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Analysis of Technology Acceptance and Flow Experience of Using Companion Robots among Older Adults in Care Center Environmental Engineering

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ABSTRACT

In this study, a companion robot system for older adults was developed, and 18 older adults from an elderly care center in Central Taiwan were recruited. Based on the results, the participants thought that the system would improve their lives and that they were willing to immerse themselves in the use of the system. However, it was difficult to use. They held different opinions on its perceived ease of use. The older the participants were, the less their perceived ease of use was. The main reason for this might have been the fact that these older adults were not good at speaking Chinese and English, and that they were also hard of hearing.

Keywords: Technology acceptance, flow experience, companion robot, older adult, care center environmental engineering.

1. INTRODUCTION

1.1 Background

As indicated by the Department of Statistics, Ministry of the Interior, R.O.C. (2018), Taiwan has begun to enter the aging society since 1993. With the elapse of years, Taiwan's demographic imbalance continues to enlarge, and it is estimated that Taiwan's elderly population will have exceeded the 20% threshold by 2026, thus heading towards the super-aged society. With the coming of an aged society in Taiwan, many problems are likely to begin to emerge, such as the high dependency ratio and the care of older adults (Gavrilov and Heuveline 2003). At present, countries are adopting the right strategies to solve the problem of an ageing population. Take older adults as an example; governments are increasing the number of care centers, equipment, and the available health care to address the problems of elderly care, or providing additional facilities to entertain the older adults (Yin *et al*. 2015).

Although older adults can be provided with adequate physical care, the aspect of psychological care has obviously been neglected. Due to the inconvenience of their movements, older adults spend a considerable amount of time in wheelchairs. Also, a caregiver must take care of many older adults at the same time so that he/she cannot interact with them too much. Thus, caregivers cannot help address the problems of loneliness and boredom faced by the older adults. Moreover, the older adults with difficulty in moving are unable to go to the entertainment centers so that, in the long term, it may not only increase their risk of dementia (Pollack 2005) but also contribute to melancholic depression (Kuo and Wang 2014). Wang, Snyder, and Kaas (2001) explored the relationship among stress levels, loneliness, and depression experienced by 201 older adults in the rural areas of Taiwan. Based on the results, there seemed to be a high association among stress level, depressive symptoms, and mood status. Therefore, it is very important for older adults to relieve their stress and anxiety.

Scholars have suggested some ways to improve the mental health of older adults. For example, Borji and Tarjoman (2020) conducted a study to determine the effect of religious intervention on older adults' vitality and sense. 88 older adults as participants recruited were from the community healthcare centers of Ilam City, Iran. The results indicated no difference in their mental vitality and fear of loneliness before the religious intervention. After the intervention, the amount of mental vitality increased, and their fear of loneliness decreased. Although religious intervention may be a good way, it is not easy to change a person's view of religion in a short time. Another easier way to improve older adults' mental health could be companion pets, although they may be hard for older adults to care for. A more practical option might be companion robots.

With the maturity of artificial intelligence technology, companion robots could be a better choice. Robinson, MacDonald, Kerse, and Broadbent (2013) explored the social and psychological impact of the pet robot, Paro, on 40 patients in care home and hospital environments. The results of the experiment showed that the interaction of the residents and the pet robot had significantly reduced the impact of loneliness on them during the experiment. These pet robots had some positive psychological ef-

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fects. First, they could reduce stress hormones. Second, they could improve brain function. Third, they could help establish social relationships. Although pet robots could reduce the loneliness of older adults, they could not provide more comprehensive services and interactions, such as talking or singing with them. Therefore, it could be a possible trend in the future to provide older adults with a more comprehensive companion robot.

1.2 Motivation and Purpose

As the technologies of artificial intelligence and robotics mature, companion robots have begun to be able to help caregivers interact with older adults, and provide some physical and psychological assistance. For example, ASUSTeK (2017) introduced the Zenbo home robot. This robot is not only affordable but also can accompany older adults. Therefore, the Zenbo robot can interact with older adults in response to their needs and help to relieve their boredom and loneliness. Also, this Zenbo home robot could perform some functions that the caregivers could not do.

However, this technology is rather novel to older adults, so we have to ensure that they could accept the Zenbo robot. Accordingly, the aim of this study was to determine whether there is a barrier when older adults operate the robot. To that end, a survey research was conducted using questionnaires to look into the users' intent to the acceptance of this technology (Davis *et al.* 1989) and their flow experience as well (Pearce *et al.* 2005). This was to ensure whether older adults could accept the robot. In the past, some studies have suggested that gender and age may influence users' acceptance and experience of new technologies (Custodero, 2007; Hauk *et al.* 2018; Lin and Yeh 2019; McFarland 2001; Tarhini *et al.* 2014; Yang and Quadir 2018).

In terms of technology acceptance, McFarland (2001) investigated the computer-related usage behaviors and attitudes in relation to the age factor. Data collection involved using questionnaires to survey high school students and industry professionals. The data of 676 people of different ages were analyzed. The results suggested that the factor of age played a strong role in understanding computer-related usage behaviors and attitudes. Tarhini, Hone, and Liu (2014) also conducted a study to explore the effect of gender and age on the relationships among the determinants affecting e-learning acceptance. Their results indicated that there were gender effects on perceived ease of use and behavioral intention. Besides, Lin and Yeh (2019) conducted a research into the way how gender affects the acceptance of virtual-reality technology. For both genders, the results demonstrated a high level of perceived playfulness, ease of use, usefulness, and use-intention scores. However, the influence of perceived playfulness on use-intention was found only for women. Recently, Hauk, Hüffmeier, and Krumm (2018) also reviewed how age relates to technology acceptance. In their study, the meta-analysis includes 144 studies covering different types of technologies and technology users in a random-effects model. The results showed that age is only related to specific technology perceptions (perceived ease of use), especially for specific technologies. Thus, they called for an age-sensitive design of specific technologies. According to the aforementioned studies, both factors of gender and age may affect the use of new technology products such as companion robots by older adults.

In terms of flow experience, Custodero (2007) examined young children's flow experience in four naturally occurring music learning environments. The study subjects were infants, two-year-old children in childcare settings, and school-aged children in Suzuki violin and Dalcroze classes. The results showed that age could affect the flow experience of music activities. In a similar vein, Yang and Quadir (2018) developed a digital game system to look into whether gender differences would have an important influence on the gaming flow experience and learning motivation. The analysis indicated that the male and female students showed similar learning motivation, but the female students had significantly higher gaming flow experience than the male students. Based on the results derived the aforementioned studies, both factors of gender and age could possibly affect the flow experience of older adults using and interacting with companion robots.

With the aforesaid in mind, this study aimed to explore the impact of gender and age on the technology acceptance and flow experience of older adults using companion robots in care center environments. The research questions of this study are given as follows: (1) What are the older adults' overall acceptance and experience of this system? (2) Does gender affect the older adults' acceptance and flow experience of the system? (3) Does age affect the older adults' acceptance and flow experience of the system?

2. LITERATURE REVIEW

2.1 Companion Robots

In recent years, due to the maturity and popularization of robotics technology, companion robots have become increasingly prevalent. Zsiga, Tóth, Pilissy, Péter, Dénes and Fazekas (2018) tested the influence of a companion robot on single older adults. In their experiment, the participants were eight self-supporting older adults who lived alone. After the field test, the researchers used questionnaires to evaluate the usability of the companion robots, and they found that the older adults had positive reactions to them. Moreover, the older adults used the Internet on their own after several weeks. The study clearly showed that a companion robot could be a good partner for older adults.

According to Jecker (2020), companion robots could provide a way to help the older adults solve problems of social isolation and loneliness, and they are expected to bring broader prospects to society. For instance, companion robots can help not only lonely older adults but also those with dementia. Also, Pike, Picking, and Cunningham (2020) explored the impact of robot companion cats on patients with dementia and their caregivers. A case study design was conducted to study the various factors. The analysis showed that the benefits of robot companion pets were obvious, and they also brought positive results for patients and their families alike.

However, human factors such as age, gender and education level may affect people's perception of robots. For example, Huang and Huang (2019) explored the older adults' acceptance of companion robots. In their study, they used interviews and questionnaires to analyze older adults' attitudes towards companion robots. They found that those older adults with a high education level showed positive attitudes towards companion robots. However, the other older adults with no experience of technology showed negative attitudes. This part of the findings indicated that education level is a crucial factor influencing older adults' preference for companion robots. Oh and Ju (2020) also explored age-related differences in the use of companion robots. They conducted an eye-tracking experiment in which 62 participants were involved. Half of them were younger adults, and half of them were older adults. They used eye trackers to observe participants' attention. In the experiment, younger adults focused on the whole robot's body. However, in contrast to the younger adults, the older adults paid more attention to the robot's face. In the interview, younger adults showed negative attitudes, but older adults showed great interests in the robot's design. In conclusion, the findings derived from both the survey and the interview data showed that older adults liked the robot's appearance more than the younger adults did.

Based on the above description, it is worth exploring how human factors affect the older adults' perception of companion robots, such as their technology acceptance and flow experience.

2.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was first proposed by Davis, Bagozzi, and Warshaw (1989). This TAM Model was proposed and intended to explain why people accept computer information systems. To be able to better predict and explain users' acceptance, it is necessary to understand the reasons why they accept or reject a system. TAM is mainly divided into five facets, *i.e.*, "perceived ease of use," "perceived usefulness," "attitude toward using," "behavior intention to use," and "actual system use" (Davis *et al.*, 1989). In addition to these five facets, TAM also allows researchers to add external variables to further explore their impact on "perceived ease of use" and "perceived usefulness." The structure of TAM is shown in Fig. 1.

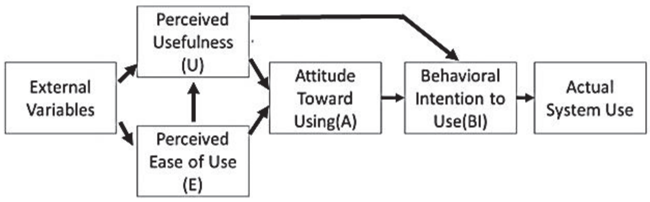

Fig. 1 Technology Acceptance Model (Davis *et al.* 1989)

In TAM, "perceived usefulness" and "perceived ease of use" are the most important factors for users to accept technology. These two factors affect the user's attitude toward using technology. Many scholars have adopted TAM to discuss the acceptance of new technology. For example, Yang and Shih (2020) conducted a study on whether the latest products would be accepted by different age groups. In their research, the five major aspects of TAM were used to explore the acceptance of novel technology by participants of different ages through their reactions. Moreover, in this modern world, artificial intelligence is currently the most actively developing technology. Sohn and Kwon (2020) used TAM theory to discuss the acceptance of artificial intelligence products by the public, and they investigated the factors influencing the acceptance of novel technologies. Besides, the technology is developing rapidly, and there are various novel technologies in different fields. In the medical field, there was a study of a new technology system for skin cancer detection (Horshama *et al.*, 2020). The research compared novel inspection technology and general inspection, and they used TAM to explore the acceptance of this medical technology.

In this study, gender and age were the external variables in the TAM model while older adults were using the companion robots.

2.3 Flow Experience

The concept of "flow" was first introduced by Csikszentmihalyi (1975). The flow experience mainly refers to the psychological mental state of a person, especially when he or she is immersed in an activity with energized concentration, optimal enjoyment, full involvement, and intrinsic interest. Also, the person is usually focused, motivated, positive, energized, and aligned. The flow experience is defined as a state of intense engagement. This engagement is expected to be heightened when individuals see value in an activity and have clear goals, an appropriate balance between challenges and skills, and immediate feedback on actions, thus having some control over the outcome of the activity (Csikszentmihalyi 1997). To experience flow, a balance between a high level of perceived challenges in a given situation and a high level of skills is required (Csikszentmihalyi 1997). However, this is determined by the individual's perceived state of how challenges and skills match each other (Csikszentmihalyi 1975).

Next, some recent application research cases of flow experience have been introduced. Gomezel and Aleksić (2020) examined the relationship among risk-taking, arising from different levels of technological turbulence, flow experience, innovation, and small firm growth. The results showed that the flow experience may promote entrepreneurs' innovation and the efficiency of small firm performance. Lu and Cheng (2020) verified the impact of perceived serendipity on flow experience and prolonged usage time. The results revealed that enabled connections and the introduction of unexpected information significantly affected perceived serendipity, which significantly impacted the flow experience. Although the induced curiosity did not significantly affect perceived serendipity, it directly affected the flow experience. Peifer, Syrek, Ostwald, Schuh, and Antoni (2020) studied the relationships among unfinished tasks at work, flow experience, and wellbeing. The results indicated a positive relationship between the flow experience and the wellbeing.

From the aforementioned research, the flow experience can measure whether a user is attracted to or immersed in a system or environment. Therefore, in this study, we explored whether older adults would be immersed in the use of companion robots. Furthermore, we also analyzed the impact of gender and age on their flow experience.

3. SYSTEM DEVELOPMENT

3.1 Design Concept

In this study, the users of this system were older adults. To avoid the problem of inoperability, the system was designed to minimize the use of the screen and replace it with voice commands because these participants were unable to see the screen clearly owing to the deterioration of their eyesight. In terms of function, many songs that older adults were familiar with had been added, so that the companion robot Zenbo could not only accompany them but also function as a multi-functional entertainment machine.

3.2 Development Tool

The App Builder Pro provided by ASUS' official website was used as the tool to develop this system. All functions were firstly designed through the interface of Scratch, such as drag blocks, and then transferred into Zenbo using the built-in program, Zenbo Player.

3.3 Features and Screenshots

The functions of this system include Daily Dialogue, Karaoke Options, and Videos. The daily dialogue was primarily designed to accompany with the older adults. The Zenbo says the corresponding daily conversational utterances whenever the user says “Hey, Zenbo” followed by a specific Taiwanese statement. Since the Zenbo does not support Taiwanese in the language bag, to make daily dialogues accessible to users of the system, we provided similar Chinese or English statements. In addition to “hello,” there are a variety of daily interactive statements (as shown in Table 1) that make the users feel that they have more than one grandchild around them.

Table 1 Daily Dialogue Function

No.	Command	No.	Command
1	Hello	6	Are you tired?
2	Good morning	7	Are you hungry?
3	You are smart/You are good	8	What do you like to eat?
4	Who are you?	9	What color do you like?
5	How old are you?		

The Karaoke function was designed primarily to increase enjoyment and reduce stress. For example, whenever the user says, “Listen to a song” in Chinese or Taiwanese, the song menu appears. The karaoke menu includes a total of 12 songs, *i.e.*, six Chinese songs and six Taiwanese songs, as listed in Table 2. Fig. 2 illustrates a screenshot of the karaoke menu, and Fig. 3 provides a screenshot of the karaoke songs being played.

This system allows users to watch videos and move accordingly, providing appropriate exercise for older adults. After saying the word of “video” in Chinese or Taiwanese, the user may select the video they like. At present, the currently built-in videos include “64 poses of Tai Chi” and “Health exercise for older adults.” The second one can even be done by older adults sitting in a wheelchair. Even those older adults, who have minor pain and slight difficulty in moving can still participate in the exercise activities.

Table 2 Karaoke Menu

Taiwanese	Chinese
Craving for spring wind	I only care about you
Wife	The moon represents my heart
Four seasons red	Sweet like honey
Moon night	One game, one dream
Rainy night flower	Red dragonfly
No one knows	Love is Like a Tidal Wave
Daydream	A singer’s applause
Roasted rice dumplings	My future is not a dream
The waves	Grandma's Penghu bay
Hard work equal win	Dream pursuer
Dance for love	The dull-ice flower
Mommy, take care.	Stories in a small town

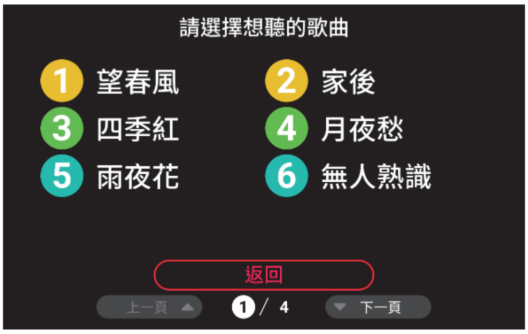

Fig. 2 A Screenshot of the Karaoke Menu

Fig. 3 A Screenshot of the Karaoke Songs Played

4. METHOD

4.1 Participants

As clearly shown in Table 3, in this study, 18 older adults were recruited as participants, 10 males and 8 females, between the ages of 60 and 99. All of them could speak Taiwanese, and 10 of them also could speak Chinese.

Table 3 Individual Participant Data

ID	Gender	Age	Language
P1	M	76	Taiwanese, Chinese
P2	F	72	Taiwanese
P3	F	99	Taiwanese
P4	F	60	Taiwanese
P5	M	88	Taiwanese, Chinese
P6	M	78	Taiwanese, Chinese
P7	F	80	Taiwanese, Chinese
P8	F	83	Taiwanese
P9	M	65	Taiwanese
P10	M	86	Taiwanese, Chinese
P11	M	65	Taiwanese, Chinese
P12	M	88	Taiwanese
P13	M	87	Taiwanese, Chinese
P14	M	83	Taiwanese, Chinese
P15	F	89	Taiwanese
p16	F	78	Taiwanese, Chinese
P17	F	99	Taiwanese
P18	M	70	Taiwanese, Chinese

4.2 Tools

Based on the technology acceptance model (Technology Acceptance Model, TAM) proposed by Davis, Bagozzi, and Warshaw (1989) and the theory of flow experience (Pearce *et al*. 2005), a 21-item 5-point Likert scale questionnaire was developed. The questionnaire was divided into three parts (perceived usefulness, perceived ease of use, and flow experience), as shown in Table 4. The reliability of each facet was greater than 0.8. This indicates that the accuracy of the questionnaire in this study was excellent.

Table 4 Survey Results of Questionnaire Reliability

Facets	Reliability (Cronbach's alpha)
Perceived Usefulness	0.808
Perceived Ease of Use	0.962
Flow Experience	0.903

4.3 Experiment Process

The experimental process of this study is shown in Fig. 4. The duration of the experiment was about 30 minutes. The participants were asked to follow the action list, and the researchers would confirm the list in sequence. Then, the participants completed the questionnaire at the end of the test to achieve the best feedback, as presented in Fig. 5.

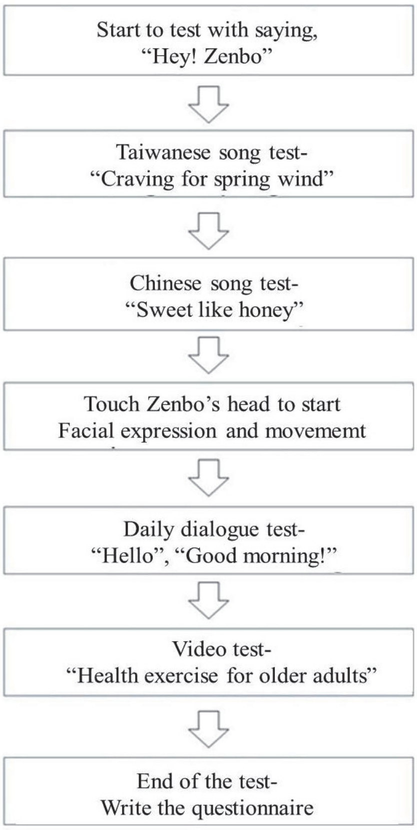

Fig. 4 Experimental Process

Fig. 5 Experiment Reality

5. RESULTS

5.1 Descriptive Statistical Results

Table 5 shows that the values of perceived usefulness and flow experience were 3.500 and 3.882, respectively. These indicated that the participants felt that the system was helpful to them, and they were also easily immersed in their interaction with the system. However, the average perceived ease of use was relatively low, only 3.167, indicating that the system had considerable room for improvement in terms of its operation. On the other hand, in Table 5, it can be seen that the standard deviation of perceived ease of use was relatively high, reaching 0.733. This indicated that the older adults had different opinions. Some found that it was easy to use while others found that it was very difficult to use. Therefore, what factors might affect the perceived ease of use is still the problem with debates.

According to the descriptive statistics of perceived usefulness, perceived ease of use, and flow experience questions shown in Table 6, the item with the highest perceived usefulness was: "This system can make me live a happier life" and the lowest were: "The interactive mechanism provided by this system makes my life more convenient" and "This system can help me get useful information in life when I need it." The scores of perceived ease of use are lower than those of perceived usefulness. Among them, "I learned the use of this system in a short time" and "The activities carried out using this system are easy to understand" score the lowest. In terms of flow experience, the highest item was "I find this activity interesting," while the lowest was "During this activity, the results of all functions are as I expected."

Table 5 Descriptive Statistics Result

Facet	N	M	SD
Perceived Usefulness	18	3.500	0.506
Perceived Ease of Use	18	3.167	0.733
Flow Experience	18	3.882	0.586

Table 6 Questionnaire Descriptive Statistics Result

Facet	Questions	Number of People	Average	Standard Deviation
Perceived Usefulness	1. I think using this system will enrich my life.	18	3.667	0.577
	2. I think using such a system is very helpful for my life.	18	3.611	0.678
	3. The interactive mechanism provided by this system makes my life more convenient.	18	3.167	0.687
	4. This system can help me get useful information in life when I need it.	18	3.167	0.687
	5. This system can make me happier in life.	18	3.833	0.898
	6. The system used in this event can improve my life.	18	3.556	0.685
Perceived Ease of Use	7. For me, learning the operation of this system is not difficult.	18	3.222	0.853
	8. I can learn the use of this system in a short time.	18	3.111	0.737
	9. The activities carried out using this system are easy to understand.	18	3.111	0.737
	10. I can quickly learn how to operate this system.	18	3.167	0.833
	11. In this event, it is not difficult for me to use this system.	18	3.167	0.833
	12. I think the interface of this system is easy to use.	18	3.167	0.833
	13. Overall, the system used in this activity is easy to learn and use.	18	3.222	0.853
Flow Experience	14. During this activity, the results of all functions are as what I have expected.	18	3.278	0.803
	15. I am strongly involved in this activity.	18	4.056	0.911
	16. I have found this activity a pleasant one.	18	4.056	0.705
	17. I am completely immersed in this activity.	18	4.056	0.780
	18. I have found this activity interesting.	18	4.167	0.687
	19. During this activity, I have found time passes quickly.	18	3.833	0.764
	20. This activity stimulates my curiosity.	18	3.778	0.711
	21. I can understand what I should do in this activity.	18	3.833	0.687

5.2 Independent Sample t-test and Result

To further analyze whether gender affected perceived usefulness, perceived ease of use, and flow experience, this study conducted an independent sample *t*-test analysis on these three aspects by gender. As illustrated in Table 7, gender was not significantly different for these three facets, and this might suggest that gender is not the main cause of the dispersion of perceived ease of use. Therefore, we further explored the influence of age on each facet instead.

5.3 Correlation Analysis

To further understand whether age would affect perceived usefulness, perceived ease of use, and flow experience, Pearson's Correlation analysis was performed to do so. As can be seen from Table 8, age had a significant correlation with perceived ease of use, but had no significant correlation with perceived usefulness and flow experience. That is, the older the person, the more difficult it is to use the system. On the other hand, Table 8 shows that perceived ease of use and flow experience were highly positively correlated; that is, the participants who found the system easier to use were more able to immerse themselves in interaction with the system. However, perceived usefulness was not significantly related to other aspects, which indicated that the older adults had subjective opinions on whether the system was useful or not.

Table 7 Gender independent sample *t*-test sample for each facet

	Gender	Number	Average	Standard Deviation	Standard Error of the Average	t Value
Perceived Usefulness	M	10	3.417	0.589	0.186	-0.749
	F	8	3.604	0.436	0.154	
Perceived Ease of Use	M	10	3.386	0.783	0.247	1.417
	F	8	2.893	0.665	0.235	
Flow Experience	M	10	3.850	0.752	0.238	-0.244
	F	8	3.922	0.389	0.138	

Table 8 Correlation Analysis of Age and Facets

	Age	Perceived Usefulness	Perceived Ease of Use	Flow Experience
Age	1	−.309	−.477*	−.418
Perceived Usefulness	−.309	1	.428	.281
Perceived Ease of Use	−.477*	.428	1	.656**
Flow Experience	−.418	.281	.656**	1

5.4 Interview Results

To further understand the possible reasons affecting their perceived usefulness, perceived ease of use, and flow experience, seven participants with the highest and lowest scores for each facet were interviewed. As can be seen from the results based on their interviews provided in Table 9, the main reasons for finding the system useful were that "Zenbo can improve physical movements through activities" and that "it makes life more enjoyable". Also, the main reasons for the perceived uselessness were including "hard of hearing" and "unable to communicate with Zenbo." The reason why the system was easy to use was that "the interaction can be generated by speaking", and the reason why the system was not easy to use was that "Some older adults can't say Hey Zenbo." Finally, the major reasons for the higher flow experience were that "It is so cute with sound and action" and that "Zenbo can sing.

Table 9 Interview Results

Facets	Name	Gender	Age	Score	Interview Content	Interview Observation
Perceived Usefulness	P6	Male	78	4	It helps improve physical movements through activities.	He used not to speak, however, after using Zenbo, he was willing to move and sing with it.
	P7	Female	80	4	It makes life more enjoyable.	
	P3	Female	99	3		Because she is hard of hearing, she does not feel Zenbo is useful.
	P5	Male	88	3.167		Because he cannot communicate with Zenbo, he does not feel Zenbo is useful.
Perceived Ease of Use	P1	Male	76	4	It can be controlled by voice.	
	P4	Female	60	4	It can interact with me by speaking.	
	P6	Male	78	4		He used not to speak, however, after using Zenbo, he was willing to move and sing with it.
	P2	Female	72	2	I can't speak English.	She can't say "Hey Zenbo".
	P3	Female	99	2	Because of being hard of hearing, I can't operate and interact with it.	Listening requires passive guidance.
	P5	Male	88	2	It didn't understand what I said, and it didn't know the songs I want to hear.	He can't communicate with the system.
Flow Experience	P4	Female	65	4.5	It is so cute with sound and action.	
	P7	Female	80	4.5	It is so cute, and it can sing.	
	P5	Male	88	2	It didn't understand what I said, and it didn't know the songs I want to hear.	He can't communicate with the system.

6. CONCLUSION AND SUGGESTIONS

Based on the above results, we can know that in terms of perceived usefulness, the older adults were generally satisfied with the system. The system could not only create a happy living environment for them but also enable them to improve their mobility and physical movements. In terms of perceived ease of use, the participants were generally dissatisfied. Although a few pointed out that it was a great advantage to interact with the system by using languages for operation, most of them thought that to operate the system was difficult for them, especially those who had difficulty in speaking Chinese or English. Besides, the operation interface of this system was not perfect, so this needed to be improved. Specifically, the operation volume could be turned up, so the way to awaken Zenbo could be changed to some extent. In terms of flow experience, the participants were satisfied with the system, and they felt that Zenbo was cute. That's because it has sound and movement, and it can also help them immerse themselves in interaction with the system by singing.

On the other hand, for these older adults, we found that gender did not affect their acceptance and flow experience of the system. However, age could affect the perceived ease of use only, but not the perceived usefulness and flow experience of the system.

Two major limitations exist in this study. First, the sample size was small, and the results could not represent all the older adults. So, a large-scale study should be conducted to examine the results of this study. Second, the experimental period was short, so future studies with longer experiments should be performed to better confirm the results of this study as well.

This study only considered the interaction mode between the Chinese language and the Taiwanese language instead of the Japanese one. However, Taiwan was a colony of Japan from 1895 to 1945, so the languages spoken the most by some older adults involved in this study were Taiwanese and Japanese. In doing so, in the future, the interaction mode between the Taiwanese language and the Japanese language in this system should be better designed for older adults so that they can use this system more easily.

REFERENCES

ASUSTeK Computer Inc. (2017). *Zenbo Smart House Partner*. https://zenbo.asus.com/tw/ (In Chinese)

Borji, M. and Tarjoman, A. (2020). "Investigating the Effect of Religious Intervention on Mental Vitality and Sense of Loneliness Among the Elderly Referring to Community Healthcare Centers." *Journal of Religion and Health*, **59**, 163-172.

Csikszentmihalyi, M. (1975). *Beyond Boredom and Anxiety*. San Francisco: Jossey-Bass.

Csikszentmihalyi, M. (1997). *Creativity: Flow and the Psychology of Discovery and Invention*. New York: Harper Perennial.

Custodero, L.A. (2007). "Observable Indicators of Flow Experience: A Developmental Perspective on Musical Engagement in Young Children from Infancy to School Age." *Music Education Research*, **7**(2), 185-209.

Davis, F.D., Bagozzi, R.P., and Warshaw, P.R. (1989). "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models." *Management Science*, **35**(8), 982-1003.

Department of Statistics, Ministry of the Interior, R.O.C. (2018). *Internal Statistics Bulletin of the 15th Week of 107*. https://www.moi.gov.tw/stat/news_detail.aspx?sn=13742. (In Chinese)

Gavrilov, L.A. and Heuveline, P. (2003). "Aging of Population." *The Encyclopedia of Population*, **1**, 32-37.

Gomezel, A.S. and Aleksić, D. (2020). "The Relationships Between Technological Turbulence, Flow Experience, Innovation Performance and Small Firm Growth." *Journal of Business Economics and Management*, **21**(3), 760-782.

Hauk, N., Hüffmeier, J., and Krumm, S. (2018). "Ready to Be a Silver Surfer? A Meta-analysis on the Relationship Between Chronological Age and Technology Acceptance." *Computers in Human Behavior*, **84**, 304-319.

Horsham, C., Snoswell, C., Vagenas, D., Loescher, L.J., Gillespie, N., Soyer, H. P., and Janda, M. (2020). "Is Teledermoscopy Ready to Replace Face-to-Face Examinations for the Early Detection of Skin Cancer? Consumer Views, Technology Acceptance, and Satisfaction with Care." *Dermatology*, **236**(2), 90-96.

Huang, T. and Huang, C. (2019). "Elderly's acceptance of companion robots from the perspective of user factors." *Universal Access in the Information Society*, 1-14.

Jecker, N.S. (2020). "You've got a friend in me: sociable robots for older adults in an age of global pandemics." *Ethics Inf Technol*. https://doi.org/10.1007/s10676-020-09546-y

Kuo, L.F. and Wang S.H. (2014). "An Experience Applying Life Review to a Geriatric Depression Patient, *The Journal of Psychiatric Mental Health Nursing*, **8**(2), 25-33. (In Chinese)

Lin, P.H. and Yeh, S.C. (2019). "How Motion-control Influences a VR-supported Technology for Mental Rotation Learning: from the Perspectives of Playfulness, Gender Difference and Technology Acceptance Model." *International Journal of Human–Computer Interaction*, **35**(18), 1736-1746.

Lu, H.P. and Cheng, Y.H. (2020). "Sustainability in Online Video Hosting Services: The Effects of Serendipity and Flow Experience on Prolonged Usage Time." *Sustainability*, **12**(3), 1271.

McFarland, D.J. (2001). *The Role of Age and Efficacy on Technology Acceptance: Implications for E-Learning*. https://eric.ed.gov/?id=ED466607

Oh, Y.H. and Ju, D.Y. (2020). "Age-Related Differences in Fixation Pattern on a Companion Robot." *Sensors*, **20**(13), 3807

Pearce, J.M., Ainley, M., and Howard, S. (2005). "The Ebb and Flow of Online Learning." *Computers in Human Behavior*, **21**(5), 745-771.

Peifer, C., Syrek, C., Ostwald, V., Schuh, E., and Antoni, C.H. (2020). "Thieves of Flow: How Unfinished Tasks at Work are Related to Flow Experience and Wellbeing." *Journal of Happiness Studies*, **21**, 1641-1660.

Pike, J., Picking, R., and Cunningham, S. (2020). "Robot companion cats for people at home with dementia: A qualitative case study on companotics." Dementia, 1471301220932780.

Pollack, M.E. (2005). "Intelligent Technology for an Aging Population: The Use of AI to Assist Elders with Cognitive Impairment." *AI Magazine*, **26**(2), 9-9.

Robinson, H., MacDonald, B., Kerse, N., and Broadbent, E. (2013). "The Psychosocial Effects of a Companion Robot: A Randomized Controlled Trial." *Journal of the American Medical Directors Association*, **14**(9), 661-667.

Sohn, K. and Kwon, O. (2020). "Technology Acceptance Theories and Factors Influencing Artificial Intelligence-based Intelligent Products." *Telematics and Informatics*, **47**, 101324.

Tarhini, A., Hone, K., and Liu, X. (2014). "Measuring the Moderating Effect of Gender and Age on E-learning Acceptance in England: A Structural Equation Modeling Approach for an Extended Technology Acceptance Model." *Journal of Educational Computing Research*, **51**(2), 163-184.

Wang, J.J., Snyder, M., and Kaas, M. (2001). Stress, Loneliness, and Depression in Taiwanese Rural Community-dwelling Elders. *International Journal of Nursing Studies*, **38**(3), 339-347.

Yang, J.C. and Quadir, B. (2018). "Individual Differences in an English Learning Achievement System: Gaming Flow Experience, Gender Differences and Learning Motivation." *Technology*, *Pedagogy and Education*, **27**(3), 351-366.

Yang, K.C. and Shih, P.H. (2020). "Cognitive Age in Technology Acceptance: At What Age are People Ready to Adopt and Continuously Use Fashionable Products?" *Telematics and Informatics*, **51**, 101400.

Yin, J.C., Gi, K.M., Yu, S.C., and Chen, L.F (2015). *Investigation Report of the Japanese Elderly Welfare Agency of the Republic of China Supervision*.
https://www.cy.gov.tw/Ap_Home/Upload/KPost_ToOut/9940/%E6%97%A5%E6%9C%AC%E8%80%81%E4%BA%BA%E7%A6%8F%E5%88%A9%E6%A9%9F%E6%A7%8B%E8%80%83%E5%AF%9F%E5%A0%B1%E5%91%8A.PDF (In Chinese)

Zsiga, K., Tóth, A., Pilissy, T., Péter, O., Dénes, Z., and Fazekas, G. (2018). "Evaluation of a companion robot based on field tests with single older adults in their homes." *Assistive Technology*, **30**(5), 259-266.