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Older adults' experience with and barriers to learning new technology: A focus group study

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Abstract

Background: Technology can be defined as any electronic device, digital service, or digital system that has been designed and developed to serve particular functions. Although these technologies can benefit older adults through their everyday activities, older adults have more difficulty than younger individuals in using and learning to use new technology. Moreover, people with different levels of technology experience may have different learning experiences. Experienced users are expected to have a better understanding of new technologies and more efficient ways of learning.
Objective: Therefore, when designing technologies for older adults, it is important to consider the barriers that older adults could encounter, the methods they can use to overcome the barriers, as well as the different needs among older adults with varied technology experiences.
Method: In this study, 40 participants were categorized into four technology experience levels based on their scores in the Technology Experience Profile. A total of eight focus group sessions, two sessions for each technology experience level, five participants in each session, were conducted.
Results: The focus group data provided insights into older adults' learning experiences by identifying older adults' attitudes toward learning new technology, learning barriers, learning method preferences, and their initial learning processes. The main findings from the thematic analysis implied that compared with older adults with a higher level of technology experience, older adults with a lower level of technology experience had fewer positive attitudes and more barriers to learning new technology. The learning barriers reported by the experienced participants were mostly associated with their learning method preferences as well as their starting points of the learning process.
Conclusion: Older adults with different levels of technology experience preferred different learning methods and encountered different learning barriers to some extent. When designing for older adults, designers should consider not only the age-related differences, but from the individual user characteristics.

Keywords: Learning process, older adults, focus group, technology experience, user experience

Background

In current product design and user interface and user experience (UI/UX) fields, the concept of technology can be generally defined as any electronic device (e.g., smartphone), digital service (e.g., social media), or digital system (e.g., voice command). Technology is prevalent in people's everyday life, especially among older adults (i.e., aged 65 and over). The range of technologies encountered in the daily lives of older adults is extensive (Czaja, Boot, Charness, & Rogers, 2019). Studies indicated that older adults who had adopted new technologies described their feelings as "keeping pace with the modern world," and not "being left behind" (Hill, Betts, & Gardner, 2015; Richardson, Zorn, & Weaver, 2002). Moreover, technology usage among older adults is growing faster than any other age group (Cotten et al., 2016). For example, the use of Facebook has grown fastest among older generations (Vogels, 2019). As for mobile device ownership, 68% of Baby Boomers and 40% of members of the Silent Generation owned a smartphone; and 52% of Baby Boomers and 33% of the Silent Generation reported that they owned tablets (Vogels, 2019).

Although the use of social media and digital devices among older adults is increasing, the use of technology by older adults is still lower than that of younger age groups to some extent. For example, older adults were much less likely than young adults to have high-speed Internet connections (Charness, Fox, & Mitchum, 2011). A study indicated that older adults' technology usage was limited to communication or searching for information about community, health, news, and travel (Olson, O'Brien, Rogers, & Charness, 2011). Technology adoption was associated with users' physical ability (e.g., vision, hearing ability, motor skills), cognitive ability (e.g., reaction

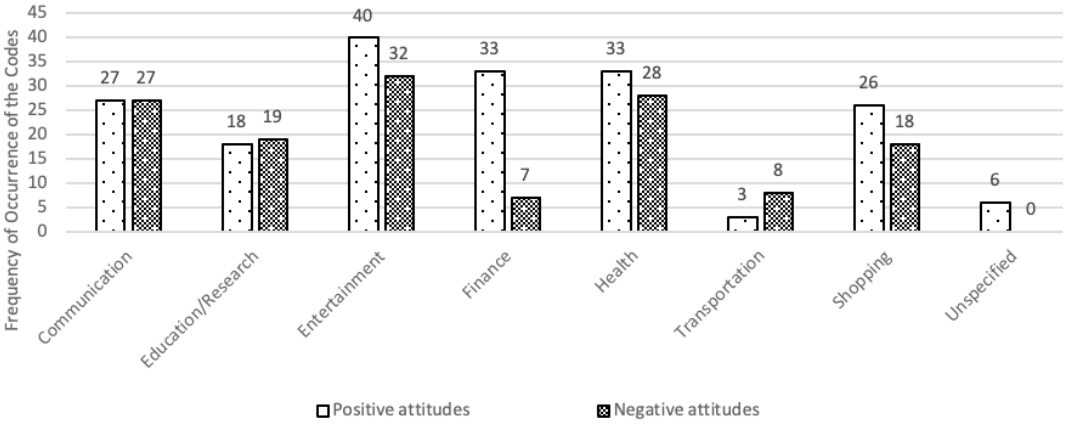

Figure 1. Distribution of frequency counts of the themes in subcategories "positive attitudes" and "negative attitudes".

time, processing speed, working memory), and pervious technology experience (e.g., first-timer vs. returning user) (Lee & Coughlin, 2015; Wang, Chen, & Chen, 2017). A study suggest that older adults experience greater difficulty than young adults when learning to use new technologies (Barnard, Bradley, Hodgson, & Lloyd, 2013). The decline of physical and cognitive abilities with aging can contribute to the barriers to and difficulties in interacting with technology. Other factors have also been recognized: (1) Familiarity with new technology (Turner, Turner, & Van de Walle, 2007; Wilkinson, Langdon, & Clarkson, 2010); (2) Attitudes toward technology (Broady, Chan, & Caputi, 2010); (3) Anxiety in learning new technology (Birdi, Pennington, & Zapf, 1997); (4) Self-efficacy in learning new technology (Tsai, Shillair, Cotten, Winstead, & Yost, 2015); and 5) Product usability (Chun & Patterson, 2012; Page, 2014). However, by providing appropriate learning methods, some of the frustration could be eliminated (Mitzner et al., 2008; Martínez-Alcalá et al., 2019). For example, older adults have a strong preference for self-training by reading manuals and other printed instructions as well as for hands-on learning through trial and error (Mitzner et al., 2008).

In terms of investigating older adults' experience with learning new technology, most of the studies were focused on understanding the age-related differences in learning technologies. Also, given that new technologies are commonly perceived as products for younger people, many studies conducted cross-sectional experiments to see how age-related differences affect task performances. Some studies indicated that older adults could experience difficulties during the learning process due to the lack of technology experience. It is well known that technology experiences play an important role in the human-computer interaction area. Technology experience affect users' task performances. A study found that experience using digital cameras similar to the digital cameras used in the experiment helped participants complete the tasks more quickly, more intuitively, and with fewer errors (Blackler, Popovic, & Mahar, 2010). Technology experience is also an important factor that affects people's attitudes and feelings toward new technology. Additionally, many studies indicated that attitudes (e.g., technology acceptance), anxiety, and self-efficacy (e.g., level of confidence) are to some extent all interconnected with each other (Holzinger, Searle, & Wer-

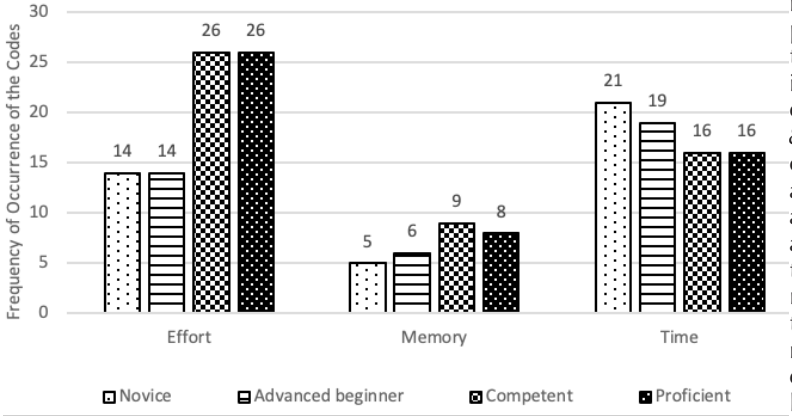

Figure 2. Distribution of frequency counts for the subthemes "effort," "memory," and "time" under the positive attitudes in four technology experience groups.

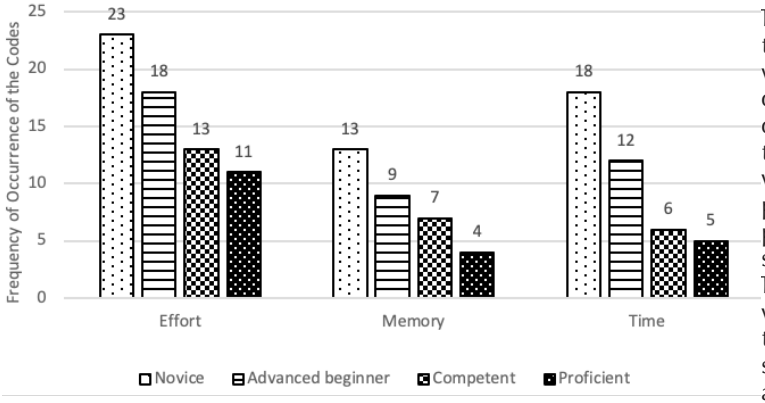

Figure 3. Distribution of frequency counts for the subthemes "effort," "memory," and "time" under the negative attitudes in four technology experience groups.

nbacher, 2011; Renaud & Van Biljon, 2008).

When people are thinking about older adults, the common notion is that they are all alike. However, older adults can be extremely diverse in many dimensions (Czaja et al., 2019). When considering design for older adults, it is essential to focus on the similarities that allow the optimization of the design. Individual differences also need to be addressed in order to determine whom the design can and cannot accommodate. There is a research gap in studying older adult users with varying levels of technology experience. Although some studies focused on the differences between novice and expert in learning new technology, most of them only included young adults (or teenagers) as participants (Lazonder, Biemans, & Wopereis, 2000; Ziefle & Bay, 2004; Blackler et al., 2010; Holzinger et al., 2011). Therefore, this research focused on highlighting technology experience differences among older adult users.

To address the research gap, the goal of this research was to answer the research question of what are the differences in learning new technologies for older adults with different technology experiences? A qualitative approach was chosen as the research method for this study. This approach is appropriate when the research goal is to make sense of complex situations or processes, learn about the experiences of participants, or gain an in-depth understanding of a phenomenon (Groat & Wang, 2013; Creswell, 2017).

Research aim

Proper attention to design could eliminate much of the frustration and barriers for older adult users in learning new technology. Moreover, older adults could become interested in using and have a desire to learn to use technology if they see the relevance of it to their lives, and appropriate learning methods are provided. When studying methods for improving the learnability of new technology, learning experiences, opinions, and attitudes toward learning new technologies are important factors. To better understand the experience with and barriers to learning new technologies among older adults, this study aimed to explore the technology learning processes among older adults with different levels of technology experience. The purpose of this study was to answer the research question while using focus groups as the primary data collection method. The study was approved by the Institutional Review Board (IRB). Data included in this article were gathered from a total of eight focus

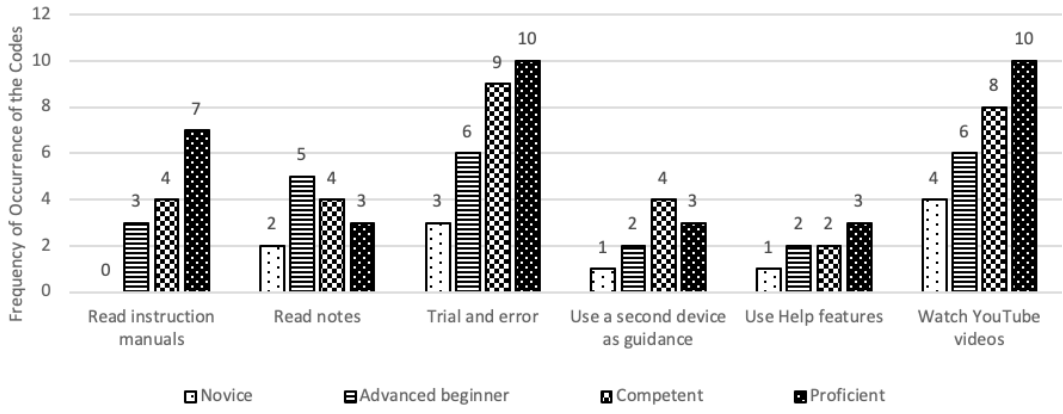

Figure 4. Distribution of frequency counts for the subtheme "learning alone" in four technology experience groups.

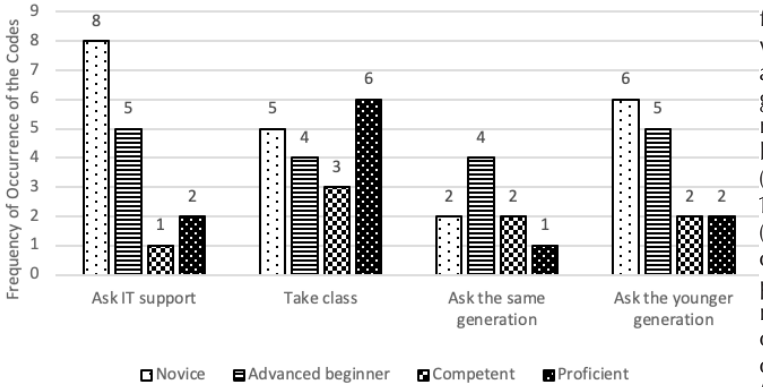

Figure 5. Distribution of frequency counts for the subthemes "learning from domain experts" and "learning from family/friends" in four technology experience groups.

groups conducted in local senior centers and senior communities. Each focus group consisted of five participants of similar technology experience. To address the aforementioned research aim, the focus group topics included: older adults' attitudes toward learning new technology, starting points of the learning process, learning barriers and difficulties, learning methods, and their opinions about different learning methods.

Method

Screening test

A Technology Experience Profile (TEP) was used as a screening test to categorize individuals into different technology experience levels. It can assess an individual's use and familiarity with various technologies (e.g., communication, computer, transportation, recreation) (Barg-Walkow, Mitzner, & Rogers, 2014). To ensure the technology experience differences among the participants in each level, individuals within the following TEP score ranges were eligible to be recruited and participate in the focus group: (1) Novice (score range 36-54); (2) Advanced beginner (score range 72-90); (3) competent (score range 108-126); and (4) Proficient (score range 144-162). These criteria did not apply to the pilot tests (as detailed in the next section). The age criterion for this study was 65 and older. After the score sorting from 104 TEP responses, a total of 40 older adults (23 females and 17 males) aged 65-87 years (M = 71.13, SD = 5.43) were recruited for this study (see *Figure S1* and *Table S1* for participant characteristics). Each technology experience level consisted of ten participants.

Pilot tests

Prior to the focus group sessions, two pilot sessions were conducted to test the structure of the focus group, as well as to ensure the understanding and comprehension of the discussion topics among the participants. The first pilot group consisted of five older adults with a similar level of technology experience (TEP score ranged from 91-126). The second pilot group consisted of five older adults in the opposite TEP scores range (two participants scored below 72, and three participants scored above 162). Based on the pilot results, the first pilot group came up with more topic-related discussions. In contrast, fewer topic-related discussions were generated from the second pilot group. Moreover, some

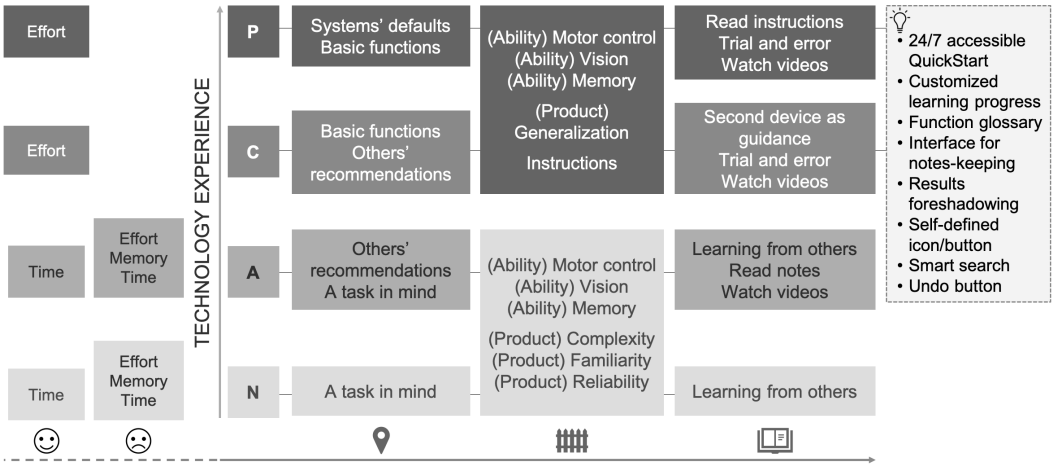

Figure 6. A synthesized older adults' learning processes based on the findings from the focus group discussions. (N: participants in the novice group; A: Participants in the advanced beginner group; C: Participants in the competent group; P: Participants in the proficient group).

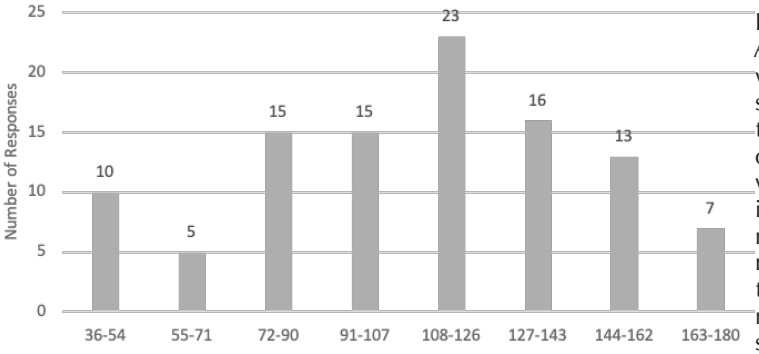

Figure S1. The number of responses in each technology experience profile (TEP) score range (n = 104).

of the participants were frustrated and got distracted by some of the discussion in the second pilot test. For example, jargon mentioned by the experienced participants were not understood by the participants with a lower level of technology experience. Therefore, more time had been spent on explanation and terminologies clarification. In order to both gain individual and shared perspectives as well as eliminate unrelated discussions that may be brought up by the technology experience differences, participants in each session were purposefully chosen and arranged. Only the participants in the same technology experience level (i.e., same TEP score range) were scheduled in the same focus group session.

Focus groups

A total of eight focus groups, with five participants in each session, were conducted in this study. At the beginning of each session, participants were asked to review the informed consent while the moderator/researcher summarized the general goals of the study and explained the rules for the discussion (e.g., speak one at a time, contribute own experiences). After collecting all the signed informed consent, the moderator started the audio-recording, and the session began. The moderator of the focus group was a Ph.D. student with a background in design research. During the focus group session, three main topics were discussed, including attitudes toward learning new technology, barriers/difficulties in learning processes, and learning methods. In addition to the audio recording, the moderator also took written notes during the discussion. Each focus group session lasted 90-100 minutes. At the end of each session, the participant received a $15 gift card as compensation for participation.

Data analysis

Audio files recorded during the focus group sessions were transcribed verbatim into Microsoft

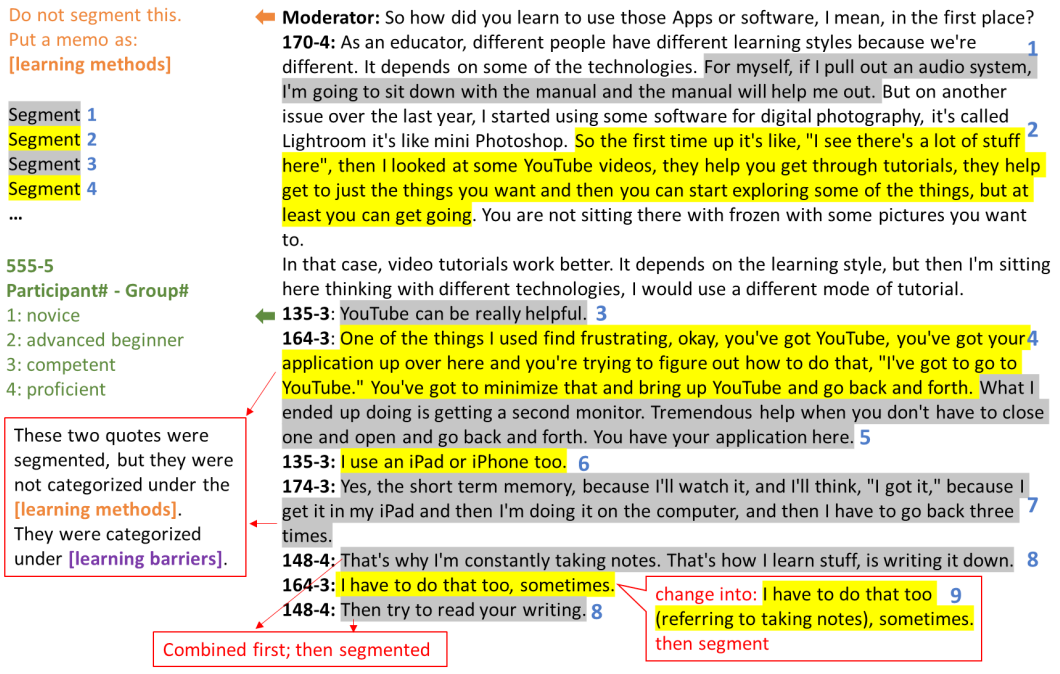

Figure S2. Example of segment scheme for focus group transcripts.

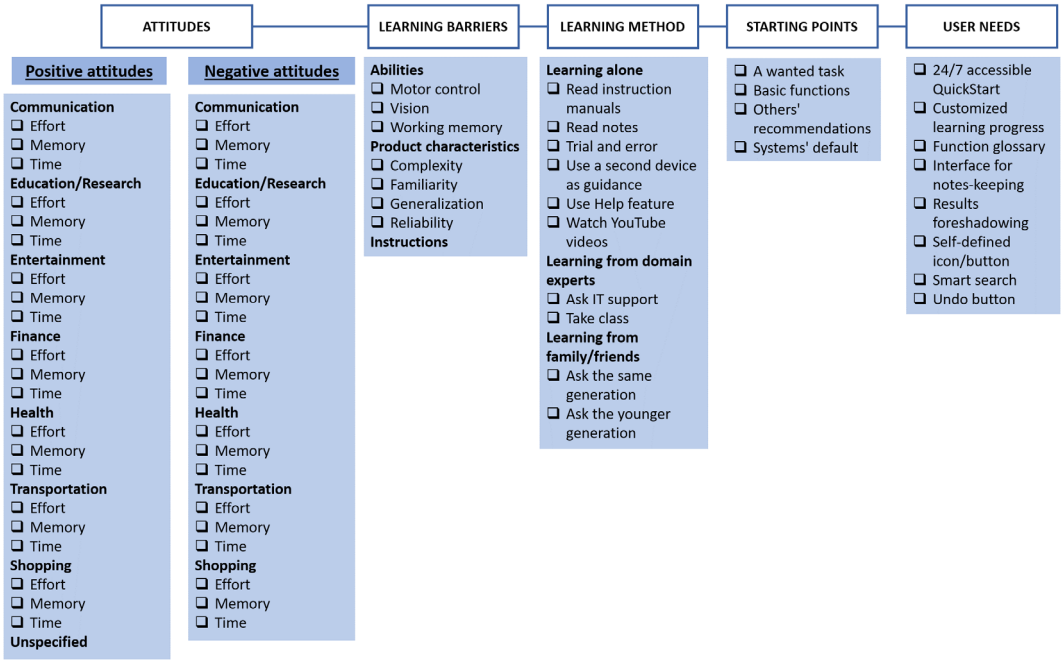

Figure S3. Overview of all categories and themes/subthemes in the thematic coding system of the focus group transcripts.

Word documents by professional transcriptionists. Transcripts were proofread and segmented into categories/subcategories, and then coded using MAXQDA 2018 (a qualitative data analysis software package) by the researcher (see *Tables S2* and *S3*, and *Figure S2* for the segment and coding scheme). Five categories were identified among all segments: (1) attitudes, (2) learning barriers, (3) learning methods, (4) starting points, and (5) user needs (see Figure S3 in the Supplementary Files for the overview of all categories and themes). After the thematic coding process, the frequency of occurrence of the codes under each theme (and subtheme) was calculated (see *Tables S4-S9* for the distribution of codes). All frequency counts for each code were sorted by the technology experience groups.

Results

Attitudes

Two subcategories were coded under the attitudes toward learning new technology: positive attitudes and negative attitudes (see *Tables S4* and *S5* for the distribution of codes). There were, overall, a greater reported number of positive attitudes toward learning new technology (total = 186) than negative attitudes toward learning new technology (total = 139).

For positive attitudes toward learning new technology, the novice group had the lowest frequency counts (frequency count = 37), while the proficient group had the highest frequency counts (frequency count = 62). A trend was identified as the frequency counts of codes regarding positive attitudes increased with the level of technology experience. For negative attitudes toward learning new technology, the novice group had the highest frequency counts (frequency count = 54), while the proficient group had the lowest frequency counts (frequency count = 20). A trend was identified as the frequency counts of codes regarding negative attitudes decreased with the level of technology experience.

A total of eight themes were identified under the two subcategories (*Figure 1*). Seven out of eight themes were the different activities that technologies can support, including communication, education/research, entertainment, finance, health, shopping, and transportation. For participants' attitudes that didn't direct to any specific activity, they were coded under the theme unspecified.

Among all the themes under the positive attitudes, entertainment had the highest frequency counts, while transportation had the lowest frequency counts. Among all the themes under the negative attitudes, technologies related to entertainment had the highest frequency counts, while finance had the lowest frequency counts.

Furthermore, themes related to the different activities that technologies can support were coded with three subthemes, including effort, memory, and time. The coding scheme was based on the

reason that participants mentioned when they were discussing their attitudes toward learning a specific type of new technology.

Among the three subthemes under the subcategory positive attitudes, the subtheme effort had the highest frequency counts (frequency count = 80), while the subtheme memory had the lowest frequency counts (frequency count = 28). The same results also showed in the frequencies counts of the codes regarding three subthemes under the subcategory negative attitudes, with subtheme effort had the highest frequency counts (frequency count = 65) and the subtheme memory had the lowest frequency counts (frequency count = 33).

Among four technology experience groups, differences were identified in the distribution of frequency counts for the three subthemes under both subcategories (*Figures 2* and *3*). For positive attitudes, the frequency counts of codes in subtheme effort increased with the level of technology experience. Moreover, the frequency counts of codes in subtheme time decreased with the level of technology experience. For negative attitudes, the frequency counts of the codes in all three subthemes decreased with the level of technology experience in all three subthemes.

Learning barriers

Three themes and seven subthemes were identified under the category of learning barriers (see *Table S6* for the distribution of codes): (1) abilities (subthemes: motor control, vision, working memory); (2) product characteristics (subthemes: complexity, familiarity, generalization, reliability); and (3) instructions. Among all three themes, product characteristics had the highest frequency counts (frequency count = 86), while instructions had the lowest frequency counts (frequency count = 13).

The four groups had similar frequencies counts for the codes regarding theme abilities. Three subthemes were identified, including (1) motor control (e.g., *"Some of it is so tiny and -- I've got big fingers"*), (2) vision (e.g., *"my vision is not good enough to notice oops it's not at the right place"*), and (3) working memory (e.g., *"…because I'll watch it, and I'll think, "I got it," because I get it in my iPad and then I'm doing it on the computer, and then I have to go back three times"*).

The distributions of four subthemes under the theme product characteristic were different among the four groups. Participants in the novice group had the most learning barriers regarding subthemes complexity, familiarity, and reliability among the four groups. As a total of 31 codes regarding the theme product characteristic were identified among participants in the novice group, 13 were coded under the subtheme complexity (e.g., *"the instruction said that 'click over here, and click here, and click here' and the next sentence is, 'if you don't like clicking, you can do this with the keyboard'. There were too many alternatives"*). In contrast, a total of four codes regarding complexity were identified among participants in the competent group and proficient group (both groups only had two frequency counts). A trend was identified as the frequency counts of code complexity decreased with the level of technology experience.

The opposite trends were identified as the frequency counts of codes regarding subthemes familiarity (e.g., *"Sending an attachment is not something that I feel familiar with at all"*) and reliability (e.g., *"every time I tried that, it crashed."*) decreased with the level of technology experience. But the differences among the four groups under these two themes were not distinct.

Under the theme instructions, the novice group had the lowest number of frequency counts (frequency count = 2), while the competent group had the highest number of frequency counts (frequency counts = 5). Some of the participants in the competent group and proficient group commented that they often encountered difficulties as the instructions or Help features were not clear enough as they were trying to do some troubleshooting by themselves.

Learning methods

Three themes were identified under the learning methods category (see *Table S7* for the distribution of codes): learning alone, learning from domain experts, and learning form family/friends. Among all three themes, learning alone had the highest frequency counts (frequency count = 102), while learning from family/friends had the lowest frequency counts (frequency count = 24).

Under the theme learning alone, a trend was identified as the frequency counts of codes in subthemes read instruction manuals, trial, and error, and watch YouTube videos increased with the level of technology experience (*Figure 4*).

Under the theme learning from domain experts, two subthemes were identified, including ask IT support (e.g., *"I went to the Verizon store at... The salespeople in there were very helpful."*) and take class (e.g., *"I learned how to send emails on my cell and all the things about the calendar in that tech-class as well."*) (*Figure 5*). The novice group had the highest frequency counts of the codes ask IT support (frequency counts = 9). In contrast, ask IT support was coded one time in the competent group and two times in the pro-

ficient group. Moreover, the competent group had the lowest frequency count of the code take class (frequency counts = 3). This subtheme was coded five times in the novice group and six times in the proficient group.

Under the theme learning from family/friends, two subthemes were identified, including ask family/friends from same generation (e.g., *"My wife is more knowledgeable than I am. She helps me figure it out."*) and ask the family/friends from younger generation (e.g., *"I FaceTime with my granddaughter. She went through all the steps for me."*). The advanced beginner group had the highest frequency counts of the codes regarding asking the same generation (frequency counts = 4). This subtheme was coded two times in the novice group and the competent group, and one time in the proficient group. Moreover, the novice group and advanced beginner group both had a higher frequency counts of the codes regarding asking the younger generation (frequency counts six and five, respectively). This subtheme was coded two times in the competent group and the proficient group (*Figure 5*).

Starting points

A starting point refers to the factor that leads the participants to perform their first task (or act) when they started their new technology learning process. Four themes were identified under the category of starting points (see *Table S8* for the distribution of codes), including a wanted task (e.g., *"I normally just did that one thing that I want to do"*), basic functions (e.g., *"I just started from some basic functions"*), others' recommendations (e.g., *"someone said to me 'have you tried this?', then I will try"*), and systems' default (e.g., *"I go to the 'Settings' first. And if there is anything I want to change or anything that I am not familiar with, then…"*). Among all four themes, others' recommendations had the highest frequency counts (frequency count = 19), while systems' default had the lowest frequency counts (frequency count = 7).

Differences were identified between technology experience groups. For theme a wanted task, the frequency counts decreased with the level of technology experience. The opposite trend was identified in theme systems' default, where the frequencies of codes decreased with the level of technology experience. The competent group and proficient group both had a higher frequency counts of the codes regarding basic functions (frequency counts four and three, respectively), while the novice group and the advanced beginner group both had a lower frequency counts (frequency counts one and two, respectively). Four technology experience groups had a similar frequency counts of the codes regarding others' recommendations.

User needs

Only participants in the competent group and the proficient group made comments in this category (see *Table S9* for the distribution of codes). During the discussions, some of the participants commented that they would like to have a jargon *"glossary"*, so that *"the functionality would be a little more clear"*. Moreover, some of the participants mentioned that they want to have an *"undo (button)"* for everything so that they can *"go back to the beginning (before everything got messed up)"*.

Additional findings

Some of the comments made during the focus groups were not segmented since they did not pertain to the learning process. Instead, the comments were more toward the aspects regarding anxiety and technology acceptance. For example, participants in the novice group were commenting that IT supports was "very expensive." In addition, security concerns were mentioned frequently by participants across all groups. Concerning security about malware/virus, safety of password management software, and privacy of health information via online portals.

Conclusions

This focus group study investigated the differences in learning new technologies for older adults with different levels of technology experience. A clear conclusion drawn from this study was that the technology experience effected many aspects of learning experience and learning process. This finding was consistent with some of the conclusions in the literature mentioned earlier (Lazonder et al., 2000; Ziefle & Bay, 2004). *Figure 6* presented a synthesized older adults' learning process based on the findings from the focus group discussions.

Five categories regarding older adults' new technology learning processes were included in the figure. They were (from left to right) positive and negative attitudes toward learning new technology, the initial point for the learning process, barriers to learning, learning method preferences, and user needs. For attitudes, initial starting points, learning barriers, and learning methods, items listed in the figure were the ones that had the highest frequency counts. User needs that were discussed during the focus groups were listed as additional insights.

Attitudes

For attitudes toward learning new technology, older adults with a lower level of technology experience had fewer positive attitudes toward learning new technology than older adults with a higher level of technology experience, especially for the aspect of effort. For example, some

of the experienced participants commented that they considered learning new technology to be a smooth and relatively easy process as it doesn't require much effort. Furthermore, older adults with a lower level of technology experience had more negative attitudes toward learning new technology than older adults with a higher level of technology experience. For example, due to the lack of technology experience, many participants in the novice group commented that learning new technology was exhausting and time-consuming, as well as increasing their anxiety. They also said that many technologies were providing too much information (or too many functions) to remember.

Learning barriers

For barriers to learning new technology, the lower level of technology experience groups reported more barriers than the higher level of technology experience groups regarding product complexity. Participants in novice and advanced beginner groups frequently mentioned that a system has "too many buttons," and they got confused very easily. The opposite trends were discovered regarding the product generalization, where the higher level of technology experience groups reported more barriers than the lower level of technology experience groups. This may be due to product generalization usually associated with the similarity (or difference) across different technologies. Only older adults who had experiences in using many different technologies could make comments on this aspect.

Learning barriers and learning methods

Furthermore, learning barriers reported by experienced older adults can be associated with their learning method preferences. For example, problems with instructions were mostly reported by experienced older adults. Individuals were more likely to learn by themselves when they were at a relatively higher level of technology experience. As user manuals or quick starters are common tools to use for people who want to learn and explore the technology by themselves, problems regarding the instructions could be pointed out by them more often.

Starting points

Differences in the starting points of the learning process were identified among four technology experience groups. Many novices commented that they did not try to start to learn technology just because there were functions or features provided to them. However, proficient older adults preferred to see what the product can provide and what's the similarity between the new technology and the technology they have already learned. At the beginning of the learning process, some of the participants commented that they usually started from the things listed on systems' default to see all the settings in order to be familiar with the product.

Starting points and learning methods

In addition, the novice older adults commented that they preferred to start with a task that they had in mind at the beginning of their learning process. This finding can be linked to the learning method preferences where the novices least preferred in reading manuals and using Help features. In contrast, they preferred learning from domain experts and learning from family/friends. Studies suggested that instructional materials for novices should be presented in a step-by-step procedural format (Mayhorn, Stronge, McLaughlin, & Rogers, 2004; Gerjets, Scheiter, Catrambone, 2004). Combining the findings from the focus group; therefore, when designing for a better learning experience, it is important to consider the user characteristics of novice older adults. For instance, a task-oriented, jargon-free interactive tutorial might facilitate novice users' initial learning process.

Additional findings

Participants in the novice group mentioned that they had financial concerns related to learning new technology. This finding was consistent with previous research, indicating that older adults with less technology experience have more negative attitudes and concerns toward technology (Broady, Chan, & Caputi, 2010). Moreover, participants from all groups frequently mentioned their concerns regarding the security of using new technology (e.g., information privacy, malware, password safety, etc.). Those discussions were not part of older adults' technology learning processes. Instead, the comments were more toward the aspects of anxiety and technology acceptance. These aspects can be considered as potential directions for future studies.

Designing for older adults

One of the goals for the UI/UX design process is to think about what the design makes users feel. Designing for a better technology learning experience is essential for creating positive experiences for users from different experience levels and in varied abilities. The stereotype may mislead designers to perceive older adults as a single cohort. However, older adults can be very diverse in terms of their physical ability, cognitive abilities, as well as their previous technology experience. When designing for older adults, designers should consider all the aspects, not only from the age-related differences but from the individual user characteristics among older adults. Based on the findings from this research, participants with different levels of technology experience preferred different learning methods

and encounter different learning barriers. Hence, older adult users would have different needs in terms of the user manuals/instructions and technology onboarding process.

By understanding the older adults' new technology learning process and evaluating learnability focused features, design recommendations were developed to improve the interaction design of new technology for older adults. Some of the recommendations can be used as design concepts for future evaluation. For older adults with a lower level of technology experience, a task-oriented learning process can provide an easy start to their learning process. For example, when learning to use a new device or app, a launching screen can be provided in the system where users will be asked about what they would want to do. Furthermore, as older adult users are becoming experienced, most of their learning barriers would occur in the later stages of the learning process. Hence, an experience-oriented learning process is recommended where proficient users can customize a self-paced user-guide material in their learning process.

Limitations and future studies

One of the limitations of this study was the number of participants in the focus groups. With ten participants in each level, it is not sufficient to identify the differences among the four levels via statistical analysis. Another limitation was the demographic background of the participants. First, most of the older adults participating in this research attained a bachelor's degree or higher, which was higher than the general older adult population. It is expected that participants with lower education levels might yield different results in the learning process and learning experiences, as well as preferences. Second, older adult participants in this study were all residents of the United States. It is expected that culture could have an impact on users' attitudes toward learning new technology and preferences.

Future studies can address the user needs that were discussed during the focus groups. Those concepts can be applied to the development of user interface features that may enhance older adults' learning experiences by minimizing those repetitive learning works or at least making the process easier. Also, future directions in this research area could examine why older adults decide not to engage with new technology with the focuses on product characteristics. This would provide further insight into the relationship between product design and perceptions of technology from non-users.

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Appendix I: Focus group discussion guideline

Session #:
Date/Time/Location:
Participant (# - TEP):
Procedures:

1. Information consent form

2. Participants review form, they can get a copy if they want to keep one

a. This study aims to explore the factors in interaction design that can influence the learning process among seniors. This focus group will be used to investigate the learning method preferences, learning processes, interactions with new

technologies, and learning tools among seniors with different levels of new technology experiences.
b. Discussions will be audio recorded
c. Feel free to ask if there is a question
d. After the discussion, get $15 gift card on site
e. Rule #1: Sharing your ideas and experiences
f. Rule #2: Don't hesitate to add anything new

3. Is there any question? Sign the form

4. Start audio recording

5. Introduction
a. The electronic/digital product
b. Service

6. Think for a moment about your daily life
a. What are the barriers or difficulties that you have experienced when you use the new technology/ during the learning process?
i. Device
ii. Interface (display)
iii. Activities (tasks; operational procedures)
iv. Visual and auditory processing
v. Working memory
vi. Schema and mental model
b. How did you get over those difficulties? (any learning method used? The approach you took?)
i. Motivation
ii. How to get rid of anxiety?
iii. Pick up what you've learned before (learning curve)
c. If you haven't yet, in your opinion, how to get over those difficulties
d. How did you make sure that you can manage the new technology?
e. The learning method preference
i. Learning alone
• Trial and error/ exploring
• Internet searching
• Using Help feature
• Reading the instruction manual
ii. Learning from domain experts
• Asking for IT support
• Taking training classes
iii. Learning with others
• Learning with partner/spouse, children, family/ friends from the same generation
• Learning with family/friends from the younger generation
• Learning with work colleagues
f. Their opinion about different learning methods/ why do you use that leaning method?

7. New technology under a different context
a. Communication
b. Learning/education/self-help activities
c. Entertainment activities
d. Shopping activities
e. Healthcare-related activities
f. Security issue/ scamming

8. What might make it easier to use technological devices (interventions)
a. When you want the learning process or training process to be introduced during the time you are using new technology?
b. Do you think the learnability of new technology is an important factor that product designers need to consider during the designing process? (how easily and quickly novice users can learn a new technology) Why?
c. Which improvement would you like to see come to market?

9. Our purpose today was to discuss any needs you have and the challenges you face now and in the future regarding learning to use new technology. Is there anything you want to add?

Table S1. Participant characteristics and technology experience profile (TEP) scores (n = 40).

		Mean (Std Dev)	
	N	**Age (Years)**	**TEP Score**
Total	**40**	**71.13 (5.43)**	**101.85 (41.39)**
Female	23	70.51 (5.26)	92.87 (41.08)
Male	17	71.94 (5.71)	114.00 (39.79)
Novice	10	69.80 (3.97)	48.00 (4.85)
Female	8	69.13 (4.19)	48.25 (5.44)
Male	2	72.50 (.71)	47.00 (1.41)
Advanced beginner	10	73.80 (7.58)	82.90 (7.39)
Female	5	74.20 (8.17)	82.40 (7.83)
Male	5	73.40 (7.89)	83.40 (7.80)
Competent	10	70.80 (4.10)	120.40 (6.40)
Female	6	70.67 (4.23)	119.50 (7.87)
Male	4	71.00 (4.55)	121.75 (3.95)
Proficient	10	70.10 (5.13)	156.10 (5.65)
Female	4	68.50 (3.11)	155.25 (4.57)
Male	6	71.17 (6.18)	156.67 (6.62)

Note: Only individuals who participated in the focus groups were included in this table.

Table S2. Description of segments scheme for focus group transcripts.

Criterion	Example
Only segment quote from participants	*Before* Moderator: How did you guys get over those difficulties? *After* Do not segment this. Instead, put a memo to mark that this is where the learning methods/tools started
Segment the quotes with participant # and technology experience group	*Before* Female participant #2: *After* [111-3]:
Only segment quotes about the participant's own experience and opinions	*Before* male participant #1: My wife always read that (referring to the product quick starter)… *After* Do not segment this
A segment must include no more than one scenario.	*Before* "I use both. YouTube is a very good resource… And sometimes I just clicked that Help button on the upper corner. But the information they provided was not very helpful." *After* "I use both. [YouTube is a very good resource…] [And sometimes I just clicked that Help button on the upper corner. But the information they provided was not very helpful.]"

Note. The example shows the comparison between *Before vs. After*. *Before* shows the transcripts showed in the original transcript. *After* shows that what the transcripts would look like after it is being segmented by the researcher by using the criterion listed in the first column.

Table S3. Segments scheme for focus group transcripts: Category.

Category	Segment example
Attitudes	(Moderator: When you think about learning a new technology, what is your attitude toward learning processes? Tell me the very first thing that pop-up in your mind.) [164-3: Exciting. An opportunity to learn.] [174-3: Scared.]
Learning barriers	(Moderator: Think for a moment about your daily life, what other barriers or difficulties that you have experienced during the time when you learned?) [140-1: What I know is, sometimes they'll say, "Okay, hit this button to get to this." Well, my laptop doesn't call it that button, so I don't know what they're talking about. Which button?] [126-4: For me, it's learning and remembering the new terminologies, the vocabularies that's associated with new stuff.]
Learning methods	(Moderator: Is there any particular learning method that you used to try to get over all difficulties or barriers?) [128-1: I paid for tech support, I call a lot.] [126-4: … if it's a Google device I have a Google tablet I can go to their help pages, they understand how to do that.]
Starting points	(Moderator: When you just got a new product, what was the first step that you tried to do in terms of the learning process? And what made you try it?) [152-4: Actually, I start off just using it to whatever the basic function I bought it for. I use it that way first.] [152-4: If I'm talking to somebody and they say, "Have you tried this or that?" Then, I'll go and experiment with that.]
User needs	(Moderator: Among all the learning methods, tools, and learning materials we just discussed, what improvement would you like to see that come with the product?) [127-4: If there was a glossary, it would help, because then I'd know, "Well, this word means that." And the functionality would be a little more clear, but, yes.] [170-4: I'm thinking in terms of software and to me one of the most important things is the undo key. When I get somewhere I didn't want to be, can I go back.]

Table S4. Complete frequency of codes for positive attitudes (subcategory).

	Frequency count				
Theme	**Novice**	**Advanced beginner**	**Competent**	**Proficient**	**(Total)**
Positive attitudes					
Communication					
Effort	3	1	3	3	(10)
Memory	2	1	2	2	(7)
Time	4	2	2	2	(10)
Total (Communication)	**9**	**4**	**7**	**7**	**(27)**
Education/Research					
Effort	2	3	6	7	(18)
Memory	0	0	0	0	(0)
Time	0	0	0	0	(0)
Total (Education/Research)	**2**	**3**	**6**	**7**	**(18)**
Entertainment					
Effort	3	1	5	6	(15)
Memory	0	2	0	0	(2)
Time	6	7	4	6	(23)
Total (Entertainment)	**9**	**10**	**9**	**12**	**(40)**
Finance					
Effort	2	4	7	7	(20)
Memory	0	2	5	4	(11)
Time	0	0	2	0	(2)
Total (Finance)	**2**	**6**	**14**	**11**	**(33)**
Health					
Effort	2	2	1	1	(6)
Memory	0	0	0	0	(0)
Time	7	7	6	7	(27)
Total (Health)	**9**	**9**	**7**	**8**	**(33)**
Transportation					
Effort	0	1	1	0	(2)
Memory	0	0	0	0	(0)
Time	0	0	1	0	(1)
Total (Transportation)	**0**	**1**	**2**	**0**	**(3)**
Shopping					
Effort	2	2	3	2	(9)
Memory	3	1	2	2	(8)
Time	4	3	1	1	(9)
Total (Shopping)	**9**	**6**	**6**	**5**	**(26)**
Unspecified	**0**	**0**	**3**	**3**	**(6)**
Total (Positive attitudes)	**40**	**39**	**54**	**53**	**(186)**

Note: The list of themes is sorted alphabetically.

Table S5. Complete frequency of codes for negative attitudes (subcategory).

	Frequency count				
Theme	**Novice**	**Advanced beginner**	**Competent**	**Proficient**	**(Total)**
Negative attitudes					
Communication					
Effort	6	2	3	3	(14)
Memory	3	2	0	0	(5)
Time	4	4	0	0	(8)
Total (Communication)	**13**	**8**	**3**	**3**	**(27)**
Education/Research					
Effort	1	1	3	3	(8)
Memory	0	0	2	2	(4)
Time	3	0	2	2	(7)
Total (Education/Research)	**4**	**1**	**7**	**7**	**(19)**
Entertainment					
Effort	6	3	0	0	(9)
Memory	7	4	1	0	(12)
Time	6	4	1	0	(11)
Total (Entertainment)	**19**	**11**	**2**	**0**	**(32)**
Finance					
Effort	1	1	1	1	(4)
Memory	1	0	2	0	(3)
Time	0	0	0	0	(0)
Total (Finance)	**2**	**1**	**3**	**1**	**(7)**
Health					
Effort	3	4	2	1	(10)
Memory	1	3	2	2	(8)
Time	2	2	3	3	(10)
Total (Health)	**6**	**9**	**7**	**6**	**(28)**
Transportation					
Effort	1	3	2	2	(8)
Memory	0	0	0	0	(0)
Time	0	0	0	0	(0)
Total (Transportation)	**1**	**3**	**2**	**2**	**(8)**
Shopping					
Effort	5	4	2	1	(12)
Memory	1	0	0	0	(1)
Time	3	2	0	0	(5)
Total (Shopping)	**9**	**6**	**2**	**1**	**(18)**
Total (Negative attitudes)	**54**	**39**	**26**	**20**	**(139)**

Note. The list of themes is sorted alphabetically.

Table S6. Complete frequency of codes for learning barriers.

	Frequency count				
Theme	**Novice**	**Advanced beginner**	**Competent**	**Proficient**	**(Total)**
Learning barriers					
Abilities					
Motor control	4	4	2	5	(15)
Vision	4	0	4	5	(13)
Working memory	5	5	6	4	(20)
Total (Abilities)	**13**	**9**	**12**	**14**	**(48)**
Product characteristics					
Complexity	13	7	2	2	(24)
Familiarity	9	5	5	6	(25)
Generalization	2	3	5	6	(16)
Reliability	7	5	5	4	(21)
Total (Product characteristics)	**31**	**20**	**17**	**18**	**(86)**
Instructions					
Total (Instructions)	**2**	**3**	**5**	**3**	**(13)**
Total (Learning barriers)	**46**	**32**	**34**	**35**	**(147)**

Note. The list of themes is sorted alphabetically.

Table S7. Complete frequency of codes for learning methods.

	Frequency count				
Theme	**Novice**	**Advanced beginner**	**Competent**	**Proficient**	**(Total)**
Learning methods					
Learning alone					
Read instruction manuals	0	3	4	7	(14)
Read notes	2	5	4	3	(14)
Trial and error	3	6	9	10	(28)
Use a second device as guidance	1	2	4	3	(10)
Use Help features	1	2	2	3	(8)
Watch YouTube videos	4	6	8	10	(28)
Total (Learning alone)	**11**	**24**	**31**	**36**	**(102)**
Learning from domain experts					
Ask IT support	8	5	1	2	(16)
Take class	5	4	3	6	(18)
Total (Learning from domain experts)	**13**	**9**	**4**	**8**	**(34)**
Learning from family/friends					
Ask the same generation	2	4	2	1	(9)
Ask the younger generation	6	5	2	2	(15)
Total (Learning from family/friends)	**8**	**9**	**4**	**3**	**(24)**
Total (Learning methods)	**32**	**42**	**39**	**47**	**(160)**

Note. The list of themes is sorted alphabetically. Subtheme read notes (under the theme learning alone) refers to the notes that individuals took from their previous learning processes. The format of the notes discussed in the focus groups included video recording, screenshots, written memos, hand draw pictures, pictures took on the phone.

Table S8. Complete frequency of codes for starting points.

	Frequency count				
Theme	**Novice**	**Advanced beginner**	**Competent**	**Proficient**	**(Total)**
Starting points					
A wanted task	7	5	3	2	(17)
Basic functions	1	2	4	3	(10)
Others' recommendations	4	6	5	4	(19)
Systems' default	0	1	2	4	(7)
Total (Starting points)	**12**	**14**	**14**	**13**	**(53)**

Note. The list of themes is sorted alphabetically.

Table S9. Complete frequency of codes for user needs.

	Frequency count	
Theme	**Competent**	**Proficient**
User needs		
24/7 accessible QuickStart	1	0
Customized learning progress	1	0
Function glossary	2	2
Interface for notes-keeping	1	1
Results foreshadowing	4	5
Self-defined icon/button	3	1
Smart search	2	0
Undo button	2	3
Total (User needs)	**16**	**12**

Note. The list of themes is sorted alphabetically. Only participants in the competent group and the proficient group made comments in this category.