Effect of a coding education program for the elderly to bridge the digital gap on digital self-efficacy

Seung-Mee Lee[1][0009-0001-6615-2846] and Seok-Ju Chun[2][0000-0003-1299-1203]

[1] Seoul Doseong elementary school, Seoul, South Korea
[2] Computer Education, Seoul National University of Education, Seoul, South Korea
1226me@naver.com

Abstract. In a context of rapid demographic and technological change, digital skills are needed more than ever for citizens to actively participate in society, but the level of digital literacy among elderly is lagging. As many services move to the digital world, the digital divide is bound to widen unless appropriate measures are taken to address elderly's fear of technology. Accordingly, this study proposed a new digital literacy education program for elderly and sought to find out what changes there were by focusing on the digital self-efficacy of the elderly. As a result, it was confirmed that the coding education program applied in this study had a positive effect on increasing the digital self-efficacy of the elderly, resulting in a statistically significant change. Improving digital self-efficacy has a positive impact on elderly's life in retirement, such as reducing depression and increasing life satisfaction. We hope that related research will be actively conducted and that 'digital inclusion' will be achieved, where elderly use digital technology to create a quality life.

Keywords: elderly, coding education, digital self-efficacy

1 Introduction

According to demographic statistics, in 1960, 8.1% of the world's population was elderly, this figure increased to 10% in 2000, and it is estimated that by 2050, 21.4% of the population will be elderly [1]. Old age spans from 20 to 30 years of age, and its length is similar to adolescence and early adulthood. Old age, as a stage in life, is as important as any other stage and deserves equal emphasis on development [2].

Over the past few decades, we have developed information technologies to disseminate information and resources and communicate with others [3]. ICT (Information and Communication Technology) is an important component of the era of the Fourth Industrial Revolution and is expanding its presence globally at an unprecedented rate [4]. Today, smartphones are used by most of the population, even in remote and less privileged areas [5]. However, the rapid pace of technological revolution, as evidenced by the increased use of digital mobile devices and the spread of ubiquitous online access, has created a digital gap due to age, social, cultural, and genre factors [6].

In the context of rapid demographic and technological change, digital skills are needed more than ever for citizens to actively participate in society, but the level of

digital use among elderly is lagging [7]. This is a global problem, and the digital gap appears to be worsening [4]. While the younger generation can effectively use today's digital devices such as smartphones, tablets, and smartwatches, the older generation has been unable to keep up with the younger generation in using these digital devices [8]. The problem of digital literacy among elderly has become a deep-rooted problem that not only causes the digital gap but also reduces the quality of life [9]. Accordingly, much research is being conducted on the reasons why older people avoid digital technology, such as the perception that they cannot learn new things due to lack of cognitive ability, vision, and motor skills [10].

Learning digital skills for elderly is becoming increasingly important for active aging and lifelong learning [7]. Efforts by the younger generation to help elderly improve their digital literacy have been insufficient, which has deepened the digital gap [8]. Regardless of age, people cannot remain passive in the face of changes that occur in both the real and virtual worlds. To avoid experiencing digital exclusion, digital education as lifelong learning that embraces all age groups is needed in response to the development of new media and technology [11].

Even if elderly have digital literacy, it is not easy for them to actively use it in real life. This is because they do not have much confidence in adapting to and applying the rapidly changing digital environment. Therefore, although education on the use of digital devices can immediately increase the digital literacy skills of elderly, the elderly may face difficulties again when faced with new devices or programs. Digital education programs for elderly should be systematically developed in structure, content, and method, considering the characteristics of elderly. Elderly people need digital self-efficacy, that is, confidence that they can perform new tasks using digital devices. The essence of improving digital literacy comes from computational thinking skills, digital literacy education programs for seniors also need to include algorithm and coding education.

In this study, we aim to develop and apply a coding education program that can fundamentally improve the digital literacy of the elderly. This study proposes a new digital literacy education program for the elderly and seeks to find out what changes there are by focusing on the digital self-efficacy of the elderly.

2 Literature Review

2.1 Elderly and digital literacy

The initial concept of digital literacy began to emerge with the development of digital technologies such as computers and the Internet. Since then, due to the rapid development of smart devices, the concept that was limited to computers and the Internet has begun to expand, and recently, digital literacy is not just the ability to use information, but also access, manage, understand, integrate, communicate, evaluate, and even included the concept of creation. Digital literacy encompasses not only the technical ability to use digital technology, but also cognitive aspects [12].

Digital literacy and skills have become a prerequisite for growth and employment, as well as health, education, and social inclusion in the digital economy. Therefore, it

is essential to equip the entire population, including adults and elderly, with digital literacy [7]. Elderly need digital literacy and able to use it to meet their needs and continue to live independently at home [2]. Digital literacy also increases accessibility for elderly living in rural areas [9].

In various studies, systems for managing the health of elderly people through digital devices have been successfully developed and used [5]. As the standard of living and life expectancy of elderly population has increased, the number of elderly people who want to enjoy a high quality of life has increased, and the concept of 'digital inclusion' has been proposed to bridge the digital gap. Digital inclusion emphasizes the importance of focusing on vulnerable groups and bridging the digital divide [13].

However, low digital literacy among elderly worldwide is becoming a problem. In the UK, the social problem of the digital divide has been shown to be serious, with more than 9.2 million people out of a population of 64 million still perceived as resistant to using modern technology [14]. Internet use in the United States has grown exponentially, but 27% of Americans aged 65 and older do not have online access, and even among those who do, 73% need help [3]. Additionally, in Poland, 75% of seniors aged 65 years or older said they do not use the internet at all, and older people have a low level of digital competency, do not feel the need for the internet, or do not use the technology due to cost issues, disabilities, privacy and security, or fear [11].

There are few digital laggards among the younger generation, but these young digital laggards have enough time, energy, and physical condition to bridge the gap with their peers. In contrast, elderly become digital laggards for a variety of reasons [15]. The root cause of elderly moving away from digital is not age, but learning difficulties, lack of confidence, technophobia, technology and accessibility interface issues, and lack of time and support for learning [7]. Accessibility, information, education, and the availability of useful applications have been the driving forces behind the use of digital technologies, as evidenced by various studies, and it has been proven that elderly have a desire to utilize technology when given the opportunity [6].

Digital literacy in old age is closely related to health and quality of life, and in particular, acquisition of information through digital, communication, and leisure activities have a significant impact on the life satisfaction and health of elderly. In the information society based on the 4th industrial revolution, improving the digital literacy of elderly can be said to be an important factor in creating a qualitative life for elderly. Therefore, greater emphasis should be placed on increasing the digital literacy of elderly.

2.2 Digital literacy education

Today, the emergence of the digital world is affecting most lifestyles. Therefore, elderly need digital literacy skills such as personal protection, data protection, digital tool selection, and online information access to survive. Digital literacy is an essential quality for today's elderly, and digital literacy education and support must be provided so that elderly can learn and live safely in the digital age [16].

To bridge the digital literacy gap, Thailand attempted to train nationwide digital literacy instructors, who also taught digital literacy basics to people in each community [16]. Various digital literacy programs are being applied, such as the LA County

Library operating programs that deal with computer devices, the Internet, and personal devices, and the San Jose Public Library providing programs to learn the basics of smartphones and computers. In addition, public libraries in the United States have consistently provided technology education and software education, as well as general Internet use and basic computer use, for adults. Digital literacy education is being implemented through lifelong learning centered on elderly as part of measures for an aging society in Japan. However, most digital literacy education programs for elderly worldwide are limited to training elderly to use digital devices, such as smartphone use, basic computer use, and Internet usage. Formal digital education is needed to bridge the digital divide and promote digital inclusion among elderly [17].

Elderly differs not only in age but also in social, cultural, and occupational aspects, it is necessary to understand the characteristics of elderly group and develop digital literacy education programs [18]. Digital literacy education for elderly requires the development of specific content that can provide practical help and customized educational materials at a level that can be applied. In addition, effective educational methods should be selected according to elderly's physical and cognitive functions, and the program should be applied using various tools. It is necessary to attempt to apply various fields of computer science, such as the basics of programming and robot education, which are the essence of improving digital literacy, to digital literacy education for elderly. In particular, the experience of creating and programming simple algorithms is expected to improve digital literacy and enhance cognitive abilities.

2.3 Digital self-efficacy

Self-efficacy has a positive effect on social interaction, and both self-efficacy and social interaction have a positive effect on attitude [19]. In particular, elderly's self-efficacy is their belief in themselves and plays an important role in maintaining their psychological stability and positive lives. In this context, digital self-efficacy has the potential to influence the psychology and emotions of elderly.

Digital self-efficacy means confidence in effectively navigating and adapting to technology in digital environments. Previous studies have evaluated it as a significant predictor of behaviors, such as task-technology fit, technology use, training assessment strategies, motivation, and work engagement [20]. People with high digital self-efficacy know which technological tools to use for what purpose, and they recognize and try to solve these technological tools. They also try to cope with the problems they may encounter while using these technological tools and they develop different solutions [21].

Many studies show that elderly can enjoy technology when they feel they can handle it and highlight digital self-efficacy as an important factor predicting hedonic use of ICT. Elderly digital users are more likely to be emotionally affected, which may affect their future use of digital technologies. Therefore, elderly should receive support until they feel they can use digital technologies on their own with sufficient confidence [22].

As many services move to the digital world, the digital divide is bound to widen unless appropriate measures are taken to address elderly's fear of technology. It has been found that digital self-efficacy is related to taking digital-related courses and that digital education should be tailored to elderly [23]. In this way, the younger generation

must continue to support and help older people who do not have digital self-efficacy to overcome their fear of digital [14].

3 Experiments

3.1 Participants

This study recruited a total of 20 people, 10 people over 65 years old, from two senior welfare centers in Seoul who wanted to participate in a coding education program to improve digital literacy. To run the program effectively, a small number of people were recruited, and 10 people were recruited from both Welfare Center A and Welfare Center B. However, the number of the elderly people who participated in more than 3 sessions of the program and participated in both pre- and post-tests was 5 from Welfare Center A and 9 from Welfare Center B. Information on the study subjects is as shown in Table 1.

Table 1. Basic information of the participants in the study

No.	Affiliation	Gender	Age
1	Senior Center A	Male	69
2			76
3		Female	68
4			76
5			80
6	Senior Center B	*Male*	74
7			75
8			76
9			78
10		*Female*	66
11			67
12			68
13			70
14			73

3.2 Procedure

This study developed a coding education program for the elderly based on various previous studies on elderly, digital literacy, and digital self-efficacy. In addition, to verify the effectiveness of this program, we analyzed studies related to digital self-efficacy measurement tools and developed a test tool suitable for the study subject. The digital self-efficacy measurement tool was administered before and after applying the program. The effectiveness verification process of this study is shown in <Table 2>.

Table 2. The process of applying program

Groups	Pre-test	Experiment	Post-test
Senior Center A Senior Center B	O1[1]	X1[2]	O1[1]

[1] Pre/Post test of digital self-efficacy

[2] Coding education program

3.3 Digital Self-efficacy scale

In this study, various previous studies related to digital self-efficacy measurement tools were analyzed [24][25]. Based on this, we divided digital self-efficacy into five areas and developed a digital self-efficacy scale for the elderly in accordance with this class. All questions were structured on a 5-point Likert scale. The internal consistency reliability of the measurement tool was found to be pre- Cronbach's α=.912 and post-Cronbach's α=.903. <Table 3> shows examples of digital self-efficacy scale questions.

Table 3. Self-efficacy scale areas

No.	Contents
1	Adapting to new technologies and products
2	Understanding new technologies and product features and using them effectively
3	Confidence to learn how to use new technologies and products
4	Managing life better using digital devices
5	Trying actively to learn new skills

3.4 Contents of program

The coding education program used COBOBLOCKS to reflect the characteristics of the elderly who are unfamiliar with digital devices and are new to coding. COBOBLOCKS is a tangible programming education tool that allows you to learn coding anytime, anywhere without a computer system or monitor, which was adopted in many studies on coding education programs targeting elementary school students [26]. Elderly people who are new to coding or unfamiliar with digital devices may find it difficult to use a computer keyboard or combine command blocks by dragging and dropping. Therefore, we developed a basic coding education program by selecting an easy and simple teaching tool that anyone can use. Through this coding education program, the elderly construct algorithms and learn the sequential and repetitive structures of coding. The specific learning contents are as shown in <Table 4>.

Table 4. Contents of classes

Period	Subjects	Contents
1	Sequence	·Introduction of program

		·Understanding LED, Sound, Dancing blocks ·Creating a sequential algorithm ·Sequential coding of LED, Sound, Dancing blocks
2	Sequence	·Understanding moving blocks ·Understanding sequential coding of moving blocks
3	Repetition	·Understanding repeat structures ·Create a repetition algorithm ·Coding moving blocks using repeat structures
4	Repetition	·Understanding infinite repetition ·Drawing with Coding using infinite repetition structure ·Closing

Fig. 1. Third period of the coding program

Fig. 2. Fourth period of the coding program

4 Results

To examine changes in digital self-efficacy among the elderly, the pre-test and post-test of the coding education program were analyzed using the statistical package SPSS 29.0. Since the collected data was less than 30 people, a normality test was conducted. As a result of the test, the Shapiro-Wilk p value was .647 for the pre-test and .104 for the post-test, which was above 0.05, confirming normality. In addition, normality was examined using skewness and kurtosis. The skewness and kurtosis of the digital self-efficacy pre-test were -.213 and -.312, and the skewness and kurtosis of the post-test were -.244 and -1.441, respectively. In both pre-test and post-test, the absolute value of skewness did not exceed 1 and the absolute value of kurtosis did not exceed 2, so it was found to meet the normality standard of skewness absolute value less than 2 and kurtosis absolute value less than 7 [27]. Therefore, the results of the elderly digital self-efficacy test of the collected data were analyzed using the paired-sample t-test. The alternative hypothesis is 'There is a difference in the digital self-efficacy of coding education program participants before and after training,' and the null hypothesis is 'There is no difference in the digital self-efficacy of coding education program participants before and after training.'

4.1 Changes in digital self-efficacy

The test results of the elderly who participated in the education program are shown in <Table 5>. The digital self-efficacy of the elderly increased from an average of 3.47 to an average of 4.00 after applying the program. The t value was -2.66 and the p value was .020*, confirming that the coding education program applied in this study had a positive effect on increasing the digital self-efficacy of the elderly and that there was a statistically significant change.

Table 5. pre- and post-test results of digital self-efficacy

Area	Pre(N=14)		Post(N=14)		T	*p*
	M	SD	M	SD		
Digital self-efficacy	3.47	0.73	4.00	0.83	-2.66	.020*

*p<.05, **p<.01, ***p<.001

Opinions were collected from the 10 elderly people who participated in the coding education program for more than three sessions. As a result, participants responded that they participated in this coding education program for reasons such as 'utilizing leisure time,' 'opportunity to learn,' and 'to experience digital culture.' In addition, responses included, 'I was able to experience digital culture,' 'I acquired useful information for daily life,' 'My fear of digital was resolved,' and 'I developed a new hobby using smart devices.' As a result, it was found that the elderly had positive changes in their daily lives through this coding education program, and that it was an opportunity to gain confidence in digital.

5 Conclusion

Today, with the development of information and communication technology, digital literacy has become essential in our lives. As the level of use of digital devices is being used as a measure of quality of life, it is becoming increasingly important for elderly to learn digital technologies.

This study developed and applied a coding education program, a digital literacy program for elderly, who are considered digitally vulnerable in an information society. Afterwards, the effectiveness of the coding education program was verified through a pre-post paired samples t-test. Accordingly, the coding education program in this study was found to improve the digital self-efficacy of the elderly. Digital self-efficacy has a positive impact on elderly's life in retirement, such as reducing depression and increasing life satisfaction. Through coding education, elderly can learn and do new things and experience becoming part of the digital society. The results of this study proved that the coding education program can be a way to increase the sense of efficacy and life satisfaction of the elderly living in the digital age.

The follow-up research proposed based on this study is as follows.

First, as in this study, various digital literacy education programs for elderly are needed to reduce the digital gap. Due to limited social and institutional support, it has been difficult for elderly to gain experience and comfort with technology. The reasons why elderly move away from digital are due to a variety of reasons, including learning difficulties, lack of confidence, technophobia, technology and accessibility interface issues, and lack of time and support for learning. Efforts are needed to overcome the digital gap through digital education for a variety of elderly people. Effective educational methods for elderly should be compared and studied by reflecting their needs and characteristics.

Second, research is needed on digital self-efficacy that affects the digital use of elderly. It is necessary to consider ways to improve digital self-efficacy, such as research on various variables that affect digital self-efficacy or studies that look at the degree of improvement through educational programs.

This study conducted coding education program for a small number of people at two welfare centers in Seoul. Also, the results of the study were conducted by selecting only an experimental group without a control group, so limited interpretation is required. However, it is significant that to resolve the increasingly deepening digital gap, an educational program for the elderly was developed and applied, and the effect on digital self-efficacy was analyzed.

Coding education program in this study is a new attempt in educational content and method and can be used as basic material for future digital literacy education programs for the elderly. We hope that related research will be actively conducted, and that ‘digital inclusion’ will be achieved, where elderly use digital technology to create a quality life.

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