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Digital competence of Vietnamese citizens: An application of digcomp framework and the role of individual factors

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Abstract
Assessment of digital competence for citizens could support the Education Action plan at a national level, a regional level, or even at a global level to enhance the digital skills and competence gap for work and life for digital transformation. This study applies the DigComp framework through a self-administered online survey to 723 citizens in Vietnam, using a sequential exploratory mixed methods research design. Data were analysed using factor analysis, standard descriptive statistics, and simple regression methods, followed by qualitative content analysis from interviews with ten respondents and a focus group discussion with eight stakeholders on digital competence. The results confirmed the validity of the DigComp framework for measuring the digital competence of Vietnamese citizens. Overall, the proficiency level of the 723 surveyed Vietnamese citizens falls between basic and intermediate levels, being more advanced in areas in information and data literacy and communication and collaboration, compared to digital content creation, safety, and problem solving. The results further showed that male citizens with a higher education level, working in the public sector, or living in province with high provincial digital transformation index rankings perceived themselves to be more digital competent than females with a lower educational level, working in the private sector, or living in the province with low provincial digital transformation index rankings. To improve citizens' digital competence, training should be designed that considers not only citizens' digital competence profiles but also their individual characteristics.

Keywords Digital competence · Digital divide · Digital inclusion · DigComp · Citizens

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1 Introduction

The groundbreaking progress in digital technology, alongside the emergence of the Covid-19 pandemic, has been accelerating the digital transformation process around the world toward realization of being a digital nation (Mehrvarz et al., 2021; Penmetsa & Bruque-Camara, 2021; Vu & Hartley, 2018). Vietnam has set an ambitious goal for a National Programme for a digital nation to develop a digital government, a digital economy, and a digital society by 2030 through Decision 749/QD-TTg. The country has accordingly defined clear goals for its digital nation: it will offer 100% of public services online, make a 30% contribution from the digital economy to the nation's GDP, and be ranked among the top 50 global e-government contenders. Although Vietnam is still in its early stage of digital transformation, plans have been implemented to achieve the national target, such as online filing and payments, electronic identity, online banking, open government data, and smart cities. At the same time, the country's internet infrastructure has been rapidly developed and is ranked 62 out of 131 countries in the World Economic Forum's Networked Readiness Index in 2022, having improved eight places since 2016 (Portulans Institute, 2022; Vu & Hartley, 2018).

Despite of potential benefits of the digital technologies, the access and ability to use the new technology are not equally distributed across the differing social groups of citizens between or even within nations – that is, what is called the digital divide (Lissitsa et al., 2022; Van Dijk, 2020). The presence of a digital divide can restrict the full participation of all citizens in a digital nation, and this creates social inequalities, which implies not meeting the Sustainable Development Goal to reduce inequalities within and between countries and ensure that no one is left behind (United Nations, 2020). Recognizing the presence of digital divide, Vietnam aims to build a knowledge society through Decision 1373/QD-TTg to equip all citizens and organisations in society with adequate digital skills, knowledge and attitudes to fully participate in a digital society, in which developing digital competence framework for citizens plays a role.

Findings from an extensive literature review by Lythreatis et al. (2022) on factors influencing the digital divide showed that level of education remained a dominant factor. As a result, to bridge the digital divide, it is crucial to identify the level of digital competence as a set of what skills, knowledge and attitudes a citizen should possess in order to catch up with global digital trends (Carretero et al., 2017; Ferrari & Punie, 2013; Gallardo-Echenique et al., 2015; Ilomäki et al., 2016). Understanding citizens' digital competence can support the development of the Education Action Plan to enhance the digital competence gap for digital transformation, and thereby foster lifelong learning. There are several studies involving assessment of citizens' digital competence. However, these have mainly focused on a specific group, such as Thai older adults in rural areas (Jantavongso, 2022; Sriwisathiyakun & Dhamanitayakul, 2022), business research students in Malaysia (Ahmed, 2022), Italian teenagers (Calvani et al., 2012), and Vietnamese youths (Le et al., 2019). Therefore, assessing digital competence across broader, different groups of citizens remains in need of further investigation.

This study employs the DigComp framework to measure the digital competence of Vietnamese citizens. It explores the relationship of their digital competence with

their individual factors, and it explores ways to improve digital competence for all citizens, because scientific evidence shows that such digital competence may be related to individual characteristics such as *age*, *level of education*, *gender*, *type of job, or his/her geographical location* (Drabowicz, 2021; He & Zhu, 2017; Lucas et al., 2021; Oyedemi & Mogano, 2018; Portillo et al., 2020). Outcomes of this study are expected to support Vietnamese policy makers considering integration of the DigComp framework into national documents to measure the digital competence of all Vietnamese citizens. The identification of digital competence gaps could help policy makers design effective training to improve digital competence with the goal of an inclusive digital nation. Furthermore, the adoption of DigComp for citizens in the case of Vietnam may support an extension of such adoption beyond the European countries to include other countries at an early stage of digital transformation, as Vietnam is.

2 Theoretical background

2.1 The European framework for the digital competence of citizens

The European Commission introduced Digital Competence, also known as DigComp, in 2013. This framework serves as the foundation for an online self-assessment tool. This tool enables individuals to evaluate their digital competence and pinpoint any gaps in knowledge, skills, and attitudes across five key areas for their employability and career development in a digital society. The framework has been developed through four versions (DigComp 1.0, 2.0, 2.1, and 2.2) to include updated examples of knowledge, skills and attitudes (Ferrari & Punie, 2013). This study has adopted DigComp framework 2.1 for two reasons. First, the framework employed Bloom's taxonomy of learning and described the knowledge, skills, and attitudes that form the foundation of digital competence across five competency areas (Ferrari & Punie, 2013) that reflect the ability of a citizen for work and for life in a digital society. Second, the framework targets all citizens, ranging from those with poor digital skills to those with advanced-level digital skills, given a large difference in internet access among European citizens, ranging from 75 to 98% (van Kessel et al., 2022). The number of Vietnam's internet users also is approximately equivalent to Europe's, reaching 72.1 million in 2022 and accounting for 50% of the population (MIC, 2022a).

DigComp 2.1. has identified five key competence areas: (i) *information and data literacy*, (ii) *communication and collaboration*, (iii) *digital content creation*, (iv) *safety*, and (v) *problem solving* (Carretero et al., 2017). *Information and data literacy* denotes an individual's capability to express information requirements, to search for data, information, and content within digital environments, to access and navigate them, and to formulate and revise personal search strategies. *Communication and collaboration* entail an individual's capacity to engage across diverse digital platforms and comprehend suitable digital communication methods within specific contexts. *Digital content creation* involves an individual's capability to generate and modify digital content across various formats and to express ideas through digital

mediums. Competence in digital *safety* indicates an individual's ability to safeguard devices and digital content, recognize risks and threats within digital environments, understand safety and security measures, and prioritize reliability and privacy. *Problem solving* encompasses an individual's aptitude to recognize technical issues while utilizing devices and navigating digital environments, and to effectively resolve them.

2.2 Digital competence and individual factors of the citizens

The relationship between digital competence of citizens and their individual characteristics such as *age*, *level of education*, *gender*, *job sector, and his/her geographical location* is supported through evidence presented in the scientific literature on digital competence. In *age*, some studies have not found a relationship between it and digital competence (Tondeur et al., 2018), while others suggest it has a negative effect (Lucas et al., 2021). It could thus be argued that a younger person, e.g., aged 18–24, who has access to and started using digital technologies earlier than older people, may have better skills and greater confidence using these technologies. However, if a person starts training in ICT use after his/her secondary educational stage or postgraduate degree, where there is a small variance in age, age has no impact on digital competence. For *level of education*, Portillo et al. (2020) found that the higher the level a person has achieved, the higher the digital competence he/she obtains. Van Deursen and van Dijk (2009) have shown that educational level achieved emerges as the primary correlating factor with the proficiency levels of operational, formal, informational, and strategic skills in utilizing online public information and services within the Dutch population. *Gender* differences in digital competence have also been observed in the literature. For instance, women seem to be less digitally competent in access and use of the Internet, which confirms a digital divide by gender (He & Zhu, 2017; Jiménez-Hernández et al., 2020), yet some authors have discovered that females have better digital skills than males in focusing on communication in a safe, responsible and effective way (Aesaert & van Braak, 2015). In *job sector*, Drabowicz (2021) has found that, compared with working in the private sector, working in the public sector has been found to be negatively associated with the level of digital skills in Poland. This indicates the need to improve the digital skills of a national workforce to ease the path into national digital transformation. Regarding *geographical location*, Oyedemi and Mogano (2018) has shown that individuals living in affluent and urbanized areas tend to have advantages due to their proximity to economic and social resources, technological infrastructure, and improved access to digital communication technologies. Consequently, it is likely that these individuals possess better digital competence. Conversely, individuals in rural and remote locations often encounter challenges in accessing similar resources and technologies, which can hinder their digital competence. In the Vietnamese context, the geographical location, along with the corresponding digital transformation index (DTI) ranking, may have a positive influence on an individual's digital competence. The DTI rankings for localities nationwide, based on the pillars of digital government, digital economy, and digital society, provide an overview of the

digital transformation progress in Vietnam and serve as a means to track the national digital transformation. The DTI, ranging from 0 to 1 point, encompasses indicators related to digital awareness, institutional transformation, digital infrastructure and platforms, information and data, social activities, cybersecurity, training, and digital human resources. Therefore, an individual residing in a province with a digital transformation index equal to or above the nationwide average DTI value of 0.49 is expected to perceive a higher level of digital competence.

2.3 Research questions

The following research questions are formulated:

RQ1: What is the validity of DigComp in the Vietnamese context?
RQ2: What is the current status of digital competence for Vietnamese citizens?
RQ3: What is the relationship between personal factors and Vietnamese citizens' digital competence?
RQ4: How can the digital competence of Vietnamese citizens be enhanced for participation in a digital nation?

3 Material and methods

This section describes the data collection procedure and the data analyses employed to answer the research questions. A sequential exploratory mixed methods research design was employed, consisting of a self-administered online survey followed by ten interviews with randomly selected respondents about their self-assessment experience and a focus group discussion with stakeholders with knowledge around digital competence. The use of mixed methods has been recommended by Clifford et al. (2020) and an extensive literature review by Zhao et al. (2021) to provide insights into the respondents' experience with the self-assessment instrument. A sequential exploratory mixed method is also widely employed in the education studies (Arslantas & Gul, 2022; Birgili & Demir, 2022; Farrokhnia et al., 2022; Rezai et al., 2022).

3.1 Data collection

Data for this study were collected based on three activities. Firstly, from May and September 2022, we conducted self-administered online survey targeting the Vietnamese citizens above 18 years of age using Qualtrics platform. Prior to the data collection, we obtained research ethics approval from our university's Research Ethics Committee. We provided comprehensive and transparent details of the survey to the respondents and obtained their consent before proceeding to collect the respondent's data. These measures were displayed prominently in the online questionnaire and explained to the respondents before they proceeded. The respondents in the survey were often reminded of their rights, and that their participation was voluntary. We also emphasise that only non-identifiable data were

collected from the respondents for research purposes. The assessment tool was adapted from DigCompSAT, a self-reflection tool associated with the European Digital Competence Framework for Citizens, which is shown in Appendix 1 (Clifford et al., 2020). DigComp 2.1 has eight levels of proficiency ranging from 1 to 8, which can be grouped into four broader levels: Foundation (levels 1 and 2), Intermediate (3 and 4), Advanced (5 and 6) and Highly Specialised (7 and 8). Considering the length of the questionnaire, which contained many questions and could be perceived as overwhelming to the respondents and potentially lead to non-response, we used the four broad levels in our questionnaire to measure the respondents' proficiency. Accordingly, the self-assessment instrument has 82 items and respondents' choices cover the three proficiency levels (i.e., foundation, intermediate, and advanced), plus an option "I have no knowledge of this / I never heard of this / I don't know how to do it / Not at all" for the lack of knowledge, skills, or attitude. The item bank was in English, which required Vietnamese translation for our Vietnamese audience's accessibility. We employed the double-translation method to ensure the content validity of the Vietnamese version: two independent Vietnamese native speakers fluent in English translated the items bank into Vietnamese. To maintain the readability and understandability of items bank to all Vietnamese, we conducted a face-to-face pilot survey in May 2022 with ten randomly selected citizens aged 18 to above 55 years old (the identified age range in the main survey), in public areas. The research team refined the items bank according to feedback from the pilot survey. Subsequently, an independent native English translator expert fluent in Vietnamese translated the content back to English. The back-translation was carefully reviewed by the research team and compared with the original English version to ensure equivalence with the original version.

Non-probability sampling strategies, consisting of convenience and snowball sampling, were facilitated for data collection. Between June and September 2022, we were invited by leaders in Binh Phuoc and Dak Nong provinces to conduct digital transformation training for the local citizens, government officials, and business owners. In-person training sessions were conducted along with a broadcast live to people within the provinces, attracting approximately 5,000 audiences across each province. After each training session, the link and QR code to our online DigComp questionnaire were displayed, encouraging people to participate in the survey. In addition, we asked people to distribute the online questionnaire to their personal networks for a broader reach. This was further distributed to the people living in Ho Chi Minh City, Binh Phuoc, Can Tho City, Binh Duong, and Hanoi to improve our sample representativeness based on the government's digital transformation index 2022 (DTI – https://dti.gov.vn). The DTI ranked the digital transformation levels of provinces based on three dimensions: digital government, digital economy, and digital society. Accordingly, Ho Chi Minh City was ranked 3rd in the country, followed by Binh Phuoc (ranked 9th), Can Tho (ranked 15th), Binh Duong (ranked 22nd), Ha Noi (ranked 40th), and Dak Nong (ranked 41st). The combined use of the convenience and snowball sampling enabled us to reach out to the relevant target segment of the population that is typically more challenging to access (Fereshteh et al. 2017).

This study received responses from a total of 755 surveyed citizens from provinces with a DTI being equal to or above 0.49, including Ho Chi Minh City (48

respondents) and Binh Phuoc (54 respondents), and those with a DTI below 0.49, including Can Tho City (133 respondents), Binh Duong (195 respondents), Ha Noi Capital (146 respondents), Dak Nong (118 respondents), and others (29 respondents). After screening for completion of the questionnaire and time spent of less than ten minutes, 32 cases were excluded from the analyses.

Summary statistics of the demographic characteristics of the surveyed citizens are presented in Table 1. Sixty-five percent of respondents are in the age range 18–34 years, and only about 9% are over 54 years old. There are more females (53%) than males (47%), and the overwhelming majority are above high school (73%). There are similar proportions of respondents working in the public and other sectors.

The second activity, in November 2022, was for interviews with ten randomly surveyed citizens equally distributed across age groups that were drawn from the list of surveyed citizens. The interviews were conducted online via Microsoft Teams. These interviews aim to provide insights into the self-assessment experience. Interview questions suggested by the DigComp framework include: (1) What are your thoughts on the complexity of the questions? Could you provide some examples? (2) How do you feel about the length of the questionnaire? (3) To what extent do you believe this questionnaire aided in your comprehension of the scope of digital skills you could acquire? (4) If there is provision of training, which subjects do you recommend? In which ways of interaction would you recommend for such training? For instance, fully online, or blended learning with the help of an IT officer.

Table 1 Demographic characteristics of the respondents

Demographic characteristics	Proportion	$N=723$
Age		
18–34	65%	473
35–54	26%	188
> 54	9%	62
Gender		
Male	47%	342
Female	53%	381
Education		
Above high school	81%	588
Others	19%	135
Job sector		
Public	59%	429
Others	41%	294
Location		
Ho Chi Minh (DTI = 0.5609)	7%	48
Binh Phuoc (DTI = 0.4954)	7%	54
Can Tho (DTI = 0.4794)	18%	133
Binh Duong (DTI = 0.4538)	27%	195
Ha Noi (DTI = 0.3535)	21%	146
Dak Nong (DTI = 0.3509)	16%	118
Others (DTI < 0.49)	4%	29

The third activity, in November 2022, was for a focus group discussion with eight stakeholders with knowledge of digital competence. The eight stakeholders' profiles are shown in Table 2. The focus group discussion was facilitated over a period of one and a half hours. At the beginning of the focus group discussion, the research team presented the aim of the project and the research team's background, followed by an explanation of DigComp framework. Next, the research team shared the outcomes of the digital competence self-assessment based on DigComp survey of 723 citizens. Two questions are asked to each person: (1) "How appropriate is DigComp to measure the digital competence of all Vietnamese citizens?" and (2) "Which ways will potentially increase the digital competence of Vietnamese citizens?".

3.2 Data analysis

The data analysis included factor analysis to assess the validity of the DigComp scale on the sample of Vietnamese citizens (RQ1), descriptive statistics to present the status quo of Vietnamese citizens' digital competence (RQ2), simple regression analyses to evaluate the effect of individual factors on digital competence (RQ3), and qualitative content analysis to assess the appropriateness of the DigComp framework for citizens in the Vietnamese context and to identify ways to enhance the digital competence of Vietnamese citizens (RQ4).

First, factor analysis was used to examine the reliability and validity of the measurement items adopted from DigComp version 2.1. The measurement items were then grouped into five digital competence areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. The internal consistency reliability was measured using Cronbach's alpha, in which values above 0.7 are recommended. Convergent validity is adequate when constructs have an average variance extracted (AVE) of at least 0.5 and composite reliability (CR) of at least 0.7) (Hair et al., 2019). Standard descriptive statistical methods were used to measure the frequency of respondents' demographic characteristics and their digital competence levels.

Digital competence areas confirmed insight into the underlying relationships with respondents' demographic characteristics using simple regression methods. The regression models were presented in the following forms:

$$DC_{i,t} = f\left(age_t, gender_t, education_t, job_t, location_t, \varepsilon_t\right) \quad (1)$$

where $DC_{i,t}$ (i = 1,2,3,4,5,6) is the average proficiency scores of each five digital competence areas (information and data literacy, communication and collaboration, digital content creation, safety, and problem solving), and the average overall score of all five digital competence areas perceived by respondents. Individual characteristics include *age* (age groups of respondent: 1 = from 18 to 34 years old, 2 = from 35 to 54 years old, 3 = above 54 years old), *gender* (gender of respondent: 1 = male, 0 = female), *education* (level of education: 1 = above high school, 0 = others), type of *jobsector* (job sector of respondent: 1 = public, 0 = others), and *location* (location classified according to the provincial digital transformation index where the respondent lives: 1 = equal or above 0.49, 0 = below 0.49). To classify the three age groups, three age dummy variables were generated

Table 2 Demographic characteristics of the stakeholders

Position	Number of stakeholders	Experience (years)	Description of role
Leader of local government	3	5–8 years	Lead and coordinate the digital transformation program of the province/city
Project manager in e-healthcare	1	15 years	Manage the healthcare systems in either public or private hospitals Develop the applications of digital technologies in the healthcare sector
Leader of bank	1	20 years	Manage the digital transformation program of the bank
Leader of university	1	23 years	Manage the quality assurance of university under various quality assurance schemes at the national and international level
Senior manager of digital business	1	7 years	Develop and manage the electronic marketplace, e-commerce
Leader of information technology association	1	> 20 years	Promote the development of information technologies to the Vietnamese community in public and private sectors Lead the digital transformation programs for micro, small and medium enterprises

accordingly. According to the population structure by age group of the General Statistics Office of Vietnam in 2021, individuals between 18–34 age group are categorized as young adults; those 35–45 are labeled as middle-aged adults; and those aged 54 and above are classified as older adults. A similar age classification was also presented in the study by Petry (2002). Factor analyses were conducted using Statistical Package for the Social Sciences (SPSS, v.25), Microsoft Excel, and regression outputs were estimated using Statistical Software for Data Science (STATA, v.15).

Finally, qualitative content analysis was applied to structure and evaluate the diverse information from the full transcripts of interviews and focus group discussion (Mayring, 2000). The results of the qualitative content analysis cover the respondents' experience with the self-assessment measurement of digital competence, and views of stakeholders for the adoption of DigComp in the case of Vietnam, and ways to improve digital competence for Vietnamese citizens.

4 Results

This section presents outcomes of the validity of the instrument, the descriptive statistics on the status quo of Vietnamese citizens' digital competence, analysis of the impact of respondents' demographic characteristics on their digital competence areas, and, finally, the outcomes of discussion with respondents and stakeholders.

4.1 The validity of DigComp to measure the digital competence of Vietnamese citizens

Vietnam has over 75 million social media users, which accounts for more than 70% of the population, placing it among the top ten countries with the highest number of Facebook and YouTube users globally (MIC, 2022b). With such a substantial user presence, Facebook has emerged as a powerful tool for connecting people and communities. However, due to the rapid growth of social media users, the centralized Vietnamese government seeks to regulate social media influencers, exercise content censorship, and restrict discussion topics to maintain control over the population. The government's objective is to shape the narrative surrounding social issues and suppress dissenting voices (Le & Hutchinson, 2022). Consequently, this study excluded the items "It matters to me to debate social or political issues online (e.g. in online forums, news sites, Facebook, Twitter)" and "I know that the EU introduced regulation on The Right to Be Forgotten (i.e. to have one's private information removed from the Internet)." as these items are not applicable in the Vietnamese context.

After removing these non-applicable items for the Vietnamese context, using factor analysis (Appendix 1), results show that all Cronbach's alpha estimates were determined as reliable (greater than the value of 0.9), and all item loadings exceeded the value of 0.6. This suggests sufficient reliability of all constructs utilized in the model. Convergent validity is deemed adequate, as constructs exhibit

Table 3 Descriptive statistics of proficiency levels in the five digital competence areas

Digital competence area	Mean	Standard deviation
1. Information and data literacy	1.71	0.62
2. Communication and collaboration	1.68	0.62
3. Digital content creation	1.39	0.64
4. Safety	1.49	0.62
5. Problem solving	1.54	0.63
Overall proficiency level	**1.56**	**0.58**

an average variance extracted (AVE) and composite reliability (CR) values exceeding 0.9.

4.2 The status quo of Vietnamese citizens' digital competence

The general descriptive statistics of proficiency level in the five digital competence areas are presented in Table 3. A score of 1 indicates the basic level, score 2 indicates the intermediate level, and score 3 indicates the advanced level. Additionally, a score of 0 represents proficiency below the basic level. The overall digital competence proficiency level falls between basic and intermediate levels, with a score of 1.56 out of 3.00. The five competence areas' scores range from 1.39 to 1.71. In particular, the respondents scored the highest information and data literacy (1.71) and communication and collaboration (1.68), followed by problem solving (1.54) and safety (1.49). Digital content creation had lowest score of 1.39. Figure 1 presents the proportion of proficiency levels in five digital competence areas among surveyed citizens. Overall, most citizens reach the basic proficiency level with 62.4%, intermediate level with 22.4%, and only 0.4% at advanced proficiency level; others were 14.8%, with no knowledge/skills/attitude.

4.3 The relationship between digital competence and individual factors

Table 4 presents the average digital competence scores and standard deviations (SD) of the independent variables. Furthermore, Table 5 shows the regression results, highlighting the relationship between the respondents' demographic characteristics and their digital competence scores. The goodness-of-fit of the models is evidenced by the adjusted R^2 at the 1% significance level, indicating a well-fitted model with independent variables possessing considerable predictive power. However, the explanatory level of R^2 was relatively low for all linear regression models, which were similar to the simple regression findings of Cattaneo et al. (2022) in analysing the personal and contextual factors influencing digital competence in a vocational context. White heteroscedasticity tests revealed that these models do not violate the assumption of homoscedasticity of the regressions and are statistically significant at the 1% level. Overall, the

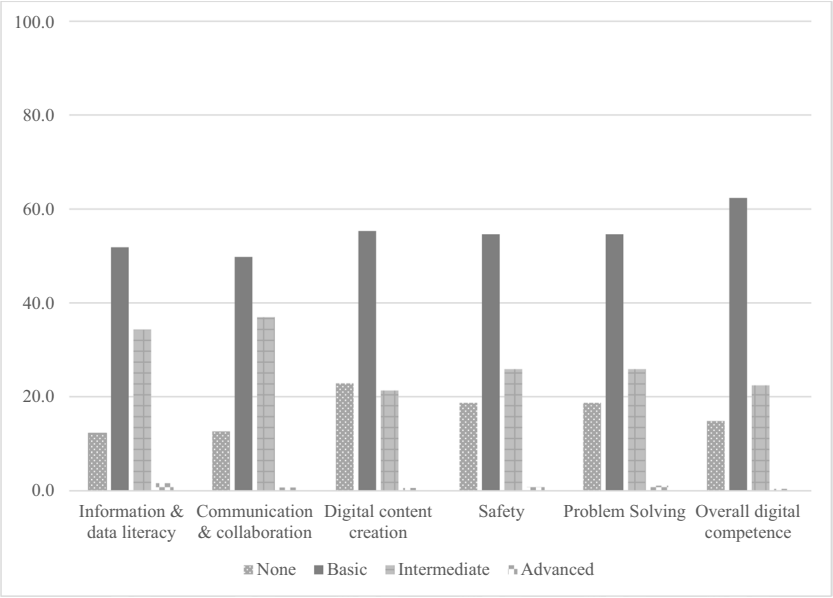

Fig. 1 Proportion of proficiency levels in the five digital competence areas among those surveyed

results show that respondents' demographic characteristics positively affect their overall digital competence scores, except for the *age* groups. This finding implies that respondents of all ages have the potential to improve their digital competence. The parameters are statistically significant at either the 1%, 5% or 10% significance level.

Regarding the five areas of digital competences, the regression results reveal the both the age groups of 18–34 and 35–54 have a significant positive impact on the area of *digital content creation*. This finding supports the general opinion that younger generations tend to exhibit better digital skills in content creation (Buckingham, 2008; Oyedemi, 2014). Similarly, *education* has a positive effect on all areas of digital competence, which reveals the crucial role of education in increasing digital competence for citizens.

The results additionally demonstrate that *gender* has a positive effect on all areas of digital competence. This indicates that male respondents are better than their female counterparts in the use of digital devices and services. Furthermore, the positive effect of *job sector* on four areas of digital competence of *information and data literacy, communication and collaboration, digital content creation, and problem solving* indicates that respondents working in the public sector are better equipped with digital competences than others.

In terms of *location*, based on the provincial digital transformation index, results show that respondents who are from the provincial digital transformation index areas higher than 0.49, such as Ho Chi Minh City, have slightly higher digital competence scores in the areas of *information and data literacy,*

Table 4 Average digital competence scores and standard deviations (SD) of the independent variables

Independent variable	Area of Information and data literacy		Area of Communication and collaboration		Area of Digital content creation		Area of Safety		Area of Problem solving		Overall digital competence	
	Average	*SD*	*Average*	*SD*	*Average*	*SD*	*Average*	*SD*	*Average*	*SD*	*Average*	*SD*
Age (18–34)	1.76	0.58	1.77	0.59	1.51	0.60	1.57	0.61	1.61	0.60	1.64	0.54
Age (35–54)	1.68	0.65	1.60	0.63	1.22	0.65	1.41	0.61	1.48	0.62	1.48	0.60
Age (> 54)	0.99	0.64	0.78	0.49	0.52	0.53	0.81	0.51	0.68	0.52	0.76	0.49
Education												
Above high school	1.81	0.57	1.80	0.55	1.50	0.58	1.59	0.57	1.65	0.57	1.67	0.52
Others	1.27	0.66	1.18	0.69	0.89	0.70	1.07	0.66	1.07	0.68	1.10	0.63
Gender												
Male	1.76	0.64	1.71	0.64	1.42	0.65	1.55	0.63	1.60	0.64	1.61	0.59
Female	1.66	0.60	1.66	0.61	1.36	0.64	1.44	0.62	1.49	0.61	1.52	0.57
Job sector												
Public	1.77	0.63	1.75	0.61	1.43	0.63	1.53	0.61	1.60	0.62	1.62	0.57
Others	1.61	0.63	1.59	0.64	1.32	0.67	1.44	0.64	1.45	0.64	1.48	0.60
Location												
Equal or above DTI 0.49	1.95	0.59	1.97	0.58	1.53	0.57	1.65	0.58	1.72	0.60	1.76	0.53
Below DTI 0.49	1.67	0.62	1.64	0.62	1.36	0.65	1.47	0.63	1.51	0.63	1.53	0.58

Table 5 Parameters and their standard errors (SE) resulting from simple linear regression analysis

Independent variable	Area of Information and data literacy		Area of Communication and collaboration		Area of Digital content creation		Area of Safety		Area of Problem solving		Overall digital competence	
	Coefficient	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*
Age (18–34)	0.238	0.413	0.089	0.398	0.945**	0.413	0.434	0.419	0.394	0.410	0.421	0.374
Age (35–54)	0.194	0.410	-0.036	0.396	0.720*	0.410	0.318	0.416	0.313	0.407	0.302	0.371
Age (> 54)	-0.208	0.408	-0.503	0.393	0.204	0.407	-0.061	0.413	-0.225	0.405	-0.157	0.369
Education	0.389***	0.058	0.431***	0.056	0.417***	0.058	0.378***	0.059	0.398***	0.058	0.403***	0.053
Gender	0.116***	0.043	0.079*	0.042	0.113**	0.043	0.130***	0.044	0.134***	0.043	0.114***	0.039
Job sector	0.109**	0.045	0.118***	0.043	0.095**	0.044	0.058	0.045	0.112**	0.044	0.098**	0.040
Location	0.183***	0.061	0.227***	0.059	0.074	0.061	0.097	0.062	0.100	0.061	0.136**	0.055
R^2	0.168***		0.230***		0.227***		0.152***		0.200***		0.222***	
Adjusted R^2	0.159		0.222		0.219		0.144		0.193		0.214	
White heteroscedasticity statistics[a]	0.53 (0.465)		0.23 (0.628)		1.81 (0.367)		1.15 (0.699)		0.05 (0.826)		0.01 (0.926)	

****Values significant at 1% level; **Values significant at 5% level; *Values significant at 10% level*

[a]*White statistics of the regressions and numbers in paratheses are P-values*

communication and collaboration than those from provinces with a digital transformation index less than 0.49.

4.4 Feedback from respondents for their self-assessment experience

Regarding the difficulty of self-assessment questions and their length, all respondents agreed that the questions were easy to answer, but the length of questionnaire was relatively long. It took them about 40 min to complete the questionnaire the first time. Respondents thought that the self-assessment questions fairly helped them to understand their digital skills, with a result at 70%, which provides a positive signal to the usage of DigComp for citizens in the Vietnamese context. Finally, in terms of the provision of training to enhance digital skills, all respondents agreed that open online courses would be an effective way to enhance their digital skills, but support from an information technology officer would be needed for respondents above 50 years of age. One example of respondent feedback is as follow:

> "*In my opinion, these questions are appropriate and easy to answer. However, I need to go through the questionnaire (first 10-15 questions) twice to familiarize myself with it. Initially, I found them difficult to understand and doubted my knowledge in this field. But after reading the response options carefully, I found them suitable. This questionnaire helped me grasp about 60% of the learnable digital skills. Taking online courses in the five areas of digital competencies would be beneficial."*

4.5 Additional information from the discussion with eight stakeholders on digital competence

Regarding the appropriateness of DigComp in the Vietnamese context, seven of eight stakeholders strongly supported the use of a referenced and well-developed digital competence framework such as DigComp for the case of Vietnam. A senior leader of the Information Technology's association and President of an Information Technology company observed that "*Once we use the same standard as other countries to measure our citizens' digital competence, we can compare our measurements with the others. The questions that are provided to Vietnamese citizens should be similar to the questions as shown in the DigComp for the Europeans*". Another local government leader added that "*DigComp can be applied in all regions of Vietnam. However, for the mountainous areas with limited internet access, self-assessment might not be achievable for everyone*". Self-assessment could be conducted with the help of an information technology officer.

A concern about the unfavorable adoption of DigComp by a senior manager of a digital business was about the appropriateness of DigComp to measure digital competence for high-tech citizens: "*I can see that online sellers have significantly improved their digital competence in the past five years. In our*

digital marketplace, sellers could make hundreds of orders a day, even up to thousands of orders a month". Therefore, another framework could be developed to measure the digital competence of such high-tech citizens, for instance, DigComp at work.

All stakeholders agreed that digital transformation in a nation is only successfully achieved with the participation of citizens. Therefore, it is most important to increase the digital competence for all Vietnamese citizens. According to the suggestions of stakeholders, there are many ways to increase this digital competence. For instance, public media could be used to increase citizens' awareness about the national digital transformation programme and promotion of the role of digital technologies in the community. The government should prioritize training in digital competence for citizens located in remote rural areas who had less advantages than those in large cities. One of the learning platforms could be the Massive Open Online Courses (MOOCs) becoming available to all citizens, which is planned for implementation by the Vietnamese government as specified in the National Education Action Plan through Decision 411/QD-TTg in 2022. MOOCs has recently introduced in various countries as potential roles to prepare citizens for participation in a digital society as well as the possibilities of lifelong learning (Bordoloi et al., 2020; Bordoloi et al., 2020; Zheng et al., 2018). The initial training could guide people on how to join e-commerce platforms, how to make online payments, and how to use online public services. A government leader suggested that training should be prioritized for village-based civil servants, leaders of micro, small and medium enterprises, leaders of cooperatives, and agricultural enterprises targeting international markets.

5 Discussion

The findings of this study provide several significant insights into digital competence of Vietnamese citizens through using the DigComp framework and its relationship with individual factors. First, this study shows that an overall proficiency level of the 723 surveyed Vietnamese citizens reached between basic and intermediate levels with a mean value of 1.56 on a 0 to three-point scale, which is above the average score. This result is compatible with the pilot tests of DigComp for citizens in Spain and Latvia, where the average proficiency levels of citizens were similarly at an intermediate level (Clifford et al., 2020). The intermediate proficiency level in the digital competence of Vietnamese citizens surveyed could result from the modification of national education programme by additional digital knowledge being provided in classes and through extracurricular activities to promote digital skills for educators and students in recent years (OpenGovAsia, 2022). In addition to the efforts of the government, businesses in Vietnam are also offering numerous opportunities to enhance the digital skills of their employees. Seventy-three percent of respondents reported being proficient in utilizing new technologies in their workplace (PwC, 2021). Such efforts have driven the national digital transformation index of Vietnam

in 2022 to be 0.60 or slightly above the average score. Moreover, surveyed citizens felt more advanced in the areas of *information and data literacy* and *communication and collaboration*, which may be attributed to the frequent use of digital technologies in their daily lives in these two areas. On the contrary, the areas in which citizens have the least confidence are digital content creation, safety, and problem solving. The low self-evaluation in digital content creation and problem solving can be attributed to the fact that individuals largely learn these skills on their own, aligning with findings from Napal Fraile et al. (2018). Similarly, the low level of cyber security knowledge among internet users has been a current concern in many developing countries, as highlighted in studies such as Chang and Coppel (2020) and Zwilling et al. (2022).

Individual factors such as *gender*, *education*, *job sector*, and *location* were found to influence digital competence of an individual. More specifically, citizens who are male are generally better at information and data literacy, communication and collaboration, digital content creation, safety, and problem solving than their female counterparts. In fact, males show a higher level of computer interest than females (Broos, 2005). Therefore, when problems are encountered with using technical devices, males are better than females in the use of different technologies to create innovative solutions, as suggested by Çebi and Reisoğlu (2020) and Esteve-Mon et al. (2020). *Education* has a strong impact on the digital competence of an individual, implying that a citizen with an education level above high school is found to outperform others in all five digital competence areas. The positive relationship between level of education and digital skills was also found in the settings of working professionals (van Laar et al., 2019) and in education (Yang et al., 2022). Furthermore, a citizen working in the public *sector* was digitally better than one working in other sectors, particularly in the areas of information and data literacy, communication and collaboration, and problem solving, which likely resulted from a training programme in digital transformation in the public sector in recent years to meet the digital government transformation agenda in Vietnam (World Bank, 2021).

Regarding *location*, it aligns with the prior expectation, citizens living and working in the provinces with a digital transformation index equal to or above 0.49 perceived themselves more digitally competent, particularly in areas of information and data literacy, communication and collaboration than their peers with lower provincial digital transformation index rankings. This positive relationship could relate to the fact that government leaders of these high digital transformation index rankings greatly support digital transformation projects. Notably, Ho Chi Minh City and Binh Phuoc are positioned in the top 10 provinces at the forefront of digital transformation, demonstrating pioneering efforts in establishing Intelligent Operation Center (IOC) and implementing digital government initiatives (MIC, 2020, 2022c). They have a strong expectation for their employees and local citizens in the adoption of digital services. Therefore, these provinces emphasised the importance of digital literacy to government leaders, government officers, citizens, and businesses in their provincial digital transformation action plans. Additionally, it has been found that *age* groups do not

have effect on an individual's overall digital competence. This can be explained through the nature of workplace requirements or learning culture in the Vietnamese context. For instance, Nguyen et al. (2022) have shown that, in the Vietnam's digital environment, about 35% of elderly people aged 60 years and older are still working, which motivates them to actively communicate with people and adapt to surrounding digital society. Likewise, in Vietnamese culture, education is considered as an essential form of capital. As such, both Vietnamese citizen and the government invest in building a lifelong learning society (Hossain, 2016; Vu, 2022). One of the government's initiatives is the promotion of a reading culture (including e-books and e-libraries) to enhance the citizens' knowledge and quality of life. A common motto displayed in schools across Vietnam is "learn, learn more, learn forever" (học, học nữa, học mãi) (Crocco et al., 2021). Results of this study overall confirm the appropriateness of the adoption of the DigComp framework for citizens in Vietnam through the online self-administered survey mechanism, interviews with respondents, and a focus group with stakeholders. The DigComp framework has also been used as a basis for the development of the Digital Literacy Global Framework by UNESCO (Law et al., 2018). However, in the Vietnam there remain challenging areas that need to be addressed, as follows:

- The statements "It matters to me to express opinions on social or political issues on discussion forums or in social media (e.g., Facebook, Twitter)" and "I know that the EU introduced regulation on The Right to Be Forgotten" need to be adjusted to fit the Vietnamese context.
- The length of the self-assessment questionnaire is relatively long as perceived by the respondents.
- The stand-alone self-assessment instrument is not applicable for limited internet access in remote areas and for the disadvantaged groups such as the elderly. Therefore, there is a need of assistance from an information technology officer.
- Different digital competence frameworks should be created for high-tech citizens.

6 Conclusion and implications

The development of a digital competence framework for citizens is considered to be an important step to support the design of training for achieving an inclusive digital nation. This study validates the use of the self-assessment instrument based on the DigComp framework for citizens in Vietnam, using a combination of quantitative and qualitative approaches. The individual factors affecting the digital competence of citizens are also analysed.

Results suggest that the digital competence of surveyed Vietnamese citizens achieves between basic and intermediate levels. A citizen with education above high school, male, working in the public sector, or living in the province with higher provincial digital transformation index is likely to have higher digital competence.

The online self-assessment instrument seems to be limited in its adoption widely for citizens, including those living in remote areas with limited internet access. Furthermore, the questions in the DigComp for citizens are not appropriate for high-tech citizens.

Findings of this study confirm the appropriateness of adopting the DigComp framework for citizens to measure digital competence of citizens in Vietnam. This provides a positive signal for countries at an early stage of digital transformation, like Vietnam, to adopt the DigComp framework. Given the low digital competence areas in problem solving, safety, and digital content creation of Vietnamese citizens, training related to these areas is recommended, for example through courses including cybersecurity, benefits and challenges using digital devices for healthcare, IT troubleshooting, and digital content creation. These courses will initially commence at a foundational level, progressively advancing toward specialized competencies aligned with individuals' strengths, passions, and employment prospects. They will also continuously offer retraining opportunities to adapt to changes in the job market (Kowalska-Chrzanowska et al., 2021; Zhuhadar et al., 2017). Such training could be prioritized for the group of citizens with education below high- school level, females, working in sectors other than the public sector, and living in the low provincial index ranking areas for digital transformation. Various training channels such as Massive Open Online Courses through online platforms or blended learning with the help of information technology officers could be considered as an effective way to increase the digital competence of a citizen, given the existing information technology officers in every village in Vietnam. Regarding the enhancement of digital citizen capabilities for a country through a training system, it is essential to create a comprehensive business model. This model should encompass the design, implementation, and evaluation phases. A robust business framework can clarify the roles of stakeholders, guarantee inclusivity for learners from various socio-economic backgrounds, and provide a sustainable financial strategy to sustain the training system. Such a model is also designed to bridge the gap in digital competences arising from individual factors at the national, provincial, institutional, and educational levels, thus fostering a digital inclusion.

This study made attempts to reach as many Vietnamese citizens as possible, aiming for a large and representative sample. To achieve this, the study utilized an online platform and employed snowball sampling technique. Only respondents who fully completed the online self-assessment were considered for analysis. For future studies aiming to measure digital competence across all groups of Vietnamese citizens in a nationwide survey, adopting the DigComp framework would be beneficial. Such studies could consider incorporating elements of AI-related items based on the latest version of DigComp, version 2.2. Moreover, to further enhance the validity of the DigComp framework for citizens, follow-up interviews or focus group discussions with additional surveyed participants can be conducted to explore the relationship between individual factors and digital competences.

Appendix 1

Reliability and validity for digital competence areas

Digital competence area	Measurement item	Convergent validity and internal consistency reliability			
		Loading > 0.50	AVE > 0.50	Cronbach's Alpha > 0.70	Composite Reliability (CR) > 0.70
Information and data literacy	I know that different search engines may give different search results, because they are influenced by commercial factors	0.74	0.58	0.93	0.94
	I know which words to use in order to find what I need quickly (e.g. to search online or within a document)	0.74			
	When I use a search engine, I can take advantage of its advanced features	0.73			
	I know how to find a website I have visited before	0.78			
	I know how to differentiate promoted content from other content I find or receive online (e.g. recognising an advert on social media or search engines)	0.81			
	I know how to identify the purpose of an online information source (e.g. to inform, influence, entertain, or sell)	0.78			
	I critically check if the information I find online is reliable	0.72			
	I know that some information on the Internet is false (e.g. fake news)	0.76			
	I know about different storage media (e.g. internal or external hard disk, USB memory, pen drive, memory card)	0.78			
	I know how to organise digital content (e.g. documents, images, videos) using folders or tagging to find them back later	0.80			

Digital competence area	Measurement item	Convergent validity and internal consistency reliability			
		Loading > 0.50	AVE > 0.50	Cronbach's Alpha > 0.70	Composite Reliability (CR) > 0.70
	I know how to copy and move files (e.g. documents, images, videos) between folders, devices or on the cloud	0.76			
	I know how to manage and analyse data using software (e.g. sorting, filtering, calculations)	0.73			
Communication and collaboration	I know how to send, reply and forward e-mails	0.76	0.55	0.96	0.96
	I know that many communication services and social media are free of charge because they are paid for by advertising	0.73			
	I know how to use advanced videoconferencing features (e.g. moderating, recording audio and video)	0.74			
	I know which communication tools and services (e.g. phone, email, video conference, text message) are appropriate to use in different circumstances	0.81			
	I am open towards sharing digital content that I think might be interesting and useful to others	0.66			
	I know how to use cloud services (e.g. Google Drive, DropBox and OneDrive) to share my files	0.76			
	I know how to change who I share content with (e.g. friends, friends of friends, everyone)	0.78			
	I know how to reference the source of documents (e.g. the author or web address) that I found online	0.78			
	I know how to apply for a job using a digital platform (e.g. fill in a form, upload my CV and photo)	0.81			

Digital competence area	Measurement item	Convergent validity and internal consistency reliability			
		Loading > 0.50	AVE > 0.50	Cronbach's Alpha > 0.70	Composite Reliability (CR) > 0.70
	I know that many public services are available on the internet (e.g. bookiI know that many public services are available on the Internet (e.g. booking a health visit, submitting tax declaration, requesting birth, marriage, residence and other certificates).ng a health visit, submitting tax declaration, requesting birth, marriage, residence and other certificates)	0.79			
	I know how to pay for goods and services that I buy online (e.g. using direct bank transfer, credit/debit cards, other online payment systems)	0.78			
	I understand the benefits of remote collaboration (e.g. reduced commuting time)	0.74			
	I know how to edit a shared, online document	0.78			
	I know how to invite others and give appropriate permissions to collaborate on a shared document	0.73			
	I am aware that I should ask permission from a person before publishing or sharing photos about them	0.75			
	I know how to recognise online messages and behaviours that attack certain groups or individuals (e.g. hate speech)	0.75			
	I can take the right measures if someone is doing the wrong thing online (e.g. an offensive comment, threats)	0.68			
	I know how to behave online according to the situation (e.g. formal vs informal)	0.77			
	I know my digital identity is everything that identifies me in online environments (e.g. usernames, likes and posts on social media, petitions signed online)	0.66			

Digital competence area	Measurement item	Convergent validity and internal consistency reliability			
		Loading > 0.50	AVE > 0.50	Cronbach's Alpha > 0.70	Composite Reliability (CR) > 0.70
	I know how to create a profile in digital environments for personal or professional purposes	0.70			
	I know how to configure the settings in my Internet browser to prevent or limit cookies	0.63			
Digital content creation	I know how to create and edit digital text files (e.g. Word, OpenDocument, Google Docs)	0.73	0.52	0.94	0.94
	I know how to express myself by creating digital content on the Internet (e.g. blog post, video on YouTube)	0.76			
	I know how to produce a multimedia presentation with text, images, audio and video elements	0.78			
	To express myself, I am careful to choose the right type of digital media depending on the audience and my aim (e.g. using social media to promote a project)	0.76			
	I am keen to create new digital content by mixing and modifying existing digital resources (e.g. a presentation with photos and a soundtrack found on the Internet)	0.68			
	I know that some digital content can be reused and reworked legally (e.g. public domain or with Creative Commons licences)	0.76			
	I know how to edit or make changes to digital content that others have created (e.g. insert a text into an image, edit a wiki)	0.80			
	I know how to create something new by mixing different types of content (e.g. text and images)	0.78			

Digital competence area	Measurement item	Convergent validity and internal consistency reliability			
		Loading > 0.50	AVE > 0.50	Cronbach's Alpha > 0.70	Composite Reliability (CR) > 0.70
	I am careful to follow the rules about copyrights and licenses of digital content that I find	0.67			
	I know that downloading or sharing digital content (e.g. music, software, films) may have ethical or legal consequences	0.69			
	I can detect when digital content is made available illegally (e.g. software, movies, music, books, TV)	0.72			
	I know which different types of licences apply to the use of digital content (e.g. Creative Commons licences)	0.69			
	I am interested in understanding how a task can be broken down into steps so that it can be automated, for example in software or by a robot	0.66			
	I know that programming languages (e.g. Python, Visual Basic, Java) are used to provide a digital device instructions to carry out a task	0.69			
	I can write scripts, macros and simple applications to automate the execution of a task	0.62			
	I know that there could be different algorithmic solutions to accomplish a specific computational task (e.g. sorting and searching)	0.71			
Safety	I understand the benefits and also the safety risks when using Internet-connected devices or systems (e.g. smart watches, smart home devices)	0.77	0.56	0.95	0.95
	I know about the importance of keeping the operating system, antivirus and other software up-to-date in order to prevent security issues	0.75			
	I know how to configure the settings of a firewall on different devices	0.65			
	I know how to recover digital information and other content (e.g. photos, contacts) from a backup	0.78			

Digital competence area	Measurement item	Convergent validity and internal consistency reliability			
		Loading > 0.50	AVE > 0.50	Cronbach's Alpha > 0.70	Composite Reliability (CR) > 0.70
	I know how to restrict or refuse access to my geographical location	0.77			
	I know how to identify suspicious e-mail messages that try to obtain my personal data	0.75			
	I know how to check that the website where I am asked to provide personal data is secure (e.g. https sites, safety logo or certificate)	0.74			
	I know which personal data I should not share and display online (e.g. on social media)	0.76			
	I am careful about checking the privacy policies of the digital services that I use	0.77			
	I am aware that I should manage the time I spend on my digital devices	0.72			
	I know how to protect myself from unwanted and malicious online encounters and materials (e.g. spam messages, identity theft emails)	0.75			
	I know about digital tools that can help older people or people with special needs	0.77			
	I seek out ways in which digital technologies could help me to live and consume in a more environmentally friendly way	0.74			
	I know that old digital devices and consumables (e.g. computers, smartphones, batteries) must be appropriately disposed to minimise their environmental impact	0.76			
	I know how to reduce the energy consumption of my devices (e.g. change settings, close apps, turn off wifi)	0.73			

Digital competence area	Measurement item	Convergent validity and internal consistency reliability			
		Loading > 0.50	AVE > 0.50	Cronbach's Alpha > 0.70	Composite Reliability (CR) > 0.70
	I know 'green' behaviours to follow when buying or using digital devices (e.g. purchase devices with Eco-label, restrain from unnecessary printing of digital files, do not leave mobile phones and laptop chargers connected without the device)	0.72			
Problem solving	When I face a technical problem, I try step-by-step to identify the problem	0.76	0.56	0.94	0.95
	I know some reasons why a digital device may fail to connect online (e.g. wrong wifi password, airplane mode on)	0.75			
	When I face a technical problem, I am able to find solutions on the Internet	0.78			
	I am able to edit the configurations of the operating system of my digital devices to solve technical problems (e.g. automatic stop/start of services, modify registry keys)	0.69			
	I usually try to find out if there is a technology solution that might help me address a personal or professional need	0.78			
	I know the main functions of the most common digital devices (computer, tablet, smartphone)	0.80			
	I know how to select the right tool, device or service to perform a given task (e.g. select a smartphone for my needs, choose a tool for a professional videocall)	0.75			
	I know technical solutions that can improve the access and use of digital tools such as language translation, magnification or zoom and text-to-voice functionality	0.79			
	I know that digital technology can be used as a powerful tool to innovate processes and products	0.76			

Digital competence area	Measurement item	Convergent validity and internal consistency reliability			
		Loading > 0.50	AVE > 0.50	Cronbach's Alpha > 0.70	Composite Reliability (CR) > 0.70
	I am willing to take part in challenges and contests, aimed at solving intellectual, social or practical problems through digital technologies	0.67			
	I can use data tools (e.g. databases, data mining and analysis software) that manage and organize complex information to make decisions and solve problems	0.73			
	I am willing to help people in my community improve their digital skills	0.74			
	I am curious about new digital devices and applications and I am keen to experiment with them whenever I find the opportunity	0.73			
	I know how to use online learning tools to improve my digital skills (e.g. video tutorial, online courses)	0.78			
	I know about new trends in the digital world and how they impact on my personal or professional life	0.76			

According to Hair et al. (2019), the average variance extracted (AVE) is calculated as the mean variance extracted for the items loading on a construct and is a summary indicator of convergence. This value can be calculated using standardized loadings:

$$AVE = \frac{\sum_{i=1}^{n} L_i^2}{n} \tag{1}$$

L_i represents the completely standardized factor loadings for the i th measured variable and n is the number of item indicators for a construct.

The construct reliability (CR) value is computed from the squared sum of factor loadings (L_i) for each construct and the sum of the error variance terms for a construct (e_i) as:

$$CR = \frac{(\sum_{i=1}^{n} L_i)^2}{(\sum_{i=1}^{n} L_i)^2 + (\sum_{i=1}^{n} e_i)} \tag{2}$$

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