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"Alexa, how do I…?": Older adults learning to use digital home assistants

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Abstract

Background: Digital home assistants can support older adults with a range of daily activities and reduce their needs for support. These benefits are only possible if the older adults can successfully learn how to use them and maintain their use over time. Research is needed to explore older adults' perspectives on learning to use digital home assistants to uncover the factors that influence their experience.
Research aim: The purpose of this study was to explore the perspectives of older adults regarding the factors that impacted their experience learning to use digital home assistants.
Methods: Participants were 35 community-dwelling older adults between the ages of 60 and 81 who reported owning a digital home assistant. This mixed-method study included questionnaires (demographics, technology experience, mobile device proficiency, technology readiness, digital home assistant usage), and a semi-structured interview designed to explore participants' attitudes, experiences, and preferences for learning to use their device based on components from the Personalized Instruction and Continued Support (PICS) Framework (i.e., user profile, environmental characteristics, and technology characteristics; Blocker, 2022).
Results: Participants discussed facilitators and barriers related to their user profile (abilities, age, attitudes and motivations); environmental characteristics (stressors, learning environment, social support); and technology characteristics (complexity, novelty, usability). Perceived barriers included instructions not being designed for their age group, memory demands, stress and distraction, lack of social support, as well as technology novelty and complexity. Perceived facilitators included general technology proficiency; expectations from others; benefits of use; ease of use; learning efficiency and memorability; as well as satisfaction and enjoyment of use.
Conclusions: The findings highlighted the need to increase the availability of education and training to support older adults' use of smart home technologies. We have provided guidelines developed from the results to provide direction for the design of instructional protocols, including specifications for intelligent instructional software.

Keywords: digital home assistants, smart home technologies, aging, technology training, technology acceptance

Introduction

Maintaining functional independence is an important contributor to aging successfully and maintaining a high quality of life. Digital home assistant technologies can support older adults with a wide range of daily activities, including entertainment, exercise, health information-seeking and time management, as well as serving as a conversational partner and providing companionship (Blocker et al., 2023; Jakob, 2022; Jansons et al., 2022; Kang et al., 2024; Koon et al., 2020; Liu et al, 2023; Pradhan et al., 2019). These devices can alleviate societal pressures associated with care needs as people age. However, benefits are only possible if older adults can successfully learn how to use these technologies and maintain use over time.

Multiple studies have shown that older adults are able to use digital home assistants and find them useful, beneficial, and enjoyable (Blocker et al., 2023; Jakob, 2022; Kang et al., 2024; Liu et al, 2023; Orlofsky & Wozniak, 2022). Some studies reported that older adults perceived digital home assistants to be easy to use and have high usability. However, much of the work examining digital home assistants and older adults was research studies that included some type of training or support (e.g., manuals; Jakob, 2022; Kang et al., 2024). Little is known about older adults' experience setting up, learning to use, and continually using digital home assistants outside of a research study, including what, if any, resources are available to support them. Digital home assistants are mostly purchased by or gifted to older adults for personal use (Orlofsky & Wozniak, 2022). They typically do not come with professional training and support beyond the included setup and basic use instructions.

Resources available to support the initial and long-term use of a technology or system are referred to as facilitating conditions in the technology acceptance literature (e.g., Chen & Chan, 2014; Venkatesh et al., 2012). Such resources are essential in supporting users in understanding the technology and its capabilities, as well as providing effective and reliable means of assistance when needed. Facilitating conditions include the instructions that come with a newly purchased product, as well as factors such as basic knowledge, available help, financial resources, accessibility, and social influences. Facilitating conditions have a direct relationship with attitudes toward technology, which in turn influence actual use (Chen & Chan, 2014).

Various factors can act as barriers or facilitators in the context of older adults learning to use technology. The research to date has primarily focused on design principles for instructional materials (e.g., style and content) and instructional protocols for older adults. For example, the materials should be accessible (e.g., sufficient-sized font and contrast), free of distracting and irrelevant information (e.g., Fan & Truong, 2018; Zwick, 2012), and presented in smaller, more concise, and explicit steps (Czaja & Sharit, 2012) to facilitate older users. Moreover, leveraging task-relevant knowledge to associate with the novel information regarding using the technology can lead to more effective learning outcomes (e.g., Lee & Coughlin, 2015; Zwick, 2012).

Regarding instructional protocols, self-paced learning is preferred and is correlated with improved learning outcomes for older adults (Beier, Teachout, & Cox, 2012; Botwinick, 2013; Callahan, Kiker, & Cross, 2003). Time to explore the technology on their own (e.g., Pang et al., 2021; Tsai et al., 2019) benefits learning and well as the opportunity to practice using it with ample support and feedback (Delahaye & Erlich, 2008; Lin, 2020; Tsai, Shillair, & Cotten, 2017). The feedback should be timely and introduce opportunities for learning from errors to understand what and why an error occurred (Czaja & Sharit, 2012). These recommendations reflect general age-related support characteristics for technology learning. Given that many technologies are not designed with older users in mind, it is possible that manufacturers' instructions that come with digital home assistants do not meet these recommendations. Furthermore, general guidelines for designing instruction and support overlook individualized and personal support needs that may vary from one older adult to another.

Older adults' perceived lack of available support is one of the primary barriers expressed in the context of technology adoption and learning (Chen & Chan, 2013; Hunsaker et al., 2019). Additionally, this perceived need may be influenced by their past experiences with attempting to use a technology, as older adults require about four times as much support in initial learning as do younger adults (Wolfson, Cavanagh, & Kraiger, 2014; Zandri & Charness, 1989). An integral aspect of facilitating conditions is "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003, p. 453). Even if some supports exist, such as an adult child, the older adult may not access them because they do not want to be a burden (Orlofsky & Wozniak, 2022).

The purpose of this study was to explore older adults' perceptions of the factors that influenced their experience when learning to use digital home assistants, including barriers and facilitators. To do so, we must understand the context of older adults' use of digital home assistants as well as their perceptions about their experiences learning to use digital home assistants. Blocker (2022) identified factors relevant to older adults' learning to use technologies and integrated the findings into a comprehensive conceptual framework. The Personalized Instruction and Continued Support (PICS) Framework (see *Figure 1*) synthesized literature across all the domains of aging, learning, motivation, and technology adoption. The framework provides direction for assessing older adults' perceptions about their experiences learning to use to use technologies, contextualizing the factors that may act as barriers and facilitators. In particular, the framework provides guidance for examining older adults' perceptions about their 'Individual Supportive Needs' and 'Personalized Support Preferences', regarding if and how these factors create facilitating conditions.

To address the goal of exploring the context of older adults' use of digital home assistants and their perceptions of barriers and facilitators of learning to use digital home assistants in the context of the PICS framework, we aimed to answer the following research questions:

1) What are older adults' digital home assistant experiences and learning methods?
2) When learning to use digital home assistants, what are older adults' perceptions of the factors that influenced their experience related to the User Profile, Environmental Characteristics, and Technology Characteristics from the PICS Framework?

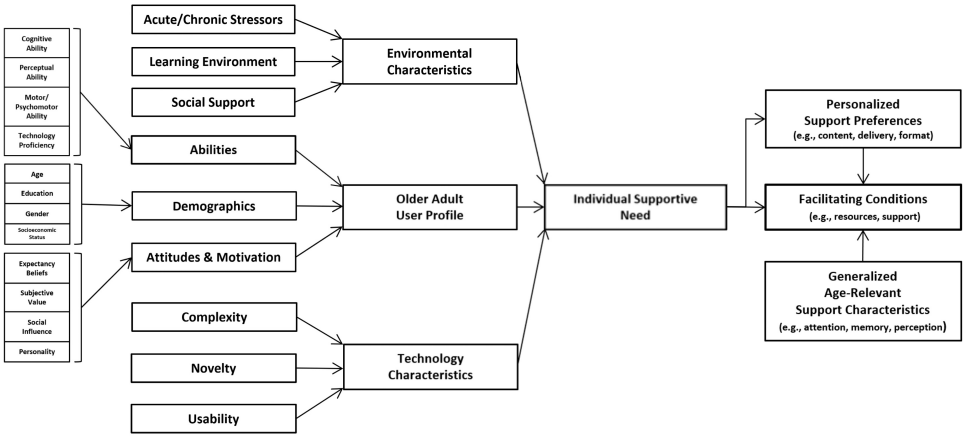

Figure 1. Personalized Instruction and Continued Support (PICS) Framework

3) What are older adults' personalized support preferences?

Methods

Participants

Participants were 35 community-dwelling older adults between the ages of 60 and 81 (see Table 1 for additional descriptives assessed by the TechSAge Background Questionnaire; Remillard et al., 2020). For qualitative studies it is both recommended and common to include samples of at least 25-30 individuals for proper data saturation (Fusch & Ness, 2015). Additional details are provided in Blocker (2022); we focus here on a subset of the background data. This study was approved by the Institutional Review Board Office for Protection of Research Subjects at the University of Illinois, Urbana-Champaign.

Recruitment materials (emails, flyers) were distributed via local and national research partners of the Human Factors and Aging Laboratory at the University of Illinois Urbana-Champaign, including the TechSAge (TechSAgeRERC.org) participant registry. Recruitment venues included senior living communities, public libraries, life-long living programs, senior centers, and the University of Illinois Urbana-Champaign's Extension Services. Facebook advertisements were used to recruit older adults throughout the United States as interviews were conducted remotely.

To be eligible for the study, participants must have been 60 years of age or older and fluent in English. Participants were screened to exclude individuals with cognitive impairment using the Modified Telephone Interview of Cognitive Status (TICS-M; score ≥ 22; de Jager, Budge, & Clarke, 2003). Participants were required to own a digital home assistant device, without specification of a particular brand (e.g., Amazon, Apple, Google) or device type (e.g., smart speaker or smart display with speaker). Due to the constraints of the COVID-19 pandemic, the data collection was done remotely using teleconference software (Zoom, with a backup OneClick.chat teleconference room in case of Zoom technical issues). Thus, participants had to be able to use a computer, tablet, or smartphone that included at least a microphone, and preferably a video camera, to facilitate a more naturalistic conversation. In addition, participants consented to the recording of the study session to allow for automated transcription of the audio using dedicated software (Otter.ai transcription software, available at https://otter.ai).

Materials

Questionnaires (see *Table 2*) were used to assess participants' technology experience, proficiency, and attitudes. In addition, we evaluated the breadth of their experience using digital home assistants.

The semi-structured interview was guided by the Personalized Initial and Continued Support (PICS) Framework for Older Adult Technology Use (Blocker, 2022) and designed to assess older adults' perceptions about the factors that impacted their experience learning to use digital home assistants. The interview script comprised 70 questions exploring participants' attitudes, experiences, and preferences for learning to use their digital home assistant. *Table 3* presents the major PICS Framework components (environmental characteristics, older adult user profile, technology characteristics) along with example interview questions. Additional interview questions pertained to other contextual themes, including acquisition, usage, learning, and expectations related to their DHA, attitudes toward

Table 1. Participant characteristics

		Frequency	%
Gender	Female	26	74.3
	Male	9	25.7
Race/ethnicity			
	White/Caucasian	34	97.1
	Black/African American	1	2.9
Education			
	High school graduate/equivalent	2	5.7
	Vocational training	3	8.6
	Some college/associate's degree	6	17.1
	Bachelor's degree	10	28.6
	Master's degree	11	31.4
	Doctoral degree	3	8.6
Living situation			
	Spouse/partner	21	60.0
	Alone	12	34.3
	Other	2	6.0
Health status (self-reported)			
	Fair	7	20.0
	Good	14	40.0
	Very good	11	31.4
	Excellent	3	8.6
Memory status (self-reported)			
	Poor	1	
	Fair	5	2.9
	Good	19	14.3
	Very good	8	54.3
	Excellent	2	22.9
Serious difficulty seeing, even when wearing glasses or contact lenses			
	Yes	5	
	No	30	
Serious difficulty hearing, even when wearing a hearing aid			
	Yes	3	
	No	32	
Serious difficulty walking or climbing stairs			
	Yes	7	
	No	26	
	Unable to walk	2	

personalized support, and perceptions about the effectiveness of personalized support (full interview script and study protocol available upon request). Iterations of the interview and its contents were pilot tested with undergraduates, subject matter experts in aging and technology use, as well as older adults meeting the study criteria. See Blocker (2022) for additional details and measures.

Procedure

Participants' eligibility was assessed via a brief telephone screening, and if eligible, they were scheduled for a videoconference interview; participants were provided instructions on how to use Zoom if needed. At the start of the interview session, the assessor acquired informed consent and administered the Technology Experience Questionnaire (Barg-Walkow et al., 2014) and the Technology Readiness Index 2.0 (Parasuraman & Colby, 2015) using Research Electronic Data Capture (REDCap; https://www.projectredcap.org). Participants were provided an optional break and then the semi-structured interview began. The interview was recorded via the Zoom meeting record feature. Once the interview was completed, the recording was stopped, and another break was offered. The assessor then administered the Mobile Device Proficiency Questionnaire (Roque & Boot, 2018) and the Digital Home Assistant Usage Survey (adapted from Koon et al., 2020). Participants were debriefed and compensated after their participation. The interview took approximately one hour to complete.

Results

Quantitative data: technology experience and proficiency

The results of the measures assessing technology experience, proficiency, and readiness are presented in *Table 2*. Regarding older adults' experience with various contemporary technologies over the past year, they reported having used, on average, a majority of the technologies over the past year. The use frequency of these devices, however, was more limited. They had a high, yet variable, mobile device proficiency score and a moderate technology readiness score, suggesting that they had a general understanding of how to perform most actions on a smartphone and an openness to technology. Regarding digital home assistant usage, the sample had a moderate general breadth score. Thus, our sample was not under- or over-experienced with the various features of the device and representative of an average user.

Qualitative data: digital home assistant experience and learning factors

We used a combination of conceptually-driven and data-driven qualitative analysis methods (e.g., Bradley et al., 2007; Braun & Clarke, 2006). As such, the coding scheme was guided by the literature and the PICS Framework (coding scheme available upon request), as well as emerging themes from the interview data. Segments were defined as an entire response to a question. All relevant codes were applied to each segment (i.e., a segment could have multiple codes) using MaxQDA, a qualitative mixed methods analysis software. An iterative approach was used to achieve coding reliability between two researchers of 87% using Cohen's Kappa statistic (Cohen, 1960). The researchers coded a transcript independently, compared results, discussed any coding discrepancies, and revised coding definitions, if necessary. After

Table 2. Technology use measures and results (N=35)

Measure	Purpose	Reference	Scoring	M	SD
Technology Experience Profile (TEP)	Assess experience with 36 different technologies within the last year	Barg-Walkow et al. (2014)	Number of technologies: Range = 0 - 36 (Higher score represents higher experience)	26.20	5.15
			Frequency of use: Range = 1 - 3 (Higher score represents higher use frequency)	1.88	0.41
Mobile Device Proficiency Questionnaire (MDPQ)	Measure mobile device use and perceived difficulty of use	Roque & Boot, (2018)	Range = 8-40 (Higher score represents higher proficiency)	34.27	6.70
Technology Readiness Index 2.0 (TRI 2.0)	Measure propensity to adopt technology	Parasuraman & Colby (2015)	Range: 1-5, Higher score represents higher technology readiness	2.96	0.99
Digital Home Assistant Usage Survey	Assess digital home assistant usage and perceived difficulty of use	Adapted from Koon et al. (2020)	Range = 0-15 (Higher score equals more breadth of digital home assistant feature use)	7.49	3.16

acceptable reliability was achieved, interview transcripts were split between the two researchers to allow for a more efficient analysis of the interview content.

Data were organized based on the components of the PICS Framework. A summary of the main themes related to digital home assistant experience and each PICS component is presented in *Table 4*.

Digital home assistant experience

To understand the context of older adults' experience using digital home assistants, we asked participants what devices they owned and primarily used, how they acquired the devices, how frequently they used them, and for what types of activities. If participants mentioned owning more than one digital home assistant, we asked them to focus during the interview on their first device given we were interested in their initial learning experience.

Digital assistant ownership and acquisition

The most common device, owned by over half of the sample, was the Amazon Echo Dot, a small smart speaker and one of the more affordable within this class of devices. Second to the Dot was the Amazon Echo Show, a digital home assistant that includes a smart display that complements the smart speaker functionality, which was owned by about one-quarter of participants. Other devices that participants reported owning, in descending order, included the Google Nest Mini (i.e., Google's product similar to the Amazon Echo Dot), the Amazon Echo smart speaker, the Apple HomePod, and the Google Nest Hub (i.e., Google's product similar to the Amazon Echo Show). Overall, Amazon devices represented over 85% of the devices owned by the older adults within the sample (30/35 total devices), reflecting findings from previous research as well as the market share of these devices within the general population (e.g., Kinsella, 2018; Koon et al., 2020). Most participants reported receiving their devices as gifts from another party (63%), such as a family member. The remaining participants came to own the device after personally deciding to purchase it for themselves. Most participants owned their digital home assistants for over two years (37%), followed by 1-2 years (31%), between six months and one year (17%), and less than six months (14%). Most participants (83%) reported using their devices at least once a day, with the remaining participants using them at least once a week. Consequently, the participants were experienced and active users of their digital home assistant.

Uses of digital assistants

When asked what they liked most about their digital home assistants, participants reported using it for a range of activities including quickly searching for information, playing music, setting alarms, timers, and reminders, the capability to connect and control other smart technologies within their environment, playing games, general productivity/organization (e.g., lists), receiving notifications or informative updates, social engagement (i.e., either interpersonally or with the device itself as a conversational partner), and security.

Learning methods and difficulties

Participants expressed using one of three primary methods to learn to use their device. These were, in descending order of endorsement, trial and error (34%), using the instructional materials that came with the device (31%), and social support/instruction (23%). Nearly 40% of participants mentioned encountering at least one difficulty learning their device, mostly stemming from a lack of understanding how the device is supposed to be operated or used (77%). As one participant stated, "The hardest thing is to remember to say 'Alexa', before we do anything… took a little time." The remaining participants mentioned experiencing technical issues that inhibited their learning process or described having issues with the usability of the supportive resources they were provided for learning. One participant shared that "[it was] somewhat difficult to get it set up. Primarily because the website wasn't fully accessible." About 85% of participants expressed encountering learning difficulties with their digital home assistant that could be linked directly to either a problematic learning infrastructure or a perceived inability to effectively or comprehensively learn their device.

Table 3. Framework components and associated examples of interview questions

Framework components	Example questions
Environmental characteristics	
Acute and chronic stressors	Sometimes, it can be difficult to learn something new or focus on a task if other important things are going on in your life, especially if those things are stressful. How do you remember feeling at the time you were learning your [DEVICE]? If feeling stressed/distracted: do you think this impacted your learning in any way? Why or why not?
Learning environment	Where did you first set up your [DEVICE]? Would you say that this was a good place for you to learn your [DEVICE]? If so: what about this place made it good for learning the device? If not: why do you think this was not a good place to learn the device?
Social support	Did anyone help you with the initial setup? If yes: who was it? Do you like having someone around when learning how to use new technologies like this? Why or why not? If not: would you have preferred to have someone there? If yes: who would you have preferred to help you? Why would you like them there? If no: why not? Did someone help you with learning your [DEVICE]? If so: who was it and how did they help?
Older adult user profile	
Abilities	Let's talk about some different abilities that might be important for learning and whether you think they played a role for you when learning your [DEVICE]. First is vision - did your vision impact learning to use the device for you? (parallel questions were asked for hearing, touch, dexterity, response speed, memory, and comprehension)
Demographics	Did you ever feel like the instructional materials or support that came with your [DEVICE] were biased in any way against you? In other words, do you think this support was not made for someone like you, specifically?
Attitudes and motivation	Think about your favorite things about your [DEVICE]. What comes to mind? In the same vein, what are your least favorite things about it? When you first got your [DEVICE], was setting it up and learning how to use it a priority for you? If so: why did you consider it a priority? If not: why did you not consider it a priority? Did you think the [DEVICE] was going to be a positive or negative addition to your life?
Technology characteristics	
Complexity	Before you first started setting up your [DEVICE] and getting familiar with it, how complex did you think it was? Do you think your opinion on how complex the [DEVICE] was before using it affected the level of instructional support you thought you would need to effectively set it up and learn how to use it?
Novelty	Do you feel like your previous technology experience helped you learn to use your digital home assistant in any way? Why or why not?
Usability	Overall, did you find the [DEVICE] easy to learn initially? Why or why not? What about over time? Have you found it to be easy to use as you have continued using the [DEVICE]?

Learning factors

We explored participants' perceptions of the learning factors they experienced when learning to use their digital home assistants, organized by the high-level components of the PICS framework: User Profile, Environmental Characteristics, and Technology Characteristics. Given the size of the sample, we focus here on variables that at least one-third of the sample felt impacted their learning to use a digital home assistant.

User profile

Participants perceived that multiple aspects of their user profile affected their learning to use a digital home assistant.

Demographics

The only demographic variable that participants perceived to influence their learning was age. About 40% of participants stated that they perceived that the instructional materials were not designed for older adults (i.e., biased regarding age).

Abilities

With respect to abilities, some participants (40%) perceived that one aspect of their cognitive ability in particular (i.e., memory), impacted their learning to use their digital home assistant. Their primary reason was that they needed to remember the procedure to use and operate the device. Participants perceived that their sensory-perceptual abilities influenced their learning. Almost half of the participants felt that their vision impacted their learning. Most described the importance of their vision for reading or seeing the instructional information presented to them during their learning experience (e.g., device instructions, visual display), and a general need to use their vision for device operation. When asked about the potential role that hearing played in their learning, almost half (43%) of the participants felt it had, with reasons involving needing to hear the instructional information or prompts that the device provided them during setup and learning, as well as a general need to hear to interact with the device. Most participants (over 85%) stated that they believed themselves to be technologically proficient, and 80% of those believed that the learning of their digital home assistant benefited from their general technology proficiency. The reasons provided were mostly related to a perceived sense of confidence that resulted from their previous technology successes, followed by a perception that their past positive experiences informed them of effective learning procedures, and lastly, that the knowledge they had gained from other technologies was directly applicable to using their digital home assistant.

Attitudes and motivation

Participants felt that attitudes and motivation, such as expectancy beliefs, subjective value (e.g., enjoyment, intrinsic value, utility value), and social influence, impacted learning to use their digital home assistant.

Regarding expectancy beliefs, almost two-thirds of the participants expressed that they were confident at the time of initial learning, whereas the remaining participants – about 35% – held either mixed or a notable lack of confidence toward their perceived ability to learn their new digital home assistant. Those who identified themselves as being confident described how this sense of confidence mostly came from prior knowledge or experience with digital home assistants. Most participants who felt they lacked confidence when they were learning to use their digital home assistant felt this belief affected

Table 4. Digital home assistant experience and learning factors from the PICS framework

	Digital home assistant experience
	Most common device, owned by over half of the sample, was the Amazon Echo Dot, followed by Amazon Echo Show. Most received their devices as gifts (63%). Most owned their digital home assistants for a year or more (68%). Most reported using their devices at least once a day (83%). Uses included searching for information, playing music, setting alarms, timers, and reminders, connecting and controlling other smart technologies within their environment, playing games, general productivity/organization (e.g., lists), receiving notifications or informative updates, social engagement and security. Trial and error (34%), using the instructional materials that came with the device (31%), and social support/instruction (23%) were the most common learning methods.
	Learning factors
User profile	
Demographics	40% stated that the instructional materials were not designed for older adults (i.e., biased regarding age).
Abilities	40% stated that their cognitive ability (i.e., memory) impacted their learning. 42% stated that their vision impacted their learning. 43% stated that their hearing impacted their learning. Over 85% identified themselves as technologically proficient and 80% of those believed that the learning of their digital home assistant benefitted from their technology proficiency.
Attitudes and motivations	66% expressed that they were confident at the time of initial learning; the remaining participants held either mixed or a notable lack of confidence in their ability to learn their new digital home assistant. Most participants reflected feeling positive about the newly acquired technology (e.g., about 40% stating they were 'happy' or 'excited') and nearly all reported enjoying the learning process overall. Over 60% expressed that they considered setting up and learning the device to be a priority for them. Most (about 83%) expressed that the digital home assistant would have an eventual positive impact on their life enabling searching for information, supporting productivity or organization, entertainment like games or music, controlling smart technologies, supporting social engagement, and security and safety features. 86% perceived that those who gifted them the device expected them to use it often.
Environmental characteristics	40% expressed feeling at least somewhat stressed or distracted when learning to use their devices, most feeling that that stress influenced their learning. Most participants set their digital home assistant up in either their living room (37%) or the kitchen (29%), and stated the location benefited learning. Most mentioned that they learned the device on their own, with fewer than 50% receiving social support (e.g., from spouses or significant others, friends).
Technology characteristics	51% expressed that their perception of the device's complexity influenced their learning, such as how much support they needed. 51% expressed that the novelty of the device played a contributing role to their learning to use the device. 90% expressed initial ease of use. 80% considered the continual learning process easy, following their initial learning. 89% stated that they considered their interactions with the device to be efficient. 94% reported high memorability for how to use the device. Over three-quarters of participants expressed not encountering technology errors. All 35 participants responded that learning how to use and using the device was satisfying, mostly due to the benefits and convenience that their device brought them.

their learning. We asked them what could have helped to address their lack of confidence, and their responses included a desire for additional and/or improved instructional support, more knowledge about the device they were learning, and access to social support. In sum, participants perceived that positive and negative expectancy beliefs both impacted learning, the former as a facilitator and the latter as an impediment.

Participants reported that their subjective value influenced their learning in terms of enjoyment, intrinsic value, and utility value. Most participants reflected feeling positive about the newly acquired technology (e.g., about 40% stating they were 'happy' or 'excited') and described the learning process as worthwhile, given the benefit they expected to receive from learning to use it. Moreover, nearly all reported enjoying the learning process overall. Over 60% expressed that they considered setting up and learning the device to be a priority for them. The primary reasons participants provided for their high enjoyment, subjective value, and utility value were that the learning process itself was generally entertaining, that they enjoyed the benefits they were getting from learning to use it and expected to continue to receive once they gained competency in using it, as well as because the process was simple or easy to do. In fact, most (about 83%) expressed that the digital home assistant would have an eventual positive impact on their life, enabling searching for information, supporting productivity or organization, entertainment like games or music, controlling smart technologies, supporting social engagement, and security and safety features. Social influence was discussed in the context of the expectations that those who gave them the device may have had regarding their usage. The majority perceived that those who gifted them the device expected them to use it often (86%).

In sum, the user profile factors that participants felt impacted their learning to use their digital home assistant included cognitive ability (i.e., memory), sensory-perceptual abilities (i.e., vision, hearing), technology proficiency, as well as attitudes and motivations (i.e., social influence, expectancy beliefs, and subjective value). Some (40%) expressed feeling at least somewhat stressed or distracted when learning, stating that those feelings influenced their learning of the device. Other user characteristic emergent themes were that participants desired a variety of methods and approaches to learning, and that they would like personalized instructions focused on their needs such as advanced uses or specific desired actions or uses. Nevertheless, in general, they expressed barriers to receiving this type of support, such as a general lack of availability.

Environmental characteristics

Participants perceived that the environmental characteristics, such as the physical environment and presence of acute or chronic stressors (e.g., poor health), influenced their learning.

Acute/chronic stressors

Some participants (40%) expressed feeling at least somewhat stressed or distracted when learning to use their device. Of these participants, over 60% felt that it influenced their learn-

ing. One participant shared that the learning process itself contributed stress, stating, "Yes. I think that it probably did impact [my learning] because the stress made me feel dumb at the beginning. I wasn't really able to focus…and it made me feel worse about what kind of things I didn't know because of it."

Learning environment
Most participants set their digital home assistant up in either their living room (37%) or the kitchen (29%), with other locations including their bedroom, office or dedicated workspace, and bathroom. Nearly all participants expressed that the location they chose was considered good for learning (e.g., allowed the device to be easily accessible for them to use and visible).

Social support
Social support was expressed as affecting participants' learning to use the digital home assistant. We asked participants about their living situation to evaluate whether others resided with them during their learning. Nearly 70% were living with others at the time, all of whom were family members, such as their significant others or other relatives (e.g., children or grandchildren). The remaining 11 participants lived alone. We asked participants about whether they recalled receiving any form of social support with their digital home assistant setup. Fewer than 50% received social support with this process (e.g., from spouses or significant others, friends), whereas the remaining participants mentioned that they learned the device on their own.

Technology characteristics
We asked participants about technology characteristics that may have impacted their learning, including complexity, novelty, and usability (i.e., learnability, efficiency, memorability, errors, and satisfaction).

Complexity
Approximately 40% of participants said they initially considered their digital home assistant to be a complex technology. Just over half of the participants (51%) expressed that their perception of the device's complexity influenced their learning, such as how much support they needed.

Novelty
Just over half said they had some knowledge of the general features and/or characteristics of digital home assistants (51%) but the remaining participants stated that they only had a high-level or general awareness only of the device's existence (i.e., no specific understanding of what the device did), that they knew little or nothing about these devices, or had only known about the potential privacy/security concerns commonly associated with them (e.g., "always listening"). Over half of the participants expressed that the novelty of the device played a contributing role (51%) to their learning to use the device. Some felt the novelty was a negative influence on their learning expectations, such as "I…was overwhelmed. I was confused. I didn't even think it came with a lot of instructions." Alternatively, some felt that the novelty had provided them with an informative yet neutral perspective on the device's setup and learning needs, and some felt it gave them a more positive perspective relevant to their anticipated learning needs.

Usability
Participants expressed that their perception of the device's usability (i.e., learnability, efficiency, memorability, errors, and satisfaction) impacted their learning. Nearly all (90%) participants expressed initial ease of use. They described the process as simple and needing little effort and expressed that the voice interface facilitated the learning process. As one participant shared, "Because you didn't really have to press any buttons…You just had to speak to her. I think it was easier than I thought." To gain a longitudinal perspective on their learning (i.e., whether they considered that the device was easy to learn over time), we asked participants to reflect on this continued experience. Most participants (80%) still considered the process easy following their initial learning, primarily due to the device working as they expected or desired, and "You learn to phrase questions in a manner that it'll give you the right response." For those who did not perceive the learning to be easy over time, the primary reasons included encountering issues and/or obstacles that arose with continued use, challenges with remembering relevant use information, that the issues they encountered initially were unchanged or unresolved with time, and that the increased complexity of additional features they desired to learn increased the difficulty they experienced toward learning them. In sum, most participants held high opinions regarding the learnability of their digital home assistant, both initially and over time. For the few participants who did not perceive the technology as having high learnability, nearly all the reasons they provided were obstacles that could be overcome with additional support for that individual.

The second usability subcomponent was that of efficiency, that is, the performance of desired tasks with little effort. We asked participants to reflect on whether they believed that their learning experience with their device could be consid-

ered efficient. A majority (89%) stated that they did consider their interactions as such, with only four participants stating they did not feel like they could perform the tasks they wanted to with little effort while learning the device. For those who felt that the learning process was efficient, their reasons included that the learning was simple; that increased experience then led to a sense of increased efficiency; and that the learning process was efficient in allowing them to start and stop learning as needed. The participants who did not perceive it as efficient felt that way because they thought it was a complicated or challenging process. As observed for the learnability subcomponent, most participants perceived their digital home assistant learning to be an efficient process, whereas those who did not described a reason that could have been overcome with additional support that reduced the challenges and complications they experienced.

The third subcomponent of usability we evaluated was memorability. We asked the participants to reflect on how easy they perceived correctly remembering how to use their digital home assistant to be during learning. Nearly all participants (94%) reported high memorability, attributed to a variety of reasons. For example, participants mentioned the habitual or continued experience with the device, the simplicity of the device, and the voice interface having facilitated their interactions. As one participant stated, "I mean, you just kind of talk to it and if it doesn't understand, you rephrase it and go on from there."

The fourth aspect of usability was related to encountering errors during the use of the system. We first asked participants to reflect specifically on whether they made or encountered what they considered to be errors when using their digital home assistant. Over three-quarters of participants expressed not encountering such issues. For those who did, the errors were related to communicating or interacting with the device and the device not working as expected, such as "When she can't pick up my diction sometimes, why she'll say something that seems pretty far afield."

The final aspect of usability that we assessed was satisfaction. We asked participants whether they found learning how to use their device to be satisfying or pleasant. Notably, all 35 participants responded that they did indeed perceive learning how to use and using the device to be satisfying, mostly due to the benefits and convenience that learning to use their device brought them. As one participant stated, "Immediate gratification. I ask for something and it's…extremely satisfying." and another shared "Now living alone, sometimes it's nice just to hear another voice." These findings, similar to their enjoyment when learning to use the device, portrayed a near-universal positivity regarding participants' satisfaction with interacting with digital home assistants. Not only did the participants appear to take pleasure in interacting with these devices to a substantial degree, but this usability component may facilitate initial and continued use of the system. This enjoyability should be leveraged in helping users gain initial competency with and continued use of digital home assistants. Overall, across all five usability subcomponents (i.e., learnability, efficiency, memorability, errors, and satisfaction), older adults found digital home assistants to be a class of technology with generally high usability. Those who did experience challenges almost universally expressed issues that could have been alleviated with specific instructional support.

Personalized support preferences

We asked participants to imagine their perfect, personal learning environment. The aspect most identified by participants was a learning space considered to be quiet, isolated, or private. Participants desired a location that would allow the device to be easily accessible, one in which instructional support would be readily available, and where social support was accessible. Almost half of the participants expressed a desire for social support for learning (49%), with the remaining participants stating they did not. Those not preferring social support explained that they had a general confidence in their own abilities to get the task done; a general/unspecified preference to do such tasks on their own; the ability to more effectively pace the task when setting it up on their own; or a personal understanding that they could get such support if it became necessary. Nevertheless, when asked if they would like social support that was personalized to them, over 70% responded positively.

Discussion

Digital home assistants have the potential to support older adults in their everyday activities and help them maintain their independence (Orlofsky & Wozniak, 2022). However, these benefits are only possible if older adults can successfully learn how to use these technologies and maintain this use over time. Given the growing aging population, it is critical that we explore ways to increase the adoption of digital home assistant technologies. Challenges when learning to use devices can pose a barrier to adoption. Facilitating conditions, related to education and training, can help older adults overcome these challenges. The results provided insights into the factors that impact older adults when learning to use

digital home assistants and highlighted what older adults perceive to be facilitating conditions during learning.

Even though participants reported that digital home assistants were relatively easy to learn to use, they did not perceive that instructional materials were designed for their age. In addition, many felt their learning was impacted by age-related declines in response speed, memory, hearing, and vision, which indeed can pose learning barriers (Sharit & Czaja, 2020). Declines in response speed may cause older adults to have difficulty formulating or verbalizing a response quickly enough, leading their digital home assistant to time out or misunderstand the command. Memory declines may reduce older adults' ability to recall specific commands (e.g., "Alexa, add bread to my shopping list"). Hearing difficulties, especially for high-frequency sounds, may cause older adults to miss key parts of responses or audio tones (e.g., timers). Even though these devices are voice-activated, declines in vision could impact older adults' ability to set them up with their phones (e.g., small icons and text on phones) and adjust the settings (e.g., privacy). These interaction challenges can reduce older adults' confidence in the device and lead to repeated requests or abandonment. Making educational information accessible (e.g., font size, contrast) and allowing supportive information to be available at all steps of the learning process, with as few navigational steps as possible, can help to compensate for age-related declines in speed, memory, hearing, and vision.

Some participants expressed feeling stress and distraction when learning, which are factors known to impede learning (Vogel & Schwabe, 2016; Weeks & Hasher, 2014). Making educational information accessible and providing ongoing support may reduce anxiety and improve self-efficacy because the older user knows where to turn when needed (for a review of such design considerations, see Czaja & Sharit, 2012). In these ways the support may encourage help seeking. Further, the older adults in our study and in others (e.g., Orlofsky & Wozniak, 2022) only used their digital home assistant for a subset of the tasks for which it can support. Education and training should review a wide spectrum of relevant functionality and features, as well as the basic tasks.

Nevertheless, almost all participants reported feelings of satisfaction and enjoyment from using their digital home assistant. Most participants expressed that the digital home assistant benefited their everyday lives and felt they had the general technology proficiency to enable them to learn to use it. They also perceived digital home assistants to have high learning efficiency and memorability. Despite some facilitators to learning, most participants still had desires for additional support.

Participants expressed a desire for a variety of methods and approaches to learning, and most expressed a preference for personalized learning support; that is, instructions specific to their needs. For example, they desired training for their level of experience as well as for the types of activities and functions they were specifically interested in. This finding is consistent with other research showing older adults' complex and diverse preferences for approaching learning in other contexts (Betts, Hill, & Gardner, 2019; Delahaye & Ehrich, 2008; Hunsaker et al., 2019). Having practice focused on topics of personal interest would also benefit learning. Compared to the approach they used to learn to use their digital home assistant most participants stated that a personalized approach would be more effective and easier to use. Moreover, many participants felt social support would facilitate their learning. Therefore, such personalized support should offer avenues of social support that older adults can turn to when desired, either from professional sources or through facilitating support from their personal network.

One possible solution for personalized training is intelligent instructional software, which holds great potential for new and continuous learning, as well as assistance over the lifespan (Jevtić et al., 2018; Pollack, 2005; Woolf et al., 2013; Tsiourti et al., 2016; Umbrico, Cesta, Cortellessa, & Orlandini, 2020). Personalized learning and the utilization of intelligent instructional agents allows for multiple facilitating conditions, including self-pacing and social support, and has been shown to be effective in enhancing learning outcomes, individual satisfaction, motivation for continued engagement, and improved perceptions of self-efficacy (Shi, Revithis, & Chen, 2002; Swartout et al., 2013; Wang et al., 2014; Xu, Huang, Wang, & Heales, 2014). Moreover, initial findings have shown that some older adults perceive intelligent virtual agents as useful, effective, and viewed positively (e.g., Bickmore, Caruso, Clough-Gorr, & Heeren, 2005; Martin-Hammond, Vemireddy, & Rao, 2019; Mihailidis, Boger, Craig, & Hoey, 2008; O'Brien, Liggett, Ramirez-Zohfeld, Sunkara, & Lindquist, 2020).

The Personalized Initial and Continued Support (PICS) Framework for Older Adult Technology Use (see *Figure 1*) was used as a guide for assessing the potential variables relevant to facili-

tating conditions for older adults learning to use a digital home assistant. Our results revealed strong qualitative support for nearly all components and subcomponents in the framework. Future research is needed to pursue this line of research further using a quantitative methodology to explore the relative impact and strength of various components for older adults learning to use digital home assistants. In addition, there is a need to expand on these findings by assessing the relevance of the PICS framework in other contexts, with other technologies, and with other populations.

Future research should further investigate older adults' longitudinal use of digital home assistants and use post-pandemic. This study took place during the COVID-19 pandemic. The pandemic, with its associated periods of social isolation, may have encouraged greater use of digital home assistants to access information, entertainment, and even provide a type of social interaction. In one study, older adults reported that they adopted new technology to connect with others since the beginning of the pandemic (Haase et al., 2021). Alternatively, the pandemic may have hindered the adoption and use of digital home assistants, particularly among individuals with limited prior experience with these types of technologies and for those who lacked in-person support from family and friends.

Of course, there are limitations to the present study, not the least of which is that the participants had all successfully learned to use their digital home assistant and had continued to use it over time. That might imply that they are early adopters (see Rogers, 2003), although their score on the TRI 2.0 was in the mid-range. Still, there are a large number of older adults with less technology experience who would be expected to encounter more challenges in learning to use a digital home assistant and may be impacted to a greater degree by barriers such as stressors, attitudes, and motivation, complexity, novelty, and usability. These challenges, along with our findings that participants 1) did not find instructional materials to be designed for their age, and 2) reported only modest amounts of social support during learning, could preclude older adults with minimal technology experience from adopting digital home assistants altogether. In this study, older adults reported that their general technology experience benefited their initial learning of the digital home assistant. In that same way, interventions to teach those with less technology experience about more ubiquitous technologies (e.g., cell phones) could benefit them when learning more advanced technologies. Likewise, gaining general technology experience may improve older adults' ability to learn broader classes of emerging technologies, not only by improving their understanding of how to use technology but also by facilitating their expectancy beliefs.

Although an appropriate sample size for this type of study (Fusch & Ness, 2015), 35 is nonetheless not fully representative of older adults and their technology experiences. In addition, our interview approach relied on the participants' memory about their experiences initially learning how to use their digital home assistant and might be influenced by their current use success, thereby underrepresenting their initial learning difficulties. Despite these limitations, the results provided valuable insights into the learning process for older adults using a technology that is relatively novel to them; their interest and willingness to learn (counter to stereotypes); and their experiences to guide recommendations for facilitating conditions that can ease adoption for broader groups of older adults.

Conclusion

The findings from this study provided guidance for education and training support. They point to the crucial need to increase the availability of education and training to support older adults' use of technologies such as digital home assistants, and provide clear direction for education and training:

- Use previous technology experience as scaffolding by making explicit parallels when they exist (e.g., if a person has experience using Siri on an iPhone, the parallels can be made as to how Alexa works similarly).
- Help users find activities and functions that they find enjoyable to facilitate learning.
- Make support available as needed for when users encounter challenges during ongoing use.
- Encourage continued experience with the device, such as daily practice.
- Provide a variety of methods and approaches to learning.
- Design materials and methods with consideration for age-related changes (e.g., memory, vision, and hearing).
- Take advantage of factors such as expectancy beliefs and subjective value by showcasing scenarios in which other older users use their digital home assistant or experience satisfaction, enjoyment, and benefits from such use.
- Strive for supportive learning environments, avoiding stress and interruptions.
- Include options for social support, such as learning in groups or pairs.
- Offer personalized instruction when possible, such as training focused on different levels (novice, advanced) as well as on different applica-

tions of interest (e.g., leisure, health, and medical). By following these guidelines, older adults can more easily learn how to use digital home assistants and other novel technologies, thereby facilitating adoption of these technologies to support their preferences for where they age and for engaging in the activities they value.

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Note. Kenneth Blocker currently works at John Deere.

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