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Article — Published Version

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Humanities & Social Sciences Communications

Suggested Citation: Toros, Emete; Asiksoy, Gulsum; Sürücü, Lütfi (2024) : Refreshment students' perceived usefulness and attitudes towards using technology: a moderated mediation model, Humanities & Social Sciences Communications, ISSN 2662-9992, Springer Nature, Berlin, Vol. 11, pp. 1-10,
https://doi.org/10.1057/s41599-024-02839-3

This Version is available at:
https://hdl.handle.net/10419/286705

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Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-024-02839-3 OPEN

Refreshment students' perceived usefulness and attitudes towards using technology: a moderated mediation model

Emete Toros[1]✉, Gulsum Asiksoy[2] & Lütfi Sürücü[3]

This study aims to understand the attitudes of Refreshment students who are active learners towards the use of technology. A model was developed by utilising four important factors impacting technology usage attitudes, namely perceived usefulness (PU), perceived ease of use (PEOU), gerontechnology self-efficacy (GTSE) and attitude towards using technology (ATUT). Quantitative research was used to test the study model. A survey was administered to 318 participants selected through convenience sampling to collect data, which were analysed using AMOS 21.0 and SPSS 26.0 software programmes. The results confirmed that PU influences the attitudes of Refreshment students towards technology usage and PEOU mediates the effect of usefulness on their attitude perception. Moreover, GTSE was found to have a moderate mediating role in the effect of PU on Refreshment students' attitude through PEOU. The results of this study hold significant implications for the design and implementation of gerontechnology. Theoretically, the findings align with the Technology Acceptance Model (TAM), suggesting that older adults are more inclined to adopt technology if they perceive it as useful and user-friendly. In practical terms, the study indicates that interventions aimed at enhancing the utility, ease of use, and accessibility of gerontechnology for older adults are likely to be effective in increasing their technology adoption. Overall, these findings underscore the importance of making gerontechnology more accessible and user-friendly, potentially enhancing older adults' technology adoption and thereby improving their overall quality of life.

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Introduction

The rising elderly population resulting from enhanced life expectancy and declining fertility rates has created an unprecedent global challenge (Lamnisos et al., 2021; Suzman et al., 2015). While 1 in 11 people were considered older (aged 65 and above) in 2019 (9%), this figure is expected to rise to 1 in 6 (16%) by 2050 (United Nations, 2019) and the projected number of individuals aged 80 years or older is expected to triple, increasing from 143 million in 2019 to 426 million by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2019). In Turkey, the proportion of the population aged 65 years and over was reported to be 7,953,555 million (9.5%) in 2020 and it is expected to increase to 20.2% by 2050 (Turkish Statistical Institute, 2021). In North Cyprus, the proportion of the population who were 60 years and older was 13% in 2017 (State Planning Organisation, 2017). The quantitative growth of the aging population is correlated with changes in the needs of the elderly, as well as changes in demographic and economic profiles, which determine different behavioural patterns (Guido et al., 2020) and necessities.

Due to this significant increase in the elderly population, efforts to combat rising ageism have increased in importance, as it may now be even more pervasive than sexism and racism (Kite et al., 2002; Levy and Banaji, 2002). Barusch (2013) emphasised the importance of changing the traditional stereotypes of the elderly as being static, sick and frugal to people demanding increased life expectancy and well-being. Acknowledging this global threat, the World Health Organisation (WHO) (1994) has been emphasising the importance of "active aging" since the early 1990s.

Active aging is defined as the process of increasing a person's physical, social, and mental opportunities to not only improve their life expectancy, but also their quality of life (Bowling and Dieppe, 2005). While the WHO's policy framework on active ageing in the Second World. Assembly on Ageing report in 2002 only contained the three pillars of health, participation and security, the notion of active aging was redefined in 2015 as the '*process of optimising opportunities for health, lifelong learning, participation and security in order to enhance the quality of life as people age*' (International Longevity Centre Brazil, 2015: 43). With the addition of lifelong learning, the number of pillars for active aging has increased to four.

Many studies in numerous countries have emphasised the physical, mental, and social advantages of the University of the Third Age and lifelong learning for both older adults and society as a whole (Dench and Regan, 2000; Narushima, 2008; Pincas, 2007; Portero and Oliva, 2007; Purdie and Boulton-Lewis, 2003; Russell, 2008; Swindell, 1993). Ageism deeply rooted in society can reinforce itself via the perpetuation of stereotypes of social isolation, physical and cognitive decline, reduced physical activity, and economic burden among older people. (Angus and Reeve, 2006). The establishment of the aforementioned programmes in universities is important to change the stereotypes for both older people and society at large. In response to this need, in recent years, "Universities of the Third Age" have been established internationally, along with "60+ Refreshment Universities" in Turkey and North Cyprus, to promote active and healthy aging among the elderly. The first 60+ Refreshment Universities in Turkey and North Cyprus were established in 2016 and 2018 on the Akdeniz University Campus and Kyrenia University Campus, respectively, with the aim of providing educational opportunities at no charge and supporting older people in leading healthier and more physically and mentally active lives (Tufan, 2016). In Refreshment Universities, students can take many different courses from different disciplines. For example, medicine related courses aim to create awareness to facilitate the detection of health problems at an early stage, while other courses include history, music, Chi Gong, biology, foreign languages, art, literature, and personal development, among others.

Within the scope of COVID-19 measures, the usage of technology has become increasingly important for the active and healthy participation of the elderly generation in society (Murciano-Hueso et al., 2022; Naor et al., 2022). Gerontechnology, which encompasses the use of electronic or digital products and services designed to promote the health, comfort, and social participation of elderly individuals (Bouma et al. 2007), has gained particular significance in this regard (Chen and Chan, 2014). Therefore, the increasing importance of technology literacy among the elderly has resulted in technology courses being included more frequently in Refreshment University programmes. Hence, this study aims to understand the attitudes of Refreshment students towards the use of technology by quantitatively assessing the relationship between Perceived usefulness (PU), Perceived ease of use (PEOU), Gerontechnology self-efficacy (GTSE) and Attitude toward using technology (ATUT). Although many studies have focused on either information technology needs (Peek et al., 2016, Peek et al., 2019) or the attitudes of the elderly towards technology usage (Cabrita et al., 2019), there is a gap in the literature with respect to the elderly who are currently involved in active learning and can help to change the stereotypes regarding this demographic group. It is important to understand whether education in older ages makes a positive contribution to the attitudes towards technology usage by helping them acknowledge its usefulness in their daily lives so that they are encouraged to use technology.

Literature review

Perceived Usefulness (PU) and Attitude toward Using Technology (ATUT). In daily life, it is essential for the customer to expect to benefit from a consumption-based product and to be satisfied with the service provided. The expectation in terms of using technological tools is related to whether the tool is useful or not. It can be said that a product that meets the intended purpose and provides the expected performance in the area it is designed to be used has a high satisfaction power. In this context, PU denotes the extent to which older adults perceive that using a specific technology will enhance their work and daily life performance (Davis, 1989).

Fishbein and Ajzen (1975) proposed that a person's attitude towards a behaviour can determine the extent to which they feel negative or positive or negative about performing that behaviour. Determining the level of emotion, one of the factors in the realisation of human behaviour, provides evaluative effects about the targeted behaviour. Behavioural action is generally under emotional siege (cathexis), which affects the decision-making levels of people and determines their attitude toward a behaviour. This effect can predominantly be seen in the acceptance and usage behaviours of technology-oriented tools (Mantello, et al., 2023).

The prevalence of technology interaction and experience underscores the significance of attitudes towards technology. Acceptance and usage behaviours should be evaluated separately when measuring attitudes and behaviours towards technology. This is supported by a growing body of literature, including studies by Alfadda and Mahdi (2021) and Ke et al. (2020), who suggested that interaction and experience can shape attitudes and behaviours in significant ways.

Attitudes and perceptions towards using technology result from an internal cycle that constitutes the cognitive process. Experiences about objects, types, and urgency of needs, time, and properties of objects can affect usage behaviour with

different levels of influence (Agarwal and Karahanna, 2000). Factors that influence people's usage behaviour toward a new technology include whether the technology is useful and easy to use, supported by people they value, increases social status, is related to their profession, and effectively performs the functions it offers (Venkatesh and Davis, 2000). In other words, the perceived benefit and ease of use of that system are highly effective on a person's acceptance and use of a new technological system (Davis, 1989).

The rationale for employing perceived usefulness to predict PEOU is grounded in the interrelationship between these constructs, which collectively impact the acceptance and utilisation of technology. The degree to which users believe that a given technology will improve their performance and productivity is a reflection of their PU. When users perceive a technology as useful, they are more inclined to consider it to be a tool that can improve their daily tasks and work efficiency. This positive perception of utility can also lead users to believe that using the technology will not be overly complicated or burdensome, hence contributing to a favourable perception of ease of use (Venkatesh and Davis, 2000).

In the literature, studies on PU and ATUT have yielded different results. For instance, Chen and Chan (2014) studied the factors influencing older Chinese adults' adoption of gerontechnology. To achieve this goal, they developed a research model based on the Technology Acceptance Model (TAM) and the Unified Technology Acceptance and Use Theory (UTAUT). According to the study's findings, there were no significant effects on PU, PEOU, and attitude towards use contrary to the findings of TAM and UTAUT. Song et al. (2022) examined the factors affecting older Chinese adults' adoption of a voice user interface (VUI) integrated into smart home systems and proposed a conceptual model. The results showed that three factors determined the participants' adoption of the VUI: PU, PEOU, and trust. In addition, the results showed that both self-efficacy and PEOU positively affected confidence but negatively affected PU. Chou et al. (2013) conducted a study to evaluate the factors that influence the use of telecare programmes among the elderly. The findings revealed that frequent use of the device was associated with a higher quality of life and greater acceptance of technology among older adults. Older adults who found telecare to be useful in addressing health issues were more likely to continue using it and had more positive views of their interpersonal relationships. Melenhorst et al. (2006) studied the factors motivating the adoption of technological innovations among older adults. Focus group discussions were conducted with e-mail users and non-user older adults about the use of traditional communication methods. The study found that older adults focused on usefulness and that barriers such as difficulty in use played a decisive role in the PU of older people's use of new technology.

The fact that older adults find gerontechnology beneficial may positively affect their attitudes towards using these technology products and services. For example, a gerontechnology product that an elderly person may find useful could be a robot that can help them at home. In this case, the older person's attitude towards the usefulness of robots may change positively, and they may subsequently prefer to use the robot more frequently. In this context, the following hypothesis has been examined:

H1: Perceived usefulness influences the attitude towards use of gerontechnology.

Perceived ease of use: its relationship with perceived usefulness and attitude toward use. The term "convenience" refers to the lack of a requirement for significant effort or difficulty (Davis, 1989). When a user considers that a system is useful for themselves, requires minimal training to learn, and they can use it without effort, they perceive it as easy to use (Dasgupta et al., 2002). The perception that technology is easy to use increases users' willingness to use it as it is user-friendly and meets user expectations (Staples et al., 2002; Tsai et al., 2022).

According to Davis et al. (1989), a person's perception of the ease of use and usefulness of new technology can significantly impact their decision to adopt it. The PEOU of a technology is positively associated with its PU and attitude towards use. When people perceive technology as easy to use, they tend to have a more positive attitude towards it (Saade and Bahli, 2005).

Users often compare the benefits of use with the effort of use. If the performance benefit according to the users is higher than the usage effort, they believe that the benefits offered by the technology will outweigh any negative perceptions (Doll and Torkzadeh, 1988).

There are studies in the literature on this subject that give different results. For instance, a pilot study conducted by Syed-Abdul et al. (2019) investigated how much older adults accept and are willing to use virtual reality (VR) technology. The study was conducted on 30 older adults and gave participants the opportunity to use nine different VR applications that promote physical activity and motivate users. The research results show that older adults positively evaluate VR technology for the purpose of supporting active aging. The study state that older adults perceive VR as useful, easy to use, and a pleasant experience. This perception is emphasised to affect the positive attitudes of older adults towards adopting new technology. The study by Tsai et al. (2022) investigated the factors that influence the acceptance of a wearable cardiac warming system among older adults. The study used an extended technology acceptance model (TAM) to identify the key factors. The results showed that PEOU, PU, and perceived risk were all important factors. The study also found that technology anxiety and resistance to change were important factors. The findings suggest that interventions to promote the acceptance of wearable cardiac warming systems should focus on reducing technology anxiety and resistance to change.

The relationship between PEOU, PU, and attitude towards use is complex and may vary depending on the technology and the context in which it is used. In general, PEOU can mediate the relationship between PU and attitude towards use. This means that the relationship between PU and attitude towards use can be influenced by the individual's perception that technology is easy or difficult to use. For example, if a person thinks that a technology is useful but difficult to use, his/her attitude towards the use of that technology may be negative. On the other hand, if they think that technology is both useful and easy to use, his/her attitude towards using that technology may be more positive. Therefore, PEOU can mediate the relationship between these constructs by influencing PU and attitude towards use. In light of this information, the following hypothesis will be examined:

H2: Perceived ease of use mediates the effect of usefulness on attitude perception.

Gerontechnology self-efficacy: relationship with technology acceptance and usage. The field of gerontechnology aims to improve the lives of the elderly by increasing their independence, preventing accidents and other health threats, compensating for obstacles, helping professional and personal caregivers, and, most importantly, creating a new field of interdisciplinary vision, research, development, and effort (Bronswijk et al., 2009). Gerontechnology is an interdisciplinary field; by combining gerontology and technology, it takes knowledge of the ageing process

and applies it to technological products, services, and environments with research and development techniques (Chen and Chan, 2014). The specific areas of research in the field of gerontechnology include home, health care, home health care, and caregiver support (Plaza et al., 2011). Gerontechnology is not only seen as a potential solution to ageing-related problems and challenges but also as a learning opportunity for older people to have new experiences, be active and enjoy themselves (Peine et al., 2015).

Gerontechnology also has goals such as compensating for the declining abilities of the person, minimising outside help, or minimising any problems that arise. This technology enables individuals and teams developing or implementing technological solutions for older adults to be informed about their goals and wishes. This information can then be used to search for possible solutions that will meet those needs (Harrington and Harrington, 2000).

GTSE refers to the degree to which an older adult feels capable of living independently in relatively good health, comfort, and safety and using technology tools to increase their social participation (Venkatesh et al., 2003).

Research has shown that self-efficacy is correlated with the use of technology and that technology anxiety reduces the intention to use it.

In this regard, Hawthorn (2007) revealed that the primary issue with older adults learning to use computers is that they perceive the learning process to be pointless because they believe they are too old to use computers. According to another study, older adults with a negative attitude towards ageing have low perceptions of their ability to perform their activities or tasks and are less confident in this direction (Paggi and Jopp, 2015). This shows that the negative attitudes of the elderly towards old age significantly affect their self-efficacy. A study by Mostaghel and Oghazi (2017) examined the relationship between gerontechnology characteristics and older adults' ease of use and PU. The study found that older adults with high self-efficacy, low anxiety, and strong cognitive abilities perceived gerontechnology as more useful and easier to use. Ha and Park (2020) investigated into the factors influencing technology acceptance in healthcare among older Korean adults with multiple chronic conditions. Utilising the Senior Technology Acceptance Model (STAM), the study identified key determinants of technology acceptance in this population. Perceived ease of use, perceived usefulness, perceived risk, gerontechnology self-efficacy, and facilitating conditions emerged as significant factors shaping technology adoption. These findings imply that interventions aimed at promoting technology acceptance in healthcare should prioritise enhancing perceived ease of use, perceived usefulness, and perceived risk while also fostering gerontechnology self-efficacy and creating supportive environments.

If an older adult has a high level of gerontechnology self-efficacy, the influence of perceived benefit and PEOU on their attitude towards using technology may be more significant. In this case, older adults may use gerontechnology products more frequently. Conversely, if an older person has a low level of gerontechnology self-efficacy, the influence of perceived benefit and PEOU on their attitude towards using it may be less significant, and they may show a tendency to use gerontechnology products less frequently. Therefore, the following hypothesis was developed:

H3: Gerontechnology self-efficacy plays a moderate mediating role in the effect of perceived usefulness on attitude through PEOU.

For this reason, four important factors, namely PU, PEOU, GTSE and ATUT, are utilised to develop a model (Fig. 1).

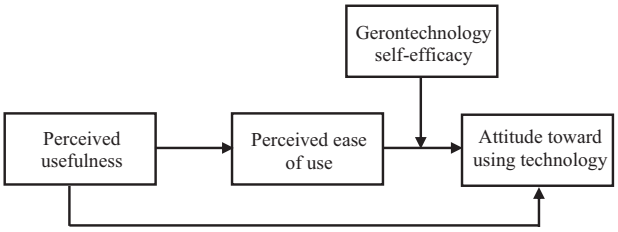


Fig. 1 Theoretical model. This figure illustrates the theoretical model of this study.

Methodology

Procedure. In this study, a quantitative research approach was used, and data was gathered through a survey method that exclusively utilised closed-ended questions. The survey was conducted after obtaining written consent from the participants selected through a convenience sampling method. The data obtained was analysed using AMOS 21.0 and SPSS 26.0 software programmes.

Firstly, for this research, approval to conduct the study was obtained from the Ethics Committee on the 1st of December 2022, with reference number FSBB/07. In Turkey and Cyprus, a limited number of universities provide 60+ Refreshment programmes (5 in Turkey, 1 in North Cyprus) and all of the coordinators of the aforementioned Refreshment Programmes were contacted. Three programme coordinators gave approval for the research to be conducted (2 in Turkey, 1 in Cyprus). Consent was obtained from the participants under the assurance of data confidentiality. Before administering the survey to the main sample, a pre-test was administered to 40 participants at a university in Cyprus to ensure that the statements could be correctly understood by the participants (who were not included in the main sample). The pilot test confirmed the clarity and readability of the items in the survey and ensured that there were no unclear statements. After confirming the survey's clarity through the pilot test, it was then administered to the main sample.

Based on information obtained from the programme coordinators, it was determined that a total of 1517 students were participating in the Refreshment programmes during the period in which the survey was being conducted. Since it was not possible to reach the entire population, a total of 450 surveys were prepared, with 150 surveys allocated for each university.

The formula suggested by Bartlett et al. (2001), which is commonly used in the literature, was employed to determine whether the sample size represented the main population.

$$n = \frac{\mathrm{N} * t^2 \mathrm{p.q}}{(\mathrm{N}-1)d^2 + t^2 * p.q} \quad n = \frac{1517 * (1.96)^2 * 0.5 * 0.5}{(1516)(0.05)^2 + 1.96^2 * 0.5 * 0.5} = 306$$

In this formula;

- N: Population size;
- n: Sample size;
- p: The probability of the event occurring;
- q: The probability of the event not occurring, (1-P);
- t: The critical value at a certain level of significance according to the Z-table; and
- d: The acceptable margin of error (Barlett et al., 2001).

According to this, it was determined that a sample size of 306 had the ability to represent the population with a sampling error of 5% and a confidence level of 95% (Barlett et al., 2001).

A total of 358 questionnaires were collected, 40 of which were excluded from the study since they were inconsistently or incorrectly filled. Thus, 318 valid questionnaires were obtained in the study which confirmed the sample representativeness

according to Bartlett et al.'s (2001) formula (<306). The data collection process lasted four weeks.

Measures. In the research, previously validated and reliable scales that have been used in many recent studies were preferred. All measurement tools (measures) comprise a 5-point Likert scale (five-point Likert scale) and items in the scales are rated from 1 to 5 (1 = strongly disagree, 5 = strongly agree).

Perceived usefulness. PU was evaluated with the 5-item scale used by Ma et al. (2016) and Guner and Acarturk (2020) in their research. The participants were asked to respond to statements about the usefulness of technology in their daily lives. Sample statements were as follows ('Using technology increases my effectiveness in my daily life', 'I find technology useful in my daily life activities').

Perceived ease of use. PEOU was evaluated with the 4-item scale used by Davis (1989) and Venkatesh et al. (2003). The participants were asked to respond to statements about using technology. Some sample statements were as follows ('I would find technology easy to use', 'I might be skilled at using technology').

Attitude towards usage. Attitude towards usage was evaluated with the 4-item scale used by Davis (1989) and Venkatesh et al. (2003). Participants were asked to respond to statements relating to their experience of using technology. Sample statements were as follows ('Technology is fun to use', 'I like to use technology').

Gerontechnology self-efficacy. In their research, GTSE was evaluated with the 2-item scale used by Marston et al. (2016). The participants were asked to respond to statements indicating their self-efficacy in technology use. A sample statement is as follows ('I can complete a task using technology just by reading the manual).

Control variables. Based on the literature, statistical control was taken as some demographic characteristics are considered to have confounding effects on ATU. Variables under control included age, education, gender.

Data analysis. AMOS 21.0 and SPSS 26.0 programmes were used in the analysis of the data. After testing the validity and reliability of the scales used in the study, the correlation between the variables was checked. Confirmatory factor analysis (CFA) was performed to test the fit of the research model. The hypotheses of the research have been verified using structural equation modelling (SEM).

Results

Demographic profile. In the study, 318 valid questionnaires were obtained. The average age of the participants was 67.33. Of these participants, 111 were men and 207 were women, and most were married (63.8%) and had a bachelor's degree (50.6%). While the majority of respondents (86.6%) were not working and lived with a spouse or partner (58.2%), they generally earned their living on a pension (88.4%).

Statistical statistics. Table 1 shows the mean, standard deviation, correlation, and Cronbach's alpha values for all variables in the study. To provide preliminary support for our research hypotheses, a correlation analysis was initially conducted. In this analysis, the point biserial correlation was used to determine the relationship between the categorical (age, gender, and education) and continuous variables (PU, PEOU, ATU and GTSE), while Pearson correlation was used to calculate the correlation between the continuous variables. The correlation coefficients are positive as expected and provide preliminary support for our research hypotheses. The results show that PU is positively and significantly correlated with PEOU ($r = 0.69$, $p < 0.05$), attitude towards usage ($r = 0.85$, $p < 0.05$), and GTSE ($r = 0.65$, $p < 0.05$). PEOU is positively and significantly associated with ATU ($r = 0.71$, $p < 0.05$) and GTSE ($r = 0.60$, $p < 0.05$). In addition, significant relationships were found between some control and research variables. Education is significantly related to PU and gerontechnology self-efficacy. Values reported on the diagonal are the Cronbach's alpha values (0.66–0.96), where values of 0.6 and above indicate that the measurements are reliable and have high internal consistency (Hair et al., 2017; Sürücü and Maslakçı, 2020).

The skewness and kurtosis values were taken into account to confirm the normality of the data. Skewness ranged from −1.26 to −0.59 (SE = 0.13), and kurtosis ranged from −0.80 to 0.34 (SE = 0.27), which shows that the responses to the variables are normally distributed (Hair et al., 2017). Variance inflation factor (VIF) values were checked to determine whether there was a multicollinearity problem in the study. Variance inflation factor scores between 1.88 and 2.26 suggested that the multicollinearity problem would not be a major concern in the analysis (Belsley, 1991).

Measurement model. Confirmatory factor analysis (CFA) was performed using the AMOS.21 programme to validate the measurement model. The measurement model consisted of four latent variables, namely PU, PEOU, ATUT, and GTSE.

There is no consensus in the literature on which fit indices should be used in CFA. However, it is acknowledged that each fit index has its own strengths and weaknesses. Therefore, emphasis is placed on evaluating different fit index values together due to these differences (Hair et al., 2017). Kline (2014) stated that GFI, NFI, IFI, TLI, and CFI values of 0.90 and above indicate acceptable fit, while values above 0.95 indicate excellent fit.

When Table 2 is examined, it can be seen that unlike the alternative models, our four-factor research model has acceptable fit indices. The findings support the idea that the research variables have discriminant validity and that PU, PEOU, ATU, and GTSE are different constructs. In addition, the fact that the Maximum Squared Variance (MSV) value is less than the average explained variance (AVE) value (MSV < AVE) and greater than the average shared square variance (ASV) value (ASV < MSV) confirms that each structure has discriminant validity (Hair et al., 2017).

The AVE value was used to evaluate the convergent validity of each construct. For Convergent validity, the AVE value is expected to be greater than 0.50 and less than the composite reliability (CR) value (Hair et al., 2017). The values presented in Table 3 show that these conditions are met and that the convergent validity criteria of each construct are met. Additionally, since the square root of each construct's AVE is greater than its correlations, discriminant/divergent validity is supported (Fornell and Larcker, 1981).

In addition, Cronbach's alphas and CR values are expected to be 0.6 and above (Hair et al., 2017; Sürücü and Maslakçı, 2020). The values presented in Table 3 show that the Cronbach's alphas values of the structures in the study are greater than 0.658 and the CR values are greater than 0.679. These are also satisfactory and meet the lower threshold criteria recommended in the literature Figs. 2 and 3.

Tests of Hypothesis. It is analysed whether the effect of PU on the participants' attitude towards using technology can be explained through PEOU (mediation).

Table 1 Means, standard deviations, Cronbach's alphas, and correlations.

Variables	Mean	SD	1	2	3	4	5	6	7
1. Age	67.33	7,43							
2. Gender[a]	1.65	0.48	−0.23**						
3. Education[b]	2.61	0.79	−0.18**	−0.13*					
4. PU	3.95	1.26	0.03	−0.02	0.11*	(0.96)			
5. PEOU	3.52	1.23	−0.09	−0.03	0.08	0.69**	(0.93)		
6. ATUT	4.05	1.24	0.01	−0.01	0.09	0.85**	0.71**	(0.96)	
7. GTSE	3.66	1.17	0.02	0.02	0.11*	0.65**	0.60**	0.64**	(0.66)

Cronbach's alphas appear in parentheses along diagonal ($N = 318$).
PU Perceived usefulness, *PEOU* Perceived ease of use, *ATUT* Attitude toward using, *GTSE* Gerontechnology self-efficacy.
*$p < 0.05$.
**$p < 0.01$.
[a]Gender: 1 = male, 2 = female.
[b]Education: 1 = Below High School, 2 = High School, 3 = University, 4 Masters, 5 = PhD.

Table 2 Comparison of Alternative Measurement Models.

Model	χ^2	df	χ^2/df	GFI	NFI	IFI	TLI	CFI	RMSEA
1-Factor Model[a]	1349.00	90	14.99	0.56	0.77	0.78	0.74	0.78	0.41
2-Factor Model[b]	990.90	89	11.13	0.64	0.83	0.84	0.89	0.84	0.18
3-Factor Model[c]	536.18	81	6.62	0.82	0.91	0.92	0.89	0.92	0.13
4-Factor Model[d]	204.01	79	2.58	0.92	0.96	0.97	0.97	0.98	0.05

$n = 318$.
PU Perceived usefulness, *PEOU* Perceived ease of use, *ATUT* Attitude toward using, *GTSE* Gerontechnology self-efficacy.
[a]All constructs combined into one factor.
[b]Perceived usefulness and perceived ease of use combined into one factor. Attitude toward using and gerontechnology. self-efficacy combined into another factor.
[c]Perceived usefulness and perceived ease of use combined into one factor.
[d]Research Model.

Table 3 Reliability, discriminant and convergent validity.

Construct	Factor loadings	Cronbach' α	CR	AVE	MSV	ASV
Perceived usefulness		0.964	0.965	0.847	0.664	0.564
PU 1	0.910					
PU 2	0.932					
PU 3	0.941					
PU 4	0.903					
PU 5	0.917					
Perceived ease of use		0.926	0.937	0.788	0.570	0.483
PEOU 1	0.869					
PEOU 2	0.890					
PEOU 3	0.906					
PEOU 4	0.886					
Attitude toward using		0.961	0.966	0.879	0.744	0.563
ATUT 1	0.950					
ATUT 2	0.963					
ATUT 3	0.924					
ATUT 4	0.913					
Gerontechnology self-efficacy		0.658	0.679	0.520	0.271	0.121
GTSE 1	0.824					
GTSE 2	0.601					

In the analysis of the data, AMOS 21 is used. The AMOS analysis results (Table 4) support Hypothesis 1 by showing that the direct effect is positive and significant $\beta = 0.612$, $t = 14.596$, $p < 0.001$. The expectations for Hypothesis 2 are that the effect of PU on ATUT is through PEOU (mediation). The results support Hypothesis 2 by showing that the indirect effect is positive and significant ($\beta = 0.293$, $p < 0.001$).

Regarding Hypothesis 3, we predicted that GTSE would have a moderating effect on the effect of PU on ATUT through PEOU (mediation). In other words, while the perception of usefulness through the perception of ease of use (mediation) is low on attitude towards using technology in participants with high gerontechnology self-efficacy, this effect will be higher in participants with low gerontechnology self-efficacy. Our results (Table 4) provide support for Hypothesis 3 ($\beta = -0.066$, $p = 0.007$).

It is estimated that the predictors of PEOU explain 47 percent of its variance (R^2: 0.470) and the predictors of ATUT explain 78 percent of its variance (R^2: 0.784).

Also, to fully support Hypothesis 3, we plotted simple slopes (Fig. 4) at SD above and below the mean of gerontechnology

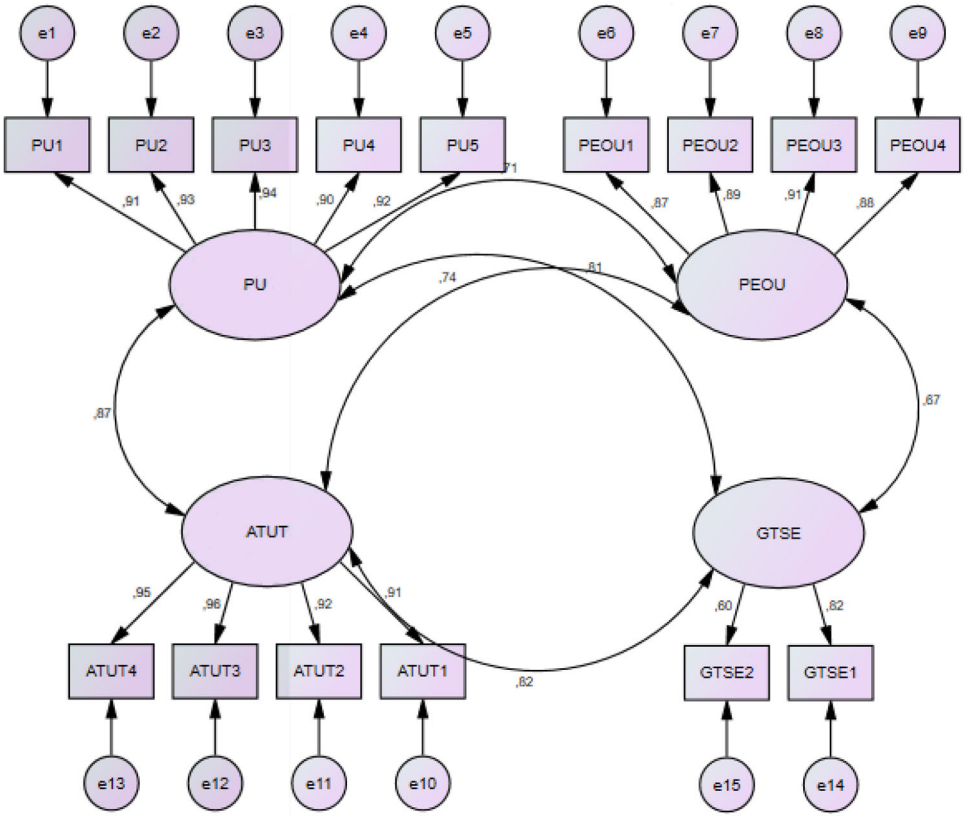


Fig. 2 AMOS output (outer loadings). This figure illustrates the outer loadings of the AMOS output of thefour factors used in this study.

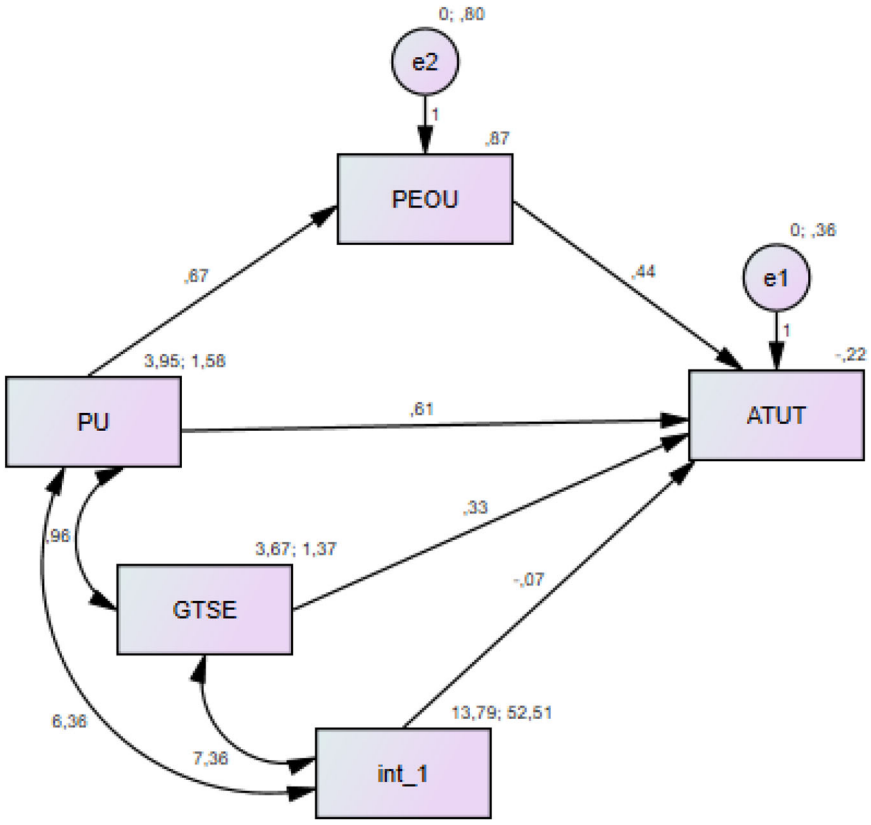


Fig. 3 SEM Model. SEM Model of the four factors used in the study.

Table 4 Results of the mediation analyses (without covariates).

	Estimate	S.E.	C.R.	P
PEOU < --- PU	0.670	0.040	160.751	***
ATUT < --- PEOU	0.438	0.094	4.641	***
ATUT < --- PU	0.612	0.042	14.596	***
ATUT < --- GTSE	0.333	0.092	3.598	***
ATUT <--- int_1(PEOU*GTSE)	−0.066	0.024	−2.719	0.007
Total Effects	PU	PEOU	int_1	GTSE
ATUT	0.905	0.438	−0.066	0.333
Direct Effects				
ATUT	0.612	0.438	−0.066	0.333
Indirect Effects				
ATUT	0.293			

PU Perceived usefulness, *PEOU* Perceived ease of use, *ATUT* Attitude toward using, *GTSE* Gerontechnology self-efficacy.
***$p < 0.001$.

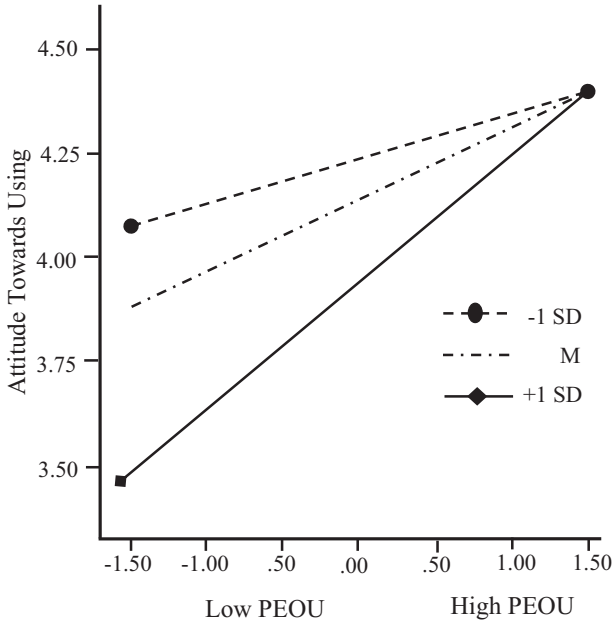


Fig. 4 Moderated mediating role of gerontechnology self-efficacy. GTSE plays a moderated mediation role in the relationship between PU and ATUT through PEOU, such that the mediating effect will be significant for high GTSE and insignificant for low GTSE.

self-efficacy. Consistent with our expectations, the slope of the relationship between PU and ATUT is strong in participants with low GTSE, whereas it is weak in participants with high GTSE. In other words, the effect of PU on ATU through perception ease of use (mediation) is higher in those with low GTSE.

Discussion and conclusion

This study investigated the relationships between various factors that may influence the adoption and usage of technology by older adults. A quantitative research approach, a relational research design, and a convenience sampling technique were used to conduct the study. A theoretical model including PU, ATU, PEOU, and GTSE was proposed to determine the conditions under which actively learning older adults' technology use can be increased.

The findings revealed that PU influences the attitudes of actively learning older adults towards technology usage and PEOU mediates the effect of usefulness on their attitude perception. This finding aligns with the TAM model (Davis, 1989), which explains the acceptance of and intention to use information technologies. TAM, a widely used model in information systems research, posits that users are more likely to use a technology if they perceive it to be both useful and easy to use. This finding is also consistent with previous research findings (Liesa-Orús et al., 2023; Mitzner et al., 2010, Venkatesh and Davis, 2000, Zambianchi et al., 2019). In the context of this study, the findings suggest that actively learning older adults who believe that using technology will be beneficial for them are more likely to use and have a more positive attitude towards it. This is likely because technology can provide older adults with access to information and resources that can help them to learn new things, stay connected with friends and family, and manage their health and well-being.

The study also found that PEOU mediates the effect of PU on ATU. This finding is consistent with the TAM and other research on technology acceptance, which has shown that users are more likely to use a technology if they believe that it is easy to learn and use (Hong et al., 2013; Shore et al., 2018). In the context of this study, the findings suggest that actively learning older adults who believe that using technology is easy are more likely to use and have a more positive attitude towards it. This is likely because older adults may be less likely to use technology if they believe that it is too difficult or complex for them to learn and use.

Finally, the study found that GTSE plays a moderate mediating role in the effect of PU on attitude through PEOU. This finding suggests that older adults with high GTSE are more likely to perceive technology as useful and easy to use; therefore, they are more likely to have a positive attitude towards using it. On the other hand, older adults with low GTSE may be less likely to perceive technology as useful and easy to use; thus, they may have a more negative attitude towards using it. This finding is in line with previous research on gerontechnology self-efficacy, which has shown that older adults with high GTSE are more likely to use technology and have a more positive attitude towards it (Broady et al., 2010, Chen and Chan, 2014; Chung et al., 2010).

The findings of this study hold significant implications for the design and implementation of gerontechnology. Theoretically, our results lend support to the Technology Acceptance Model (TAM) (Davis, 1989), which asserts that users are more likely to adopt and utilise technology if they perceive it as both useful and easy to use. The present study's findings indicate that PU and PEOU are significant predictors of ATUT in older adults, suggesting the continued relevance of TAM in understanding technology acceptance in this demographic. Furthermore, our findings extend the TAM by demonstrating the moderating role of GTSE in the relationship between PU and PEOU. This implies that older adults with higher GTSE are more likely to perceive technology as both useful and easy to use, leading to a more positive attitude towards its adoption and usage.

The findings of this study also carry practical implications for the design and implementation of gerontechnology. Firstly, our results suggest that gerontechnology interventions should prioritise enhancing the perceived usefulness of technology for older adults. This could be achieved by emphasising the potential benefits of technology in improving their daily lives, such as facilitating access to information and resources, fostering connections with friends and family, and enabling effective health and well-being management. Secondly, gerontechnology interventions should also aim to make technology more user-friendly for older adults. This could involve developing user-friendly interfaces, providing clear instructions and tutorials, and offering personalised support. Finally, our findings suggest that gerontechnology interventions should target older adults with lower

GTSE. These interventions could focus on increasing their confidence and self-efficacy in using technology, thereby enhancing their perceived usefulness and ease of use.

Future research and limitations. The study participants comprised refreshment university students studying in Kyrenia, Antalya and Izmir, treating them as one heterogeneous group engaged in active learning. However, it will be useful to assess whether there are any differences between these various refreshment groups' attitudes towards using technology. In future studies, a comparison could be made between the attitudes of refreshment students and senior citizens towards using technology. Although previous research has compared senior citizens and young adults' use and acceptance of technology (Guner and Acartürk, 2020), it will be even more beneficial to compare the attitudes of refreshment students who are actively learning and senior citizens who are not to better understand the impact of active learning on the elderly.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Received: 9 June 2023; Accepted: 15 February 2024;
Published online: 29 February 2024

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Author contributions

Conceptualisation all the authors, data collection, introduction, conclusion, limitations, proof reading and editing Emete Toros, literature review, discussion Gülsüm Aşıksoy, methodology and results Lütfi Sürücü.

Competing interests

The authors declare no competing interests.

Ethical approval

All procedures performed in this study were in accordance with the ethical standards of the university. Ethical clearance and approval were granted by University of Kyrenia Research Ethics Committee (reference number FSBB/07, date 1/12/2022). All procedures in this study were in accordance with the institutional research and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent

This article has obtained informed consent from all the participants prior for the publication. All the participants accepted and voluntarily participated in the study after the researcher assured them of anonymity and that their responses were solely for academic purposes.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-024-02839-3.

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