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Effect of a digital literacy through workshop training programs on older adults: a quasi-experimental study

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ABSTRACT

In Bangkok, Thailand, workshop training programs aimed at enhancing digital literacy among older adults have been developed. The objective of this study was to assess whether a structured digital literacy workshop could improve mobile device proficiency among older adults in Bangkok. This program consisted of six workshops focusing on mobile devices such as smartphones or tablets. This quasi-experimental study investigates the impact of these workshops on digital device usage among urban community adults aged 60 and above. Digital literacy was assessed using the mobile device proficiency questionnaire (MDPQ-16) at three stages, they are baseline (pretest), immediately after program completion (post-intervention), and one month later (follow-up). A total of 84 older adults participated in these workshop training programs. Our findings indicate a significant increase in mobile device proficiency (P<.000). Participants showed substantial improvement in digital literacy at both the posttest and intervention assessments compared to pretest, with no significant difference observed between posttest and intervention scores. However, participants aged 70 and older with lower education levels demonstrated comparatively lower levels of digital literacy. These findings underscore the importance of implementing structured and accessible digital literacy training for older adults, particularly for those with lower educational attainment, to reduce digital disparities and promote inclusive access to essential digital services.

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1. INTRODUCTION

In 2022, the global population aged 65 years and above amounted to 771 million, representing nearly 10% of the world's population. Due to its strong population growth, this group is expected to increase to 24% by 2100 from its anticipated 16% by 2050 [1]. In Thailand, 14 million older adults (aged 60 and above) constituted 20% of the population in 2023, classifying the country as a complete aged society. Within the next 15 years, Thailand is projected to become a super-aged society, with older adults comprising 30% of the total population [2], [3]. However, Thailand faces significant challenges in adequately preparing to meet the needs of its aging population, one major challenge is digital exclusion. The COVID-19 pandemic amplified this issue, leaving marginalized groups particularly older adults behind in accessing essential

online information [4], [5]. Digital inequality stems from disparities in internet access, digital competence, and support systems [6], [7], with the pandemic further exacerbating these gaps [8]. Many older individuals perceive digital technologies as complex and burdensome [9], and their lack of familiarity with such tools leaves them vulnerable to risks such as financial fraud [10]. Digital literacy is crucial in closing this divide. It empowers older adults by enhancing their independence, enabling access to healthcare and government services, promoting mental well-being, and fostering social inclusion [11]–[13]. However, these skills do not come naturally and require guided learning opportunities [14]. Despite the known benefits, there remains a lack of structured, community-based programs that evaluate the impact of digital literacy training on mobile device usage among older adults in Thailand.

This study addresses this research gap by designing and implementing a structured, 6-session digital literacy workshop tailored to older adults in Bangkok. The objective was to assess whether such a program could significantly improve participants' mobile device proficiency. The research question guiding this study is: Does a structured digital literacy workshop significantly improve mobile device proficiency among older adults in Bangkok? Findings from this study aim to inform national digital inclusion strategies and support the development of inclusive technologies and learning interventions for aging populations.

2. LITERATURE REVIEW

Digital literacy for older adults involves more than basic technical skills; it encompasses the ability to evaluate information, engage ethically online, and maintain autonomy through digital tools [15], [16]. Studies emphasize that age-related challenges in adopting digital technology are not only technical, but also social and psychological [17], [18]. According to Thailand's 2020 national survey of older persons, most individuals aged 60–69 reported using smartphones, whereas those aged 70 and older were more likely to use basic phones [19]. Barriers to digital engagement include limited experience, physical or cognitive decline, and a lack of confidence. Moreover, the absence of contextualized learning support systems makes the integration of technology even more difficult for seniors [20], [21].

Recent systematic reviews of digital literacy training programs for the elderly underscore key instructional elements, including repetition, hands-on learning, and the use of printed guides and peer collaboration [22]. Social support during device setup has also been shown to increase both short-term adoption and long-term digital autonomy [21]. In recent years, international scholars have examined the evolving challenges of digital adoption among older adults, particularly through the lenses of digital addiction, digital leadership, and digital inclusion. For example, Karakose *et al*. [23] conducted a bibliometric analysis that revealed significant global disparities in digital competence among the elderly. Similarly, Karakose *et al*. [24] emphasized the critical role of digital leadership in promoting equitable access and advancing lifelong learning, particularly in aging populations.

These findings underscore the pressing global need for inclusive digital interventions that are responsive to local cultural and demographic contexts. In Thailand, formal digital training programs targeting older adults remain limited in both accessibility and evaluation. This study addresses this gap by investigating the effects of a structured digital literacy workshop on mobile device proficiency among older Thai adults. Measuring mobile device proficiency serves as a key indicator for assessing the effectiveness of such training programs. However, previous research has often lacked a specific focus on evaluating proficiency outcomes, particularly in the context of older adult learners [25], [26].

3. METHOD

3.1. Theoretical framework

The research framework of this study draws upon multiple theoretical underpinnings relevant to digital literacy and aging. In particular, the mobile device proficiency questionnaire (MDPQ-16) used as the principal measurement tool, aligns with constructs derived from the technology acceptance model (TAM) and self-efficacy theory [27], [28]. These frameworks emphasize the roles of perceived usefulness, ease of use, and confidence in technology-related tasks as key predictors of digital behavior, especially among older adults [27], [29].

The workshop curriculum was also informed by principles of adult learning theory (andragogy), which highlights the importance of relevance, experiential learning, and autonomy in instructional design for adult learners. The hands-on, task-oriented, and contextually relevant design of the 6-session program reflects these principles [26]. This theoretical grounding ensured that the intervention was not only practical but also psychologically and socially appropriate for the target population. The study assumes that increased digital literacy leads to greater autonomy, improved quality of life, and enhanced social inclusion among older

adults. These assumptions are embedded in the design of both the intervention and the instruments used for measurement, enabling consistent alignment between theory, methods, and outcomes [25], [29].

3.2. Study design

This quasi-experimental study was conducted in an urban community setting of Bangkok, Thailand, specifically involving members of a senior citizen club in the Dindaeng District. A convenience sample of participants was recruited for six workshops. The total population of older adults in the area was 26,632 [30]. Inclusion criteria comprised individuals aged 60 years or older, affiliated with the senior citizen club in Dindaeng District, Bangkok, and possessing a mobile device with internet connectivity. Considering the qualifications of project participants from the total population in the area, it was found that there were 130 people who met the criteria.

Recruitment proceeded in three steps. They are: i) outreach through multiple channels club bulletin boards, home-visit flyers delivered by community health volunteers, and a telephone-tree message circulated by club coordinators; ii) telephone screening against four eligibility items (age ≥60 years, club membership, ownership of an internet-enabled mobile device, and capacity to give informed consent); and iii) face-to-face confirmation at the first workshop. Of the 130 preliminarily eligible individuals, 93 attended the orientation session and 84 ultimately provided written consent. Recruitment efforts, including billboard and brochure publicity, targeted the Bangkok senior citizen club. With a predetermined sample size of 80 participants, based on a one-tailed test, effect size (d) of .62, α of .05, and statistical power (1-β) of .95 [31], recruitment yielded 94 potential participants. Confirmation of enrollment occurred at the first workshop, where participants also affirmed their mobile device ownership and signed informed consent forms. Despite initial interest, five individuals cited health concerns or lack of interest, while four faced transportation difficulties, resulting in a final sample of 84 participants.

The data collection timeline included three phases: baseline (January 2023), immediate post-intervention (February 2023), and 1-month follow-up (March 2023). Data on sociodemographics, type of device, frequency of device use, and participant autonomy were gathered at baseline (pretest). Autonomy data were also collected at pretest and immediately post-intervention. Digital literacy information was obtained at pretest, posttest, and one month post-intervention. The 16-question MDPQ-16 [25], [32] was utilized to gauge digital literacy. No validated instruments for assessing digital literacy in the Thailand population were available; however, the MDPQ-16 serves as a suitable measure due to its comprehensive and adaptable components. The MDPQ-16 was adapted by a professional native Thai-speaking translator. The questionnaire yields scores ranging from 8 to 40, distributed across eight domains: mobile device basics, communication, data and file storage, internet usage, calendar functions, entertainment applications, privacy settings, and troubleshooting/software management. Each question offers the same number of response options, with scores ranging from 1 to 5 points. Participants completed the questionnaires following clear explanations, and assistance was offered to those encountering any difficulties.

3.3. Intervention

The digital literacy workshop program implemented interventions using participants' chosen mobile devices, including smartphones or tablets. This program consisted of six workshops held at a venue provided by the older adults club in the Dindaeng District of Bangkok. Each workshop had a duration of approximately one hour, with activities divided into 45 minutes of engaging in digital tasks and 15 minutes dedicated to exchanging experiences within a conversation circle. The digital activities included a selection of applications chosen based on their capacity to stimulate learning skills. These comprised: i) A definition or configuration app and an email app, aimed at training users in touch and manual dexterity for mobile use. The definition or configuration apps focused on touch and device handling, stimulating motor skills, while the email app aimed to enhance touch and manual dexterity; ii) Apps such as Line, TikTok, Facebook, and YouTube were utilized for interactive tasks, facilitating activities like sharing pictures, videos, information, and communication; iii) A mobile banking application was incorporated to train users in various forms of digital transactions, including making purchases and paying bills through e-wallets or digital wallets, utilizing methods such as text, image, bar code, and quick response (QR) code; and iv) Government applications like Paotung, Thaichana, and Mohpromt were also included to familiarize participants with their functionality and usage [26].

The intervention was tailored for older adults by incorporating age-friendly instructional techniques, such as simplified instructions, large-print manuals, and slower pacing of content delivery. Each session prioritized repetition and peer assistance to accommodate varied levels of cognitive and physical ability. This digital literacy education curriculum encompasses six key modules designed to progressively develop participants' digital literacy skills. The first module introduces basic smartphone operation, including baseline assessments, app installation, Wi-Fi connection, and typing. Module two focuses on leveraging entertainment applications like Line, TikTok, Facebook, and YouTube for interactive tasks that promote

information sharing and communication. Module three equips participants with the knowledge and skills to conduct various digital transactions through e-wallets, utilizing methods like text, image, barcode, and QR code. Module four teaches calendar management, enabling participants to schedule appointments, set reminders for doctor visits, social gatherings, and other events. Module five emphasizes the importance of data privacy and security by teaching participants to create strong passwords and utilize anti-fraud applications. Finally, module six equips participants with the ability to register for and navigate government-issued applications, facilitating access to essential services, as shown in Table 1.

The workshops were conducted under the guidance of a seasoned instructor specialized in teaching older adults how to utilize technology. Additional assistance was provided by one or two monitors who supported the participants throughout the sessions. The workshops followed a structured approach, comprising the following steps. The first is the trainer elucidated the purpose of the app featured in the session. Secondly, the trainer demonstrated the app's usage through detailed, step-by-step instructions. Lastly, participants engaged in hands-on practice with the app. Should any difficulties arise, the trainer and monitors addressed them individually or collaboratively, ensuring participants' comprehension and progress. Importantly, the trainer and monitors refrained from physically handling the participants' mobile devices, instead guiding them verbally, thus encouraging active and independent use of their devices.

This approach fostered participants' autonomy and proficiency, empowering them to navigate their devices without reliance on external assistance. All workshops were conducted by the same team of researchers, maintaining consistency across locations. Each session accommodated no more than 20 participants, maintaining a ratio of five instructors to four participants to ensure personalized attention and support. Additionally, all participants received a comprehensive project manual containing detailed instructions for utilizing the apps covered in the workshops. The workshop program spanned from January to June 2023.

Table 1. Digital literacy education curriculum for workshop program

Week	Education topic	Content	Duration (minute)
1	Basic smartphone operation	Baseline assessments, app installation, Wi-Fi connection, and typing.	60
2	Entertainment applications	Promote information sharing and communication from Line, TikTok, Facebook, and YouTube.	60
3	Internet banking	Knowledge and skills to conduct various digital transactions through e-wallets, utilizing methods like text, image, barcode, and QR code	60
4	Calendar management	Enabling participants to schedule appointments, set reminders for doctor visits, social gatherings, and other events.	60
5	Data privacy and security	Teaching participants to create strong passwords and utilize anti-fraud applications.	60
6	Government applications	The ability to register for and navigate government-issued applications, facilitating access to essential services.	60

3.4. Measures

All participants completed a survey that included basic demographic information and the MDPQ. The MDPQ was administered to assess whether technology proficiency relates to attitudes toward wearable and mobile technologies promoting physical and cognitive health. The survey utilized a 16-item abbreviated version of the MDPQ, where participants rated their proficiency with mobile devices such as smartphones and tablet computers. The MDPQ consists of eight subscales: mobile device basics, communication, data and file storage, internet, calendar, entertainment, privacy, and troubleshooting and software management. Each subscale is scored on a scale ranging from 1 to 5, with lower scores indicating lower proficiency levels: "1=never tried", "2=not at all", "3=not very easily", "4=somewhat easily", and "5=very easily". Each subscale in the short form comprises two questions, and scores are averaged to determine the subscale score based on the published scoring criteria.

Total MDPQ scores are calculated by summing all subscale scores, resulting in scores ranging from 8 (indicating the lowest proficiency across all subscales) to 40 (indicating the highest proficiency). Participants' digital self-efficacy and autonomy in technology use were inferred from their responses on the MDPQ subscales and additional autonomy-specific questions added to the baseline and post-intervention assessments. Digital literacy was analyzed, using the MDPQ-16. The adjusted self-reported variables were gender (male or female), age (determined by birth year and categorized into groups: 60-64, 65-69, and ≥70 years), and educational level (according to the Thailand system of education). The educational level was transformed into categories (years of formal schooling): primary education (1-4 years); basic education (5-7 years); junior high school education (8-10 years); senior high school education (11-12 years); and higher education (more than 12 years).

Participants provided self-reported information on their marital status (single, married, divorced, or widowed), household composition, and job status (retired, employed, or unemployed). Regarding household composition, participants were requested to indicate the number of individuals currently residing in their homes, specifying whether it was single occupancy, married or cohabiting without dependent children, married or cohabiting with dependent children, single-parent household, or another multi-person arrangement. The evaluation of the workshop program intervention comprised three feasibility indicators: recruitment, adherence, and workshop satisfaction. The recruitment rate was computed by dividing the total number of recruited individuals by the number of available vacancies per workshop (set at 10). Adherence to the intervention was assessed based on the number of participants who attended all workshops relative to the total number of workshop participants.

3.5. Data analysis

The psychometric properties of the MDPQ-16 were assessed using exploratory factor analysis (EFA), employing the principal axis factoring extraction method, and reliability measures including Cronbach's α and McDonald's ω. Sampling adequacy was confirmed by the Kaiser-Meyer-Olkin (KMO) test, yielding a value of .758. Additionally, the Bartlett test of sphericity for the EFA model (χ266=807; P<.001) indicated appropriate correlation structures for factor analysis. High internal consistency was demonstrated by Cronbach's α (α=.828) and McDonald's ω (ω=.773), suggesting excellent reliability.

An independent 2-tailed t-test and 1-way analysis of variance (ANOVA) were used to compare two or more groups. Baseline data comparisons employed nonparametric alternatives, including the Mann-Whitney test and Kruskal-Wallis's test. Inferences regarding variables at pretest, post-intervention, and follow-up were made through paired-sample two-tailed t-tests, while differences across the three time points were examined using repeated-measures ANOVA. Cohen's d was employed to calculate effect sizes for the t-test. The relationship between digital literacy was explored using linear regression, both in raw analysis and after adjustment for gender, age, and education. To estimate the impact of time on digital literacy, a longitudinal analysis model employing generalized estimating equations (GEEs) was employed. This approach extends the generalized linear model to accommodate within-subject correlation across repeated measures, treating time as a variable. The database underwent transformation from "wide" to "long" format to facilitate analysis of within-subject missing data. Significant P values were defined as those having 95% confidence intervals less than.05. All statistical analyses were conducted using SPSS version 29.0.2.0 (IBM Corp., Armonk, NY, USA).

3.6. Ethical considerations

This subsection summarizes additional safeguards implemented to protect participants. The intervention was a minimal-risk, community-based digital-literacy workshop for older adults. Sessions were delivered by trained facilitators; participation was voluntary; and participants could pause or withdraw at any time without penalty or loss of benefits. To protect privacy, no direct identifiers (e.g., names, national ID numbers, phone numbers, and exact addresses) were recorded on study instruments. Each participant was assigned a unique study code; the re-identification key was stored separately from the analytic dataset and was accessible only to the principal investigator. Paper forms were kept in locked cabinets within restricted-access offices; electronic files were stored on password-protected, institutionally managed servers with role-based access control and routine backups. Aggregate reporting was used to avoid re-identification. Any adverse event or complaint was to be documented and reported to the ethics committee in accordance with institutional SOPs within 7 days of awareness. Participants received non-coercive tokens (e.g., refreshments and local travel reimbursement); no deception was used. Given the older-adult population, accessibility accommodations were provided (e.g., large-print materials, extended time, and when needed an independent witness during the consent process). Data will be retained for 5 years and then securely destroyed (paper: cross-cut shredding; electronic: secure deletion).

4. RESULTS

4.1. Demographic factors and mobile device usage

Out of the 93 participants in this study, 84 finished the intervention, meaning they attended all six of the program's workshops. The 90.5% (76) were female, 67.9% (57) were between the ages of 65 and 69, and 45.2% (38) had less than four years of education (primary education). Most (54.8%) single solely single occupancy a home. The 81.0% (68) of the participants had retired status. As for the participants' devices, 97.6% (82) of them used smartphones, while 91.7% (77) of them used an Android operating system. A total 96.4% (81) of participants had owned their mobile device for more than a year, and 94.0% (79) were frequent users. The majority of participants (97.6%) had self-mobile, as presented in Table 2.

Table 2. Baseline demographics and mobile device usage in workshop programs of the participants

Characteristics	Participants (n=84), n (%)	Digital literacy score, mean (SD)	p-value	95% CI of mean
Gender			.032	
Female	76 (90.5)	27.02 (2.88)		26.362–27.678
Male	8 (9.5)	24.74 (2.81)		22.391–27.089
Age group (years)			.811	
60-64	18 (21.4)	26.42 (3.60)		24.630–28.210
65-69	57 (67.9)	26.97 (2.62)		26.275–27.665
≥70	9 (10.7)	26.53 (3.64)		23.732–29.328
Educational level (years)			.307	
Primary education (1-4 years)	38 (45.2)	26.53 (2.21)		25.804–27.256
Basic education (5-7 years)	17 (20.2)	26.82 (3.43)		25.056–28.584
Junior high school education (8-10 years)	12 (14.3)	26.75 (2.67)		25.054–28.446
Senior high school education (11-12 years)	15 (17.9)	26.88 (3.94)		24.698–29.062
Higher education (more than 12 years)	2 (2.4)	31.55 (1.20)		20.768–42.332
Marital status			.007	
Single	8 (10)	23.86 (3.71)		20.758–26.962
Married	27 (32)	24.74 (2.81)		23.628–25.852
Divorced	24 (29)	27.92 (3.13)		26.598–29.242
Widowed	25 (30)	27.09 (2.13)		26.211–27.969
Household composition			.443	
Single occupancy	50 (60)	27.02 (2.85)		26.210–27.830
Married/cohabiting with no dependent children	17 (20)	26.75 (2.63)		25.398–28.102
Married/cohabiting with dependent children	5 (6)	26.36 (4.60)		20.648–32.072
Single parent family	1 (1)	21.40 (.00)		–
Another multi-person household	11 (13)	26.70 (3.04)		24.658–28.742
Job status			.759	
Retired	68 (81)	26.76 (2.94)		26.048–27.472
Employed	4 (5)	27.70 (1.75)		24.915–30.485
Unemployed	12 (19)	26.74 (2.93)		24.878–28.602
Mobile device purchaser			.472	
Self	82 (98)	26.82 (2.97)		26.167–27.473
Other	2 (2)	26.00 (.57)		20.879–31.121
Frequency of device use			.087	
Frequent	80 (95)	26.95 (2.90)		26.305–27.595
Infrequent	4 (5)	24.56 (2.86)		20.009–29.111
Type of mobile device used			.037	
Smartphone	82 (98)	26.69 (2.87)		26.059–27.321
Tablet	2 (2)	31.55 (1.20)		20.768–42.332
Mobile device operating system used			.716	
Android	77 (92)	26.80 (2.95)		26.130–27.470
iOS	7 (8)	26.89 (3.00)		24.115–29.665
Length of mobile device ownership			.531	
More than 1 year	81 (96)	26.85 (2.96)		26.195–27.505
Less than 1 year	3 (4)	25.63 (2.44)		19.569–31.691

Based on participant demographics and mobile device usage in workshop programs, we assessed digital literacy in our study. The scores from literacy questionnaires indicated that participants initially had low baseline digital literacy scores. To determine higher digital literacy levels, we calculated the proportion of participants whose baseline scores exceeded half of the maximum possible score, given that the questionnaires lacked a predefined cutoff point. Specifically, 50% (42 out of 84) of participants achieved a score equal to or greater than 27 points (mean score), with a range spanning from 8 to 40 points. Notably, participants who owned their own devices, used smartphones frequently, or had owned their devices for over a year demonstrated better digital literacy scores. Additionally, participants with higher education levels exhibited stronger digital literacy compared to those with less education.

4.2. Longitudinal digital literacy analysis

Repeated-measures analyses were undertaken to track digital-literacy trajectories from baseline (pretest) through two post-workshop assessments while statistically controlling for gender, age, and educational attainment, as shown in Figure 1. Digital literacy increased markedly from pretest (M=26.0) to the immediate posttest (M=31.7), $t(83)=17.04$, $p<.001$, Cohen's $dz=1.86$, 95% CI [1.497, 2.223]. No additional change was detected between the immediate and one-month follow-ups ($p>.05$), indicating that the initial gains were maintained, as in Figure 1. Self-reported autonomy measured on a 0–40 visual gradient scale ranging from orange (low) to green (high) also rose substantially, from M=17.88 at baseline to M=30.50 at follow-up, $t(83)=32.50$, $p<.001$, Cohen's $dz=3.55$, 95% CI [2.974, 4.126].

Across demographic subgroups, both males and females, younger (<60 year) and older (≥60 year) adults, and participants with ≤12 years versus >12 years of education all demonstrated positive trajectories, as in Figure 2. Figure 2(a) shows all age groups (60–64, 65–69, ≥70) improved, Figure 2(b) shows both gender improved similarly, and Figure 2(c) shows higher education consistently outperformed lower education. Participants with higher education consistently outperformed their less-educated counterparts at every time-point. Scale-level inspection of the MDPQ-16 revealed significant pre to post workshop gains on all sub-scales, as in Table 3, with the exception of basic skills, which approached but did not exceed the Bonferroni-corrected significance threshold. For instance, the entertainment sub-scale improved from M=2.70±.97 to 4.35±.76, t(83)=16.92, p<.001, Cohen's dz=1.84, 95% CI [1.486, 2.192]; basic skills yielded t(83)=17.04, p<.001, Cohen's dz=1.86, 95% CI [1.497, 2.223]. Figure 3 visualizes the pattern of change across all 6 sub-scales.

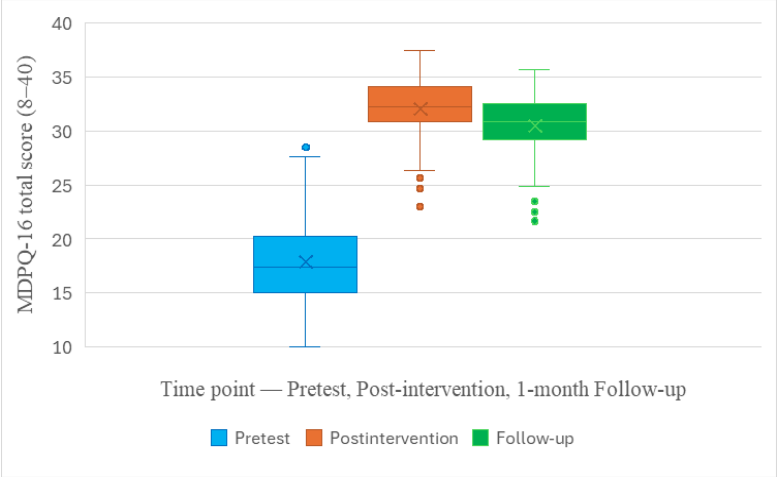

Figure 1. Mean MDPQ-16 total scores at pretest, immediate post-intervention, and 1-month follow-up

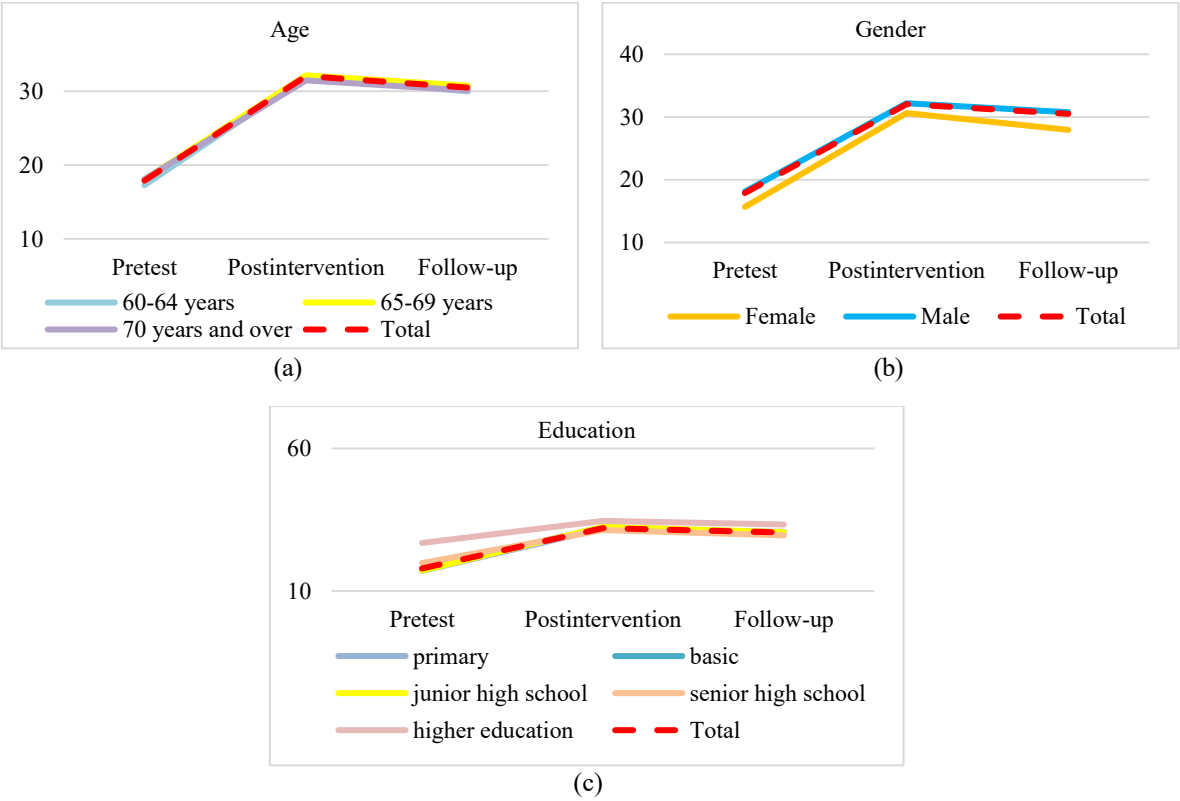

Figure 2. The subgroup trajectories of: (a) all age groups, (b) both genders, and (c) education level

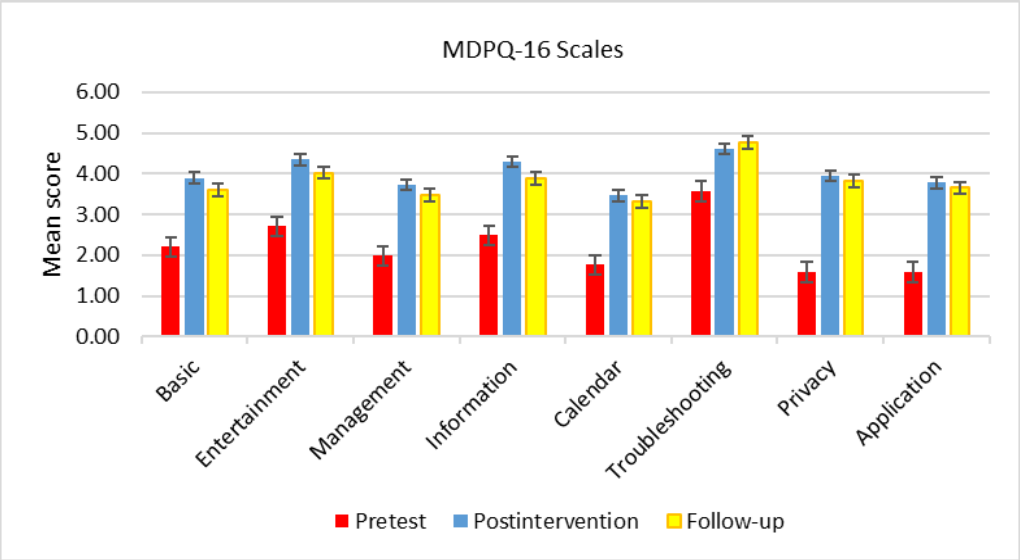

Figure 3. Digital literacy at pretest, post-intervention, and follow-up by MDPQ-16 scale

Three demographic factors age, gender, and educational attainment were selected as covariates, because together, they represent the core personal, social, and structural resources that shape digital participation. Age indexes life-course cognitive capacity and cumulative exposure to technology; gender signals socially ascribed roles that mediate access and motivation; and years of schooling proxy the cultural capital and literacy necessary for complex online tasks. Analyses grounded in resource-appropriation theory and digital-inequality research consistently identify these three variables as the strongest predictors of e-skill acquisition among adults, making them the most parsimonious and theoretically justified set for modelling workshop outcomes [33], [34]. Constraining the multivariate analysis of variance (MANOVA) to this triad therefore maximizes explanatory power while avoiding model over-parameterization. The digital-literacy scale scores were analyzed with MANOVA. Preliminary diagnostics confirmed that Box's test of equality of covariance matrices was non-significant for every grouping factor gender (Box's M=14.873, F(8, 2560)=1.520, p=.156), age (M=21.449, F(16, 2639)=.970, p=.481), and education (M=19.732, F(32, 7181)=.880, p=.650) verifying the homogeneity of covariance assumption (p>.05 throughout). On that basis, significant multivariate effects detected by MANOVA were followed up with Bonferroni-adjusted pairwise comparisons.

Table 3 displays the results of a MANOVA examining the scores from various scales in relation to participants' gender. For the two domains that yielded statistically significant gender differences, female participants out-performed their male counterparts on basic skills (M=3.299 vs 2.563; F(1, 82)=8.556, p=.004, partial eta squared (ηp^2)=.094, 95% CI [.010, .240]) and on application management (M=3.063 vs 2.430; F(1, 82)=6.939, p=.010, partial eta squared (ηp^2)=.078, 95% CI [.005, .217]). Both effects fall within the small-to-medium range, indicating that women either entered with, or acquired, stronger proficiency in these foundational and app-handling facets of mobile use. Significant differences identified by the MANOVA were subsequently examined with Bonferroni-adjusted pairwise comparisons. By contrast, gender exerted no statistically significant influence on the remaining six sub-scales—entertainment (F=.010, p=.921, partial eta squared (ηp^2)<.001, 95% CI [.000, .051]); management (F=.496, p=.483, partial eta squared (ηp^2)=.006, 95% CI [.000, .081]); information (F=.640, p=.426, partial eta squared (ηp^2)=.008, 95% CI [.000, .088]); calendar (F=2.257, p=.137, partial eta squared (ηp^2)=.027, 95% CI [.003, .133]); take a photo (F=1.120, p=.293, partial eta squared (ηp^2)=.013, 95% CI [.001, .104]); and privacy (F=1.387, p=.242, partial eta squared (ηp^2)=.017, 95% CI [.001, .112]). These negligible effect sizes suggest broadly comparable performance between genders in higher-order management, information retrieval, scheduling, imaging, and privacy-related tasks.

Table 4 summarizes the MANOVA conducted to evaluate age related differences in mobile digital-literacy sub-scales. Age exerted a statistically significant influence on only one domain "privacy" where participants aged 60–64 scored markedly lower (M=2.816) than those aged 65–69 (M=3.234), with the ≥70 cohort occupying an intermediate position (M=3.000). The omnibus test confirmed this pattern, F(2, 81)=3.512, p=.034, partial eta squared (ηp^2)=.080, 95% CI [.005, .219], indicating a small to medium practical effect that suggests younger old adults may feel less confident managing privacy settings than their

older peers. For the remaining seven MDPQ-16 sub-scales basic (F=.921, p=.402, partial eta squared (ηp^2)=.022), entertainment (F=1.860, p=.162, partial eta squared (ηp^2)=.044), management (F=1.978, p=.145, partial eta squared (ηp^2)=.047), information (F=.236, p=.791, partial eta squared (ηp^2)=.006), calendar (F=.038, p=.963, partial eta squared (ηp^2)<.001), take a photo (F=.492, p=.613, partial eta squared (ηp^2)=.012), and application (F=.443, p=.644, partial eta squared (ηp^2)=.011) age effects were non-significant, with partial eta squared (ηp^2) values all below .05. These negligible effect sizes indicate broadly comparable performance across age strata in foundational navigation, entertainment use, device management, information retrieval, scheduling, imaging, and general app handling, suggesting that the workshop's instructional design was equally effective for participants aged 60–64, 65–69, and ≥70 in these skill areas.

These findings suggest that age does not significantly influence most aspects of digital literacy among older adults, except in the domain of privacy. The aim of this analysis was to explore whether digital literacy scores differed across age groups in specific skill areas. The absence of significant differences in most factors implies that, regardless of age, older adults can perform comparably in using mobile devices when given adequate training. The significant variation in the "privacy" factor highlights a potential area of concern; it may reflect that younger senior (60–64) feel less confident managing privacy settings, which may require targeted support in future training programs.

Table 3. MANOVA results of the scores of the participants according to the gender variable

Sub-scale (MDPQ-16)	Gender	N	Mean	*Ss*	F	p-value	Partial eta squared (ηp^2)	95% CI of mean
Basic	Female	76	3.299	3.921	8.556	.004*	.094	.010–.240
	Male	8	2.563					
Entertainment	Female	76	3.693	.005	.010	.921	<.001	.000–.051
	Male	8	3.666					
Management	Female	76	3.088	.471	.496	.483	.006	.000–.081
	Male	8	2.833					
Information	Female	76	3.573	.275	.640	.426	.008	.000–.088
	Male	8	3.378					
Calendar	Female	76	2.877	1.038	2.257	.137	.027	.003–.133
	Male	8	2.499					
Take a photo	Female	76	4.288	.331	1.120	.293	.013	.001–.104
	Male	8	4.501					
Privacy	Female	76	3.145	.527	1.387	.242	.017	.001–.112
	Male	8	2.875					
Application	Female	76	3.063	2.897	6.939	.010*	.078	.005–.217
	Male	8	2.430					

Note: * p<.05 (two-tailed; Bonferroni-adjusted)

Table 4. MANOVA results of the scores of the participants according to the age variable

Factor	Age	N	Mean	*Ss*	F	p-value	Partial eta squared (ηp^2)	95% CI of mean
Basic	60-64	18	3.028					
	65-69	57	3.284	.923	.921	.402	.022	.005–.124
	≥70	9	3.278					
Entertainment	60-64	18	3.925					
	65-69	57	3.590	1.794	1.860	.162	.044	.000–.165
	≥70	9	3.851					
Management	60-64	18	2.815					
	65-69	57	3.204	3.647	1.978	.145	.047	.000–.169
	≥70	9	2.668					
Information	60-64	18	3.463					
	65-69	57	3.585	.205	.236	.791	.006	.000–.082
	≥70	9	3.538					
Calendar	60-64	18	2.879					
	65-69	57	2.834	.036	.038	.963	<.001	.000–.059
	≥70	9	2.814					
Take a photo	60-64	18	4.418					
	65-69	57	4.284	.294	.492	.613	.012	.012–.100
	≥70	9	4.240					
Privacy	60-64[a]	18	2.816					
	65-69[b]	57	3.234	2.526	3.512	.034*	.080	.005–.219
	≥70[c]	9	3.000			a<c<b		
Application	60-64	18	3.075					
	65-69	57	2.957	.401	.443	.644	.011	.013–.097
	≥70	9	3.147					

Note: different superscript letters (a–c) within rows indicate significant between-group differences at * p<.05 (Bonferroni-adjusted)

Table 5 presents the results of the analysis of scores from eight digital-literacy sub-scales across five education levels. Statistically significant contrasts emerged in four domains. Basic skills rose steadily from junior-high to higher-education participants (F(4, 79)=5.782, p<.001, partial eta squared (ηp^2)=.226, 95% CI [.090, .390]), underscoring the foundational advantage conferred by formal schooling. A similar upward trend appeared for entertainment (F(4, 79)=3.254, p=.016, partial eta squared (ηp^2)=.141, 95% CI [.030, .300]). By contrast, the take a photo scores peaked at the senior-high stratum and dipped among degree holders, yet the omnibus effect remained significant (F(4, 79)=3.884, p=.006, partial eta squared (ηp^2)=.164, 95% CI [.044, .330]). Privacy also varied by education (F(4, 79)=3.957, p=.006, partial eta squared (ηp^2)=.167, 95% CI [.045, .328]); junior-high graduates out-performed both primary- and senior-high cohorts, suggesting that intermediate schooling may cultivate the optimal blend of experience and caution for managing security settings. No significant education effects were detected for management (F=2.129, p=.085, partial eta squared (ηp^2)=.097), information (F=2.409, p=.056, partial eta squared (ηp^2)=.109), calendar (F=1.501, p=.210, ηp^2=.071) or application (F=1.708, p=.157, partial eta squared (ηp^2)=.080). The small effect sizes (partial eta squared (ηp^2)<.11) across these domains indicate that, once trained, participants perform comparably in higher-order management, information retrieval, scheduling, and general app handling regardless of educational background.

Table 5. MANOVA results of the scores of the participants according to the education level variable

Factor	Education level	N	Mean	Ss	F	p-value	Partial eta squared (ηp^2)	95% CI of mean
Basic	Primary[a]	38	3.312					
	Basic[b]	17	3.333			.000*		
	Junior high[c]	12	2.597	9.400	5.782	c<d<a <b<e	.226	.084–.392
	Senior high[d]	15	3.212					
	Higher education[e]	2	4.670					
Entertainment	Primary[a]	38	3.561					
	Basic[b]	17	3.881			.016*		
	Junior high[c]	12	3.333	5.799	3.254	c<a<b<d<e	.141	.031–.298
	Senior high[d]	15	3.597					
	Higher education[e]	2	4.670					
Management	Primary	38	3.122					
	Basic	17	2.706					
	Junior high	12	3.167	7.620	2.129	.085	.097	.011–.243
	Senior high	15	3.022					
	Higher education	2	4.670					
Information	Primary	38	3.434					
	Basic	17	3.421					
	Junior high	12	3.779	3.862	2.409	.056	.109	.016–.259
	Senior high	15	3.691					
	Higher education	2	4.585					
Calendar	Primary	38	2.684					
	Basic	17	2.893					
	Junior high	12	3.221	2.736	1.501	.210	.071	.003–.207
	Senior high	15	2.879					
	Higher education	2	2.835					
Take a photo	Primary[a]	38	4.132					
	Basic[b]	17	4.432					
	Junior high[c]	12	4.375	4.033	3.884	.006*	.164	.044–.325
	Senior high[d]	15	4.645			e<a<c<b<d		
	Higher education[e]	2	3.665					
Privacy	Primary[a]	38	3.258					
	Basic[b]	17	2.884			.006*		
	Junior high[c]	12	3.473	5.285	3.957	d<b<e<a<c	.167	.045–.328
	Senior high[d]	15	2.744					
	Higher education[e]	2	3.170					
Application	Primary	38	3.026					
	Basic	17	3.276					
	Junior high	12	2.804	2.955	1.708	.157	.080	.005–.220
	Senior high	15	2.747					
	Higher education	2	3.330					

Note: education groups: a=primary (1–4 yrs), b=basic (5–7), c=junior high (8–10), d=senior high (11–12), e=higher (>12). Superscript letters (a–e) indicate Bonferroni post-hoc results; groups with different letters differ (p<.05). Asterisks denote ANOVA significance: * p <.05

While the analysis found overall improvements in digital literacy among all age groups, participants aged 70 and above and those with lower educational attainment showed comparatively smaller gains. This

may be attributed to several factors, including reduced cognitive flexibility, unfamiliarity with formal learning environments, and potential anxiety related to technology use among older individuals. Socio-cultural factors, such as limited exposure to technology in daily life, traditional learning styles, and reliance on family members for digital tasks, may also contribute to these disparities. Participants with lower educational backgrounds may face greater challenges in grasping abstract digital concepts, interpreting app instructions, or navigating privacy and security settings. Although the statistical findings confirmed significant gains in mobile device proficiency, particularly in communication and transaction-related tasks, the practical implications warrant further discussion. Increased post-intervention scores may reflect greater confidence in performing digital tasks, enhanced autonomy in managing personal affairs online, and reduced dependence on others for accessing essential services. These improvements have the potential to empower older adults to engage more fully with e-health, financial, and social platforms, suggesting that such training programs can be an important instrument for promoting digital inclusion and well-being. Future interventions should consider adaptive pacing, peer learning models, and culturally relevant content to address these cognitive and social barriers.

5. DISCUSSION

This 6-session workshop generated domain-specific yet practically meaningful gains in mobile digital literacy among community-dwelling older adults in Bangkok. Medium effect sizes for the basic (partial eta squared (ηp^2)=.226, 95% CI [.09, .39]) and entertainment (partial eta squared (ηp^2)=.141, 95% CI [.03, .30]) sub-scales parallel those reported in Portugal's the Online Technological Inclusion Workshops (OITO) project, where mentor-guided classes lifted seniors' confidence in everyday smartphone use [26]. Such hands-on formats complement observational modelling approaches that bridge the mobile gap for elders with limited prior exposure [35] and when combined with structured peer interaction, can reduce social isolation and fraud vulnerability highlighted in rapid evidence syntheses [36]. Although age did not moderate most outcomes, the privacy sub-dimension revealed that adults aged 60-64 lagged behind the 65-69 cohort (partial eta squared (ηp^2)=.080, 95% CI [.005, .219]), echoing Korean findings that the "younger-old" show lower security self-efficacy and thus require more scaffolded practice [37]. Programs such as Gluu Essentials, which blend one-to-one coaching with repeated micro-tasks, demonstrate how personalized pacing can consolidate skills across age bands [38], while tablet-based group sessions that leverage social support further accelerate uptake among digitally excluded seniors [39]. Our gender pattern female outperforming male on basic and application tasks reverses the modest male advantage often seen in controlled classroom studies of prospective teachers [40] and mixed-age community samples [41]. Sociocultural roles in Thailand, where grandmothers commonly manage household messaging and payments, likely contribute to this divergence and resonate with "lifeworld" ethnographies of technology adoption in later life [42]. Educational attainment displayed the steepest gradient: participants with >12 years of schooling consistently surpassed junior-high graduates, corroborating Latin-American evidence that blended-delivery workshops disproportionately benefit highly literate learners [43] and Thai data showing that task repetition and pictorial cues are crucial for low-literacy groups [44]. Similar stratification has also been reported in sport-education contexts, where baseline digital skill predicts e-learning engagement [45].

Several limitations temper these conclusions. First, self-selection and a 90% female composition may inflate posttest gains; future studies should adopt stratified random sampling and recruit through municipal registries to reach harder-to-access men and digitally excluded households. Second, some cells most notably the higher-education subgroup (n=2) were under-powered for detecting small effects. Third, reliance on self-reported MDPQ-16 scores may overestimate functional proficiency; integrating timed performance tasks, passive mobile-usage logs, and follow-up qualitative interviews would yield a richer picture of sustained behavior change. Finally, the absence of a long-term follow-up precludes claims about skill retention. Addressing these gaps would align the work with large-scale, mixed-methods trials such as Singapore's Project Wire Up, which paired longitudinal tracking with home-based coaching to document durable gains among low-SES elders [46]. Even so, the present findings offer actionable guidance: coupling mentor-led workshops with peer-support networks, adaptive pacing, and privacy focused micro-modules could help Thailand's digital-government agenda ensure that e-wallets, LINE hospital services, and other data-driven platforms remain accessible, safe, and confidence-building for the nation's rapidly growing senior population.

The present study yields three culturally grounded insights for digital inclusion research. First, we observed a striking gender reversal whereby Thai older women outperformed their male counterparts on basic and application-level mobile skills a pattern seldom reported internationally. This divergence accords with Thailand's matri-centric ethos: while male are culturally designated as household breadwinners and decision makers, female remain primary stewards of day-to-day subsistence activities purchasing groceries, paying utility bills, settling school fees, and managing other domestic finances. As these routine tasks migrate to online platforms, female's dual roles as mothers and wives increasingly compel them to become early

adopters of digital tools and technologies. National surveys of Thai seniors likewise reveal a modest female advantage in digital literacy scores, echoing our findings [47]. Second, our 6-session workshop generated a very large and durable effect (Cohen's $dz=1.86$) despite participants' low baseline proficiency. Third, we provide the first psychometric evidence that the Thai adapted MDPQ-16 exhibits excellent reliability among adults aged ≥60. Collectively, these contributions extend current theory and offer culturally specific guidance for the design of inclusive digital interventions.

6. CONCLUSION

This quasi-experimental investigation confirms that a short, mentor-guided workshop can yield statistically and practically meaningful improvements in older adults' mobile digital-literacy skills: medium-sized effects were observed for the basic and entertainment domains, with smaller yet positive shifts elsewhere. The pattern of change, however, was not uniform. Participants aged ≥70 years and those with limited schooling progressed more modestly than their younger or more-educated peers, whereas femlae and highly educated seniors derived the greatest benefit; adults aged 60–64 remained least confident with privacy controls. These nuances highlight the need for differentiated pacing, scaffolded security modules, and outreach strategies that actively engage digitally excluded male and low-literacy groups. Strengthening such sub-populations' competencies would enhance their autonomy and safeguard their participation in Thailand's expanding e-government ecosystem particularly e-wallet and LINE-based health services.

Study limitations are self-selected, female-dominant sampling; very small higher-education subgroup; reliance on self-report; and the absence of longitudinal follow-up temper generalizability. Future work should employ stratified random recruitment, triangulate questionnaire scores with behavioral log data, and monitor retention over extended intervals. Notwithstanding these caveats, the present findings add to the growing body of evidence that targeted, context-sensitive programmers are pivotal for bridging the digital divide in rapidly ageing urban societies such as Bangkok.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
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E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

All participants provided written informed consent before any study-related procedures were initiated, consistent with the protocol approved by the institutional ethics committee.

ETHICAL APPROVAL

This study adhered to the principles of the Helsinki Declaration and all applicable institutional and national legislation. The ethics committee on human research at Suan Sunandha Rajabhat University gave its clearance to the study (approval number: SSRU-HREC No. 61-065-2-1).

DATA AVAILABILITY

All underlying data supporting the study's findings are fully presented within the article itself.

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