 2022; Seale 2020).

Researchers have demonstrated that participating in intellectually stimulating activities can help older adults maintain and even improve cognitive health and plasticity (Li et al. 2022; Ferguson et al. 2023). In addition to neurological benefits, lifelong cognitive learning provides older individuals with new knowledge and skills, opportunities to connect with others, and avenues to continue using their talents to enrich our society (Gerdes 2022). While today's e-learning is often not tailored to older populations, thoughtfully designed online education can provide additional avenues to accessible, enriching cognitive exercise, and social connection for adult learners (Lu et al. 2022; Ramirez and Inga 2022).

The global pandemic and the subsequent mass migration to virtual learning further spotlighted this issue and the need for rapid advancement in the design of online education for older learners (Charters and Murphy 2021) by forcing a shift to remote learning that changed the way many institutions provide classes permanently (Duncan and Joyner 2022; Abdullateef 2022). Further research is needed to refine digital learning design in ways

that purposefully leverage modern technology to promote quality of life, relationships, newfound skills, and ongoing growth in late adulthood as described by the World Health Organization's (2022) "healthy aging" initiative.

This study begins by exploring recent (2020–2023) literature across domains of cognitive aging, technology use, instructional design, and e-learning through the lens of adults aged 55 and over. This exploration paired with results from survey data conducted in the U.S. is used to inform e-learning design recommendations. The survey instrument used was originally created and conducted in Greece by Pappas et al. (2019) to inform design practice recommendations to better serve older adult learners pursuing cognitive-based e-learning.

Overall, the review of prior research from the original study (Pappas et al. 2019) is comprehensive but outdated and geographically specific. The study presents original data of over 100 older adults surveyed, which provides direct insight into the targeted design audience. However, the survey sample is in one location (Greece) and is skewed in terms of education level of the participants, which may affect the results of the survey and its generalizability. This research, which combined literature analysis and survey data to make recommendations for design specified for older generations, is a step in a much larger process and research field that is needed and that we hope to contribute to through our work. The instrument used to survey participants in the original study was rigorously tested and showed validity, making it a viable tool to use in future, expanded research studies. The instrument is discussed further in the Methods sections.

2. Literature Review

2.1. Cognitive Changes and Lifelong Learning Needs

The aging process is often associated with a decline in cognitive functions such as attention, working memory, problem-solving skills, and executive function (Baudouin et al. 2009; Clark et al. 2006; Taki et al. 2011). Engaging in lifelong learning activities can significantly mitigate these effects and improve cognitive health (Baudouin et al. 2009; Clark et al. 2006; Ferguson et al. 2023; Taki et al. 2011) and foster cognitive plasticity well into adulthood (Ferguson et al. 2023; Li et al. 2022). This suggests significant potential for cognitive exercise through e-learning (Ferguson et al. 2023; Kueider et al. 2012).

E-learning can be a vital tool in providing these cognitive exercises, highlighting the importance of designing learning environments that accommodate the cognitive profiles of older adults (Kueider et al. 2012; Pappas et al. 2019). Effective e-learning environments should, therefore, provide cognitive stimulation tailored to the capacities and limits of older adults (Baudouin et al. 2009; Clark et al. 2006; Ferguson et al. 2023; Kueider et al. 2012). Pappas et al. (2019) emphasized designing e-learning environments that consider integrating constructivist and self-directed learning approaches, which support the aging brain's capacity to process new information efficiently. This foundation underscores the need for tailored e-learning solutions that can accommodate the unique cognitive profiles of older adults (Lu et al. 2023).

2.2. Technological Familiarization and Barriers among Older Adults

Despite a gradual increase in digital engagement among older adults, substantial barriers hinder rapid widespread technology adoption. While older adults are increasingly engaging with technology, significant gaps remain, particularly familiarity with newer devices, such as smartphones and tablets (Pappas et al. 2019; Pew Research Center 2014; Chen and Lou 2020). Other prominent barriers include physical limitations, education disparities, technology anxiety, and socio-economic factors that impeded full engagement (Kim et al. 2023; Pappas et al. 2019; Papi-Galvez and La Parra-Casado 2023; Pew Research Center 2014; Vogels 2021). Additionally, challenges such as lower income, lower education levels, and rural versus urban living can exacerbate the feelings of anxiety toward new technologies (Papi-Galvez and La Parra-Casado 2023; Pew Research Center 2014; Quan-Haase et al. 2016). The US states in which at least half of the population has internet

access have 64.9% coverage as of the most current, 2022, data states, showing significant swaths of area still without readily available access (US Census Bureau 2024) with 7% of the population not engaging with internet at all (Perrin and Atske 2021).

These barriers underscore the need for supportive measures in accessible e-learning platforms to bridge the gaps between technology and older learners (Pew Research Center 2014; Papi-Galvez and La Parra-Casado 2023). Overcoming these barriers requires careful consideration of the design and delivery of technological education to this demographic. Effective e-learning designs for this demographic must therefore consider physical, psychological, and socio-economic accessibility, ensuring that technology serves as a bridge rather than a barrier to learning (Fang et al. 2019). Addressing the digital divide requires policy interventions and educational practices that ensure older adults are not left behind as learning moves increasingly online (Eynon and Malmberg 2021).

2.3. E-Learning Preferences and Instructional Design for Enhanced Engagement

Older adults benefit from clear, logically structured, and sequential e-learning content. Instructional designs that incorporate step-by-step comprehensive content presentation, regular assessments, and concise modules can significantly enhance learning by reducing cognitive overload (Pappas et al. 2019; Martin et al. 2020; DeAngelis 2021). These approaches should align with adult learning theories, emphasizing constructivist, self-directed, and experiential learning strategies (Martin et al. 2020; Pappas et al. 2019; Boot et al. 2020). These strategies help scaffold complex tasks and reduce unnecessary cognitive load, accommodating age-related changes in information processing (Boot et al. 2020; Martin et al. 2020).

E-learning for older adults should be carefully crafted to accommodate their sensory, cognitive, and motivational needs (Sharifi and Chattopadhyay 2023). This includes designing clear, navigable, and visually appealing interfaces that encourage continued engagement and learning. Archambault et al. (2022) and Caskurlu et al. (2020) highlight the importance of instructor presence in online learning, which can significantly enhance student satisfaction and perceived learning. The literature suggests that providing older adults with scaffolded support, regular practice and assessments, and opportunities for social interaction within e-learning platforms can significantly enhance their engaged learning experiences.

2.4. Emerging Technologies and Adoption Challenges

Emerging technologies such as extended reality (XR) and artificial intelligence (AI) hold potential to revolutionize learning for older adults. These technologies provide immersive and personalized educational experiences, which can be particularly beneficial for older adults who may require more customized educational approaches (Stanney et al. 2023; Chaipidech et al. 2022). However, the adoption of these technologies can be hindered by apprehensions about new technology use.

E-learning systems designed for older adults should leverage these technologies in ways that are intuitive and aligned with adult learning principles, ensuring that these tools enhance rather than complicate the learning process. The willingness to adopt such technologies varies, indicating the need for instructional designs that are effective and acceptable to older learners. Addressing these challenges involves integrating andragogical principles (Knowles et al. 2005) and ensuring that technology use is relevant to the learners' needs and life contexts. Implementation of these technologies must be intuitive and aligned with andragogical principles to enhance their adoption and effectiveness in older adult education (Stanney et al. 2023; Chaipidech et al. 2022).

2.5. Addressing Ageist Assumptions and Promoting Inclusivity to Enhance Access

Ageist assumptions can adversely affect the adoption and effectiveness of e-learning for older adults (Mace et al. 2022; Mannheim et al. 2021). Policies and practices must ac-

tively counteract these biases by promoting inclusive, adaptive, and personalized learning environments that respect and leverage the capabilities of older adults (Bernacki et al. 2021).

To combat ageism and enhance access, e-learning environments must also be inclusive, adaptive, and personalized. Designing with respect for older adults' dignity and life experiences, and actively promoting digital literacy and inclusivity are crucial for ensuring they are not left behind in the digital learning landscape (Mace et al. 2022; Eynon and Malmberg 2021).

2.6. Synthesis and Future Directions

This review synthesizes recent findings with past research to outline effective strategies for enhancing e-learning among older adults. Integrating insights from cognitive science, technology adoption, and instructional design is essential for supporting older adults in their educational pursuits effectively. This review also synthesized recent advancements and ongoing challenges in e-learning for older adults, emphasizing the need for educational technologies that are accessible, engaging, and cognitively beneficial. It highlights the importance of adaptive and personalized learning environments that consider cognitive and technological needs for the aging population.

By refining instructional approaches and optimizing e-learning environments for older adult populations, we can better support older learners' desire for lifelong learning. Furthermore, we can further learner engagement beyond content and encourage active participation in society, ultimately enhancing older adults' quality of life and cognitive resilience in later years. By integrating these findings into the design and implementation of e-learning platforms, educational technologists and designers can create more effective and fulfilling learning experiences for older adults. This approach addresses the unique needs and preferences of this demographic and aligns with broader goals of lifelong learning and cognitive vitality in later life. Combining this informed synthesis of the current literature with a survey in the U.S. of adults 55+ allows us to further develop and determine design suggestions for e-learning platforms that take older adults' needs and preferences into consideration.

3. Methods

This study explored the cognitive profile and associated learning needs and preferences of older adults that should guide the design of an e-learning platform. Specifically, two questions were asked when analyzing the survey dataset:

1. What is the level of familiarity and attitudes towards the use of information and communication technologies among older adults in the U.S.?
2. What features and learning approaches do older adults in the U.S. prefer in terms of structure, content, assessment, and media use in an e-learning course?

3.1. Research Design

Design-based research emerges as an optimal methodology for the iterative development of online learning interventions tailored to older adults' needs, as seen in the research ideas brought forward by Pappas et al. (2019). Such methods allow for rapid adjustments to platforms and activities based on direct feedback from learners. Design-based research (DBR) incorporates perspectives, assets, and lifelong experience to generate localized design principles that can drive continuous refinement (Hoadley and Campos 2022). Design-based research has been brought forward in the research and implementation of andragogy principles by a variety of researchers in different ways (Ślósarz et al. 2022; Pappas et al. 2019). Some research has put forward survey instruments to be used in the initial learner analysis of adult learners but rarely is the instrument specific for older adult learners. By situating this research project within a learner analysis survey instrument that was designed specifically for the study of best e-learning practices for older adults, we are able to ground future iterations of courses and work in knowledge gleaned from the target

participant demographics. The first step in this cyclical process is to glean knowledge of the target learning audience through the U.S. modified survey instrument.

3.2. Procedure

This study's purpose was to continue exploring learning profiles of older adults within the context of online learning. Therefore, the questionnaire from Pappas et al. (2019), originally created for this use, was applied in a new geographic location, the United States, to replicate the study and expand on the findings. The survey was distributed through various platforms, including social media, email lists, flyers, and organizations with membership geared toward adults 55 and over. All who encountered the survey were welcome to participate if the criteria (age and location) were met and snowball sampling of participants sharing the survey with others was also utilized. The survey was open to participants for approximately 6 months. The first phase of this study, an updated literature review from the original study, confirmed and expanded the known barriers about technology acceptance in older adults and the instructional design practices that can be utilized to best fit the needs of this population. The second phase of this study distributed a modified (for best language use in a U.S. setting) replication of the "Older Adults and Information and Communication Technologies" survey from the original study (Appendix A). The questionnaire was distributed in accordance with methods described in the study's IRB, which included verbal dissemination, utilizing social media and snowball effect online, sending emails in relevant networks to the population, and utilizing QR codes for easy access to the survey when this study was presented at various meetings and conferences. A consent and age verification page began the survey and only data from participants who completed 100% of the survey was kept for analysis. All valid data were then analyzed using Jamovi Version 2.4 (The Jamovi Project 2024), an open-source statistical analysis software.

3.3. Participants

The dataset used for this study consisted of 203 online survey participants, 55 years of age or older, who live in the United States. Table 1 shows the descriptive demographic statistics that make up the sample of this dataset. The mean age of the participants who completed this survey was 64.8 years of age (SD = 6.36). This was found to be similar when dividing the sample by sex with the mean age of female participants 64.5 (SD = 6.55) and male participants mean age of 65.3 (SD = 6.05). For this sample, 61.6% (n = 125) of participants were female and 38.4% (n = 78) of participants were male. In total, 65.1% of the participants had obtained an education of a bachelor's degree or higher (Table 2). Most of the sample resided in an urban area (74.4%), defined by the U.S. Census as a city, suburb, or town with more than 2500 people, and the rest resided in rural surroundings (25.6%), defined by the U.S. Census Bureau as countryside, farm, small town with less than 2500 people. A large majority of participants lived in a single-family household (95.6%), with only 3.9% living in an apartment or condominium and a single participant living in a retirement facility or nursing home.

Table 1. Sample demographics and descriptive statistics.

Variable	All Participants	Female	Male
Sample	203	125	78
Mean Age	64.8	64.5	65.3
Age SD	6.36	6.55	6.05
Urban Residence	151 (74.4%)	94	57
Rural Residence	53 (35.6%)	31	21
Single-Family Household	194 (95.6%)	121	73
Apartment or Condominium	8 (3.9%)	3	5
Retirement or Nursing Home	1 (0.5%)	1	0

Table 2. Education and profession.

Variable	Frequency	Percentage
Education Level		
Less than high school	2	1.0%
High school diploma or GED	18	8.9%
Some college, no degree	38	18.7%
Associate degree or technical school	13	6.4%
Bachelor's degree	72	35.5%
Graduate or professional degree	60	29.6%
Current Work Status		
Full-time (35+ h)	79	38.9%
Part-time (less than 35 h)	28	13.8%
Retired or purposefully not working	90	44.3%
Unemployed, actively seeking work	6	3.0%
Type of Employment		
Management, business, sales, and office	77	37.9%
Tourism and service occupations	2	1.0%
Natural resources, construction, and science	23	11.3%
Production, transportation, and material moving	5	2.5%
Government/public administration	26	12.8%
Education and research	47	23.2%
Health industry	23	11.3%

The current work status of the participants was much more evenly distributed, with 38.9% working 35+ h per week, 44.3% retired or purposefully not working, 13.8% working part-time (less than 35 h per week), and a small number having been unemployed or looking for work when completing the survey (3.0%), as seen in Table 2. The most common career type (Table 2) in the sample was management, business, sales, and office occupations (37.9%), with education and research careers also noted as a predominant category (23.2%).

Three different physical attributes of the participants were measured by difficulty to help determine conditions which may affect the way participants interact with technology: vision, hearing, and touch. The participants were also asked if they used assistive devices to improve any of these senses (Table 3). A little over 10% of the sample used assistive devices to improve sight, hearing, or difficulty with touch. More than double of those participants using assistive devices were male. Difficulty with each sense (sight, hearing, touch) was measured using a Likert scale and the use of assistive technology in a yes/no format. The sample participants, on average (median), had slight difficulty with sight, slight difficulty with hearing, and little to no difficulty with touch.

Table 3. Physical difficulties with touch, hearing, and sight.

Variable	All Participants	Female	Male
Difficulty with Sight (median)	2—slight difficulty	2	2
Difficulty with Hearing (median)	2—slight difficulty	1	2
Difficulty with Touch (median)	1—little to no difficulty	1	1
Assistive Devices	22 (10.8%)	7	15

3.4. Measures

We began by conducting a thematic literature review through the university database and Google Scholar over the themes described in the original study (Pappas et al. 2019) and constraining research to that published between 2020 and 2023. Next, we reviewed the survey instrument and modified it to use as an online survey for a U.S. audience via Qualtrics (2020) software (Version March 2024, Qualtrics, Provo, UT, USA). An example of this is changing "civil center" and "province" into "urban" and "rural" surrounding areas. The modified survey instrument (Appendix A) consisted of 29 questions and an optional comment section for participants to add any additional knowledge or opinions

they felt relevant to the study or survey. The survey questions were divided into the original instrument categories:

- Demographic questions;
- Familiarization to technologies;
- Learning approach;
- Specifications to e-learning modules.

The structural validity of the original survey instrument was measured by the strength of correlation between individual results (Pappas et al. 2019) using Pearson's correlation coefficients for attitude toward technology, learning preferences, and e-learning in the original study. Internal reliability was calculated for the instrument using Cronbach's Alpha coefficient (0.926).

4. Results

The results of the survey were further examined in three different categories: familiarization with technology, learning preferences, and specifications to e-learning modules. The average, and standard deviation were considered for each variable, as well as the overall confidence or ability levels. The results provide insights into the technology usage patterns, learning preferences, and skill levels of the 203 respondents.

The data revealed a high level of internet and smartphone adoption, with over 95% using the internet daily and 96.6% owning a smartphone (Table 4). However, the time spent on various online activities varies, with finding information ranking highest and online shopping and banking ranking lowest (Table 5). The respondents expressed the greatest confidence in basic mobile application tasks like calling and texting, while games ranked lowest in confidence (Table 6).

When it comes to learning new technology skills, a strong preference emerges for visual demonstration, step-by-step instructions, and the use of examples and graphics. Interestingly, despite the high technology adoption, most respondents acquired their skills through self-teaching or workplace learning rather than formal courses. These findings paint a picture of a tech-savvy sample that is most comfortable with everyday applications and favors practical, visual learning approaches. Each category is examined in greater detail in the following sections.

Table 4. Technology available at home and participant's abilities assessed on a Likert scale.

Technology	Percent of Total	Participant Ability (Mean, SD)
Basic Cell Phone	42.4%	3.89, 1.03
Smartphone	96.6%	3.6, 0.864
Tablet	72.9%	3.31, 1.01
Desktop Computer	87.2% (or laptop)	3.54, 0.84
Internet	92.6%	3.6, 0.733
Laptop		3.48, 0.852

Table 5. Online activities ranked from top (1) to bottom (5) as most time to least time spent while using the internet.

Online Activities	Mean	Standard Deviation
Finding information	1.75	0.986
Communication	2.02	1.04
Entertainment	3.73	1.23
Shopping	3.78	0.876
Banking or forms	3.73	1.24

Table 6. Mobile phone application confidence using a Likert scale.

Applications	Mean	Standard Deviation
Average overall confidence	4.01	0.805
Calls	4.61	0.726
Video calling	3.78	1.20
Text messages	4.5	0.78
Web browsing	4.26	0.942
E-mail	4.42	0.86
Social media	3.63	1.17
Games	2.71	1.41
Alarm clock	4.25	1.16
Calculator	4.42	0.932
Reminders	3.77	1.34
Notes	3.67	1.33
Maps	4.06	1.06

4.1. Research Question 1: Familiarization with Technologies

All participants in this study had access to at least one type of technology at home and the majority had access to the internet (92.6%) and/or a smartphone (96.6%) at home (Table 4). The results also show that almost all participants had an email account (99%) and used search engines such as Google (99.5%).

Most participants ranked finding information as their number one activity online followed by communication, entertainment, paying bills, and online shopping (Table 5). When asked about their confidence in a variety of mobile applications, on average, the participants felt most confident using their mobile device for calling and least confident when using their device for game applications (Table 6). The majority of participants (85%) were confident using all hardware listed in the survey (keyboard, mouse, and touchscreen). On average, the participants felt they had moderate abilities in the use of all technologies assessed (Table 4).

The participants had a high average confidence while using mobile applications and had the most confidence in making phone calls (Table 6). The data suggest that communication-related features (Calls, Text Messages, and E-Mail) and basic utility features (Calculator, Web Browsing, and Alarm Clock) are the most frequently used, while entertainment-related features (Games and Social Media) have lower usage rates and higher variability among users.

When asked if they would be interested in learning to better use technology, 65% of participants answered yes, with most participants indicating their primary interest target being a computer or smartphone.

A chi-square test of independence was run to explore the impact of demographics (gender, education, residence, work status) on abilities of technology and confidence in internet use. Gender was not found to be impactful on any technology ability or confidence in the use of the internet. Education and current work status were also found to have no significant statistical impact on respondents' belief in their technology abilities or confidence while using the internet. However, the surrounding area of participants' residence was shown to have a statistically significant impact on their ability to use the internet ($x^2(4, N = 203) = 11.1$, $p < 0.026$). The United States has an average of 82.6% total population per state with internet coverage; the states in which at least half of the population has internet access have 64.9% coverage as of 2022 state data, as mentioned previously (US Census Bureau 2024). Lower internet access is often seen in more rural areas in the United States.

4.2. Research Question 2: Learning Approach and Specifications to E-Learning Module Preferences

In terms of interest in taking an online class, 61.5% of participants indicated a positive interest if the opportunity presented itself. Respondents to the survey, on average, felt that watching a demonstration or seeing visuals matched their learning style best (mean = 0.709, SD = 0.455), followed by reading instructions and information (mean = 0.399, SD = 0.491),

practicing and doing exercises (mean = 0.31, SD = 0.464), hands-on learning (mean = 0.281, SD = 0.45), and listening to instructions and information (mean = 0.212, SD = 0.41).

When asked about the specific importance of different e-learning approaches, the participants felt step-by-step instructions to be most important (mean = 3.94, SD = 0.821) and quizzes after lessons to be of least importance (mean = 2.93, SD = 1). The respondents felt that all features listed in the survey as specifications of e-learning modules would be useful in an online class (Table 7).

Table 7. E-Learning approach and delivery preferences.

E-Learning Approaches and Delivery	Mean	Standard Deviation
Personalized or self-directed lessons	3.28	0.935
Lesson groups by topic	3.48	0.886
Clear order of lesson	3.78	0.913
Step-by-step instructions	3.94	0.821
Activities after lessons	3.27	0.975
Questions during lessons	3.55	0.918
Seeing my scores quickly	3.45	1.02
Quizzes after lesson	2.93	1
Short and complete lessons	3.97	0.773
Examples	4.18	0.709
Describing key terms in a lesson	3.86	0.78
Using pictures and graphics	4.05	0.743
Video lessons	3.93	0.83
Revisiting work after each lesson	3.69	0.836

When prompted to include anything else they would like to see in an online course or would like to make additional comments about their technology or learning preferences, 46 participants provided comments. Of those 46 responses, 10 were a "no" or "none" type response. A constant comparative analysis of the remaining 36 responses yielded results in which seven themes emerged (Table 8).

Table 8. Additional Participant Feedback.

Themes	Frequencies	Quotes
Familiarity to technology		
Technological preferences and competence	3	"I am not an expert with technology, but I enjoy using it. I have learned to be less timid with it. When I have been able to watch a process and practice a process I feel more comfortable." "Stop treating 55+ like we don't understand tech. . .our generation built it."
Learning Preferences		
Personal interaction with instructors	10	"There needs to be some level of personal interaction, and the course instructor should be part of that. Just getting feedback from the machine is beyond irritating and the reason I have quit participating in classes in the past." "To be able to verbally communicate with the instructor if need be." "More people connection, meaning we should be able to ask questions to a person rather than fumble through FAQS from a computer."
Flexibility and accessibility	5	"I would like the ability to return to the online course (if it was recorded) to review areas of difficulty." "Flexible schedule and due dates for lessons." "Offer during different hours, evenings, afternoons, and days."
Engagement and feedback	3	"Must be engaging." "In courses that I have taken, the most important thing is timely feedback. An inattentive instructor ruins a class faster than poor graphics."

Table 8. *Cont.*

Themes	Frequencies	Quotes
Specifications to e-Learning Modules		
Course materials and prerequisites	5	"I prefer to receive materials electronically in advance of the class so I can take notes on the slides/handouts. I appreciate prerequisite suggestions to gauge course level." "EX: learning to place photos into text. Instructor explain, show examples from her own work, then offer individualized instruction and critiquing, suggestions, etc."
Interactive elements	4	"Perhaps an interactive critique of skills as you perform an exercise—like having an instructor looking over your shoulder." "Hands on practice." "Perhaps a method of interaction such as on the Zoom app where questions can be asked off to the side by typing such comments/questions for the moderator."
Cost and quality concerns	2	"You did not ask about the cost—that is an important factor. Also, there is the risk of not knowing the quality of the class before paying for it. Also, synchronous vs. asynchronous is an important factor." "An on-line course does not appeal to me at this time. I prefer to be in a class in person with a teacher and other people."

5. Discussion

The results of this work provide valuable insights into leveraging e-learning for aging populations, promoting cognitive health, and enhancing technology skills among older adults. By designing e-learning platforms with intention and a focus on accessibility, we can contribute to the overall quality of life and support active-aging initiatives.

The original survey created and applied in the study of 103 Greek adults aged 55+ found lower technology familiarity with smartphones and tablets versus computers. Most of those surveyed learned these technologies through self-study or family, with more highly educated and internet-confident participants preferring autonomous learning. When this survey was conducted in the U.S., technology familiarity was not correlated to education in a statistically significant way but instead tied to surrounding living areas (rural vs. urban).

Instructional design recommendations from the survey results included step-by-step content delivery, regular assessments, short and comprehensive modules, examples and graphics of learning concepts, explanatory videos to explain content or skills, and more tailored content based on education level for the initial study. The results from this study mimicked suggestions for examples, graphics, and explanatory videos as key components in e-learning modules.

This updated literature review reveals that many of the original findings on cognitive aging and technology adoption patterns persist today. However, new research also uncovers remaining gaps in understanding accessibility barriers and design needs across diverse global contexts. Major themes that emerge are the continued cognitive benefits of lifelong learning despite age-related decline, the persistence of lower technology familiarity among older adults, and preferences for constructivist learning approaches tailored to adult learners. However, limitations around generalizability point to the need for further research. Accessibility barriers like lower digital skills, physical impairment, and anxiety must be continually addressed in design.

The responses revealed a strong desire for interactive elements and personalized feedback specifically tailored to older adults. The participants were frustrated with automated feedback, emphasizing the need for real-time instructor involvement and immediate answers to questions. This suggests older learners value human interaction to reduce anxiety and enhance engagement. Flexibility in course structure, such as recorded sessions and adjustable schedules, was also important. The respondents noted the importance of

revisiting challenging materials and learning at their own pace. The survey highlighted the need for clear, step-by-step instructions and practical examples to cater to different levels of technological proficiency. These findings underscore the importance of designing e-learning environments that combine technology with human interaction, detailed guidance, and flexible learning paths to meet older adults' unique needs effectively.

Critical lingering gaps include a lack of contemporary insights from larger, more diverse samples of older adults worldwide. While preliminary recommendations can be made, additional research is imperative to create truly personalized, equitable e-learning for older populations. Future studies should utilize updated instruments to survey heterogeneous samples of older learners globally on their technology usage, attitudes, and learning needs. Participatory design methods that engage older adults in iterative refinement of platforms and instructional strategies are key to ensuring learner-centered e-learning.

6. Limitations

The lack of diversity in residential living may be a possible limitation when generalizing these findings for older adults who live in retirement communities or nursing homes. Additionally, only 3.0% of the participants were actively looking for work and unemployed, making the results limited when addressing those seeking education for employment. Because this survey was conducted online, there is an assumption to be made that those taking it have a higher level of technology familiarity and accessibility than the general population of 55 and over in the U.S. However, for the purposes of this study, in regard to lifelong learning design of e-modules, adults who were actively on the internet would be the primary audience.

7. Conclusions

By situating this research project within a learner analysis survey instrument that was designed specifically for the study of best e-learning practices for older adults, we are able to ground future iterations of courses and work in knowledge gleaned from the target participant demographics. The first step in this cyclical process is to gain knowledge of the target learning audience through the U.S. modified survey instrument. Future work will ground course development in the design considerations found through this survey and work with participants 55 and older to create e-learning opportunities that best suit the content needs and platform design of those learners.

Only through human-centered, evidence-based research can we achieve the goal of empowering older adults as capable lifelong learners with online education optimized to their strengths and preferences. This research demonstrates promising progress, but substantial work remains to fully transform online learning into an equitable, accessible space that promotes healthy cognitive aging across the lifespan.

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Appendix A. Survey Questions

1. Use the dropdown box to select your gender.
2. Which description is best suited to the area you live?
3. What is the highest degree or level of school you have completed?
4. What best describes your current residence?
5. Do you live alone?
6. Who do you currently live with?

   * *Question skipped if participant answers yes to 5*
7. Which of the following best describes your current work status?
8. During your career, which area best describes the type of work you have primarily held?
9. Do you use assistive devices (hearing aid, life alert, etc.)?
10. Which of the following technologies do you have regular access to or availability of? (Select all that apply)
11. Please rate the level of difficulty you experience with each of the following senses on a scale of 1 to 5: (Likert scale defined)
12. Please rate your proficiency in using the following devices on a scale of 1 to 5 (Likert scale further defined)
13. Are you interested in learning to better use any of these technologies?
14. Which of the following would you like to learn to better use? (Select all that apply.)

    * *Question skipped if participant answers no to 13*
15. Do you have someone to help you when you have questions while using technology?
16. How often do you use the internet?
17. How confident do you feel when you use the internet?
18. Thinking back, how did you learn to use internet-based technologies like computers, smartphones, and or tablets? (Select all that apply.)
19. Do you have an email account?
20. Have you ever used an electronic search engine such as Google or Bing?
21. Rank the following categories of online activities from 1 (most time spent) to 5 (least time spent) based on your personal internet usage:
22. How confident do you feel using the following mobile applications: (Likert scale defined)
23. How confident do you feel using the following devices: (Likert scale defined)
24. If you had the opportunity to take an online class to learn more about a hobby, skill, or topic you're interested in, how likely would you be to enroll in that class?
25. When it comes to learning new things, which description fits you best? (Select all that apply.)
26. If you did take an online class, how important would these features be for the way you prefer to learn? (Likert scale)
27. If you were attending an online class, decide how useful it would be for you to see each of the following in a lesson. (Likert scale)
28. Is there anything else you would like to see in an online course? Are there additional comments you would like to make about your technology or learning preferences? Add them here!

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