Examining the learning outcomes of elderly through multimedia teaching system in Taiwan

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Abstract: The elderly often fear technology products in Taiwan, because the complexity of technology and the lack of information create barriers for the elderly to use technology. The trends of an aging population and digital product advances mean that new technology products can enrich elderly lives, if learning barriers can be overcome. This study utilises quasi-experimental design and a multimedia teaching system (MTS) as an intervention programme. Seventy-nine older adults (over 65 years old) participated in this study; 39 older adults belonged to the comparison group, and the other 40 were in the experimental group. Subjects’ post-test scores were used for evaluating the learning outcome after implementing the intervention programme. The study shows that elderly using MTS improved their learning outcomes significantly more than others who did not. The elderly who received both the MTS and played speed-controlled instruction on their own improved more than those only receiving the MTS. This outcome will benefit those who use technology-based learning among the elderly.

Keywords: elderly; multimedia teaching system; human information processing; cognitive load.

Reference to this paper should be made as follows: Chen, S.F. (2017) ‘Examining the learning outcomes of elderly through multimedia teaching system in Taiwan’, Int. J. Applied Systemic Studies, Vol. 7, Nos. 1/2/3, pp.1–12.

Biographical notes: Su Fen Chen received her PhD in Business Administration from National Taipei University. National Taipei University of Technology is at Taipei City and is the number one ranked technological university in Taiwan. Her most recent PhD is from the School of Social Service from Fordham University in New York. She has had an internationally distinguished and pioneering career as an educator and influencer in the field of social work specialising in gerontology. She is the Director of Department of Education of Keelung City Government in Taiwan.

This paper is a revised and expanded version of a paper entitled ‘Examining the learning effected of elderly through the multimedia assisted instruction design’, presented at The 5th International Conference on Frontier Computing, Tokyo, Japan, (ID:WS-2-010) on 13–15 July 2016.
1 Introduction

In almost every country around the globe, the proportion of people aged 65 and over is growing faster than any other age group, as a result of both longer life expectancies and a decline in fertility rates (U.S. Census Bureau, 2010). In particular, according to the estimates by the National Development Council of Taiwan’s government (2014), the senior population will continue to grow from 2014 until 2060. In comparison with 2014, the total population in 2060 will be reduced by 24.2%, and the elderly population increased by 160%. Based on these issues, some have a negative image and misunderstanding or bias of older people’s learning abilities, which affects the promotion of the opportunity for older adults to learn and develop their potential. In fact, Taiwanese caregivers for the elderly face not only the problem of elders’ physical health, but also the need to encourage older people’s willingness to learn actively, and to follow the pulse of society to learn new skills and knowledge, which can be combined with their wealth of life experience to enjoy a happy life. Therefore, it is important to create a suitable operation for products’ interface, as well as an effective multimedia teaching style to assist the elderly and make the e-learning environment accessible. Establishing a good learning environment and media for older adults will make it easier for them to adapt to digital technology, be happier in their lives, and re-engage in society.

1.1 Background and significance

Due to recent medical, scientific, and technological progress, longevity has increased. Ministry of the Interior (MOI) of Taiwan published that a person’s average life span in Taiwan is 80.2 years old; men have an average life expectancy of about 77.01 years, and women’s averages 83.62 years (MOI, 2016). However, longevity is not always a welcome development in individuals or societies, because of the general impression that the elderly have demonstrated functional decline, and many suffer from dependency, depression, and dementia at the individual level. There is also the fear of bankruptcy due to the Social Security Issuance (SSI) budget, rising healthcare costs, and the burden to younger generation at the population level. Taiwan’s government recently presented a revised Law of Health Issuance and regulations of retired military and government personnel in the Legislative Yuan, as an attempt to prevent financial deterioration due to the increasing aging population. Meanwhile, Taiwan’s government is submitting the new National Pension Reform policy to extend the retirement age to 65 for all of the officers and teachers (EY, 2017). All these strategies emphasise preventing the national financial bankruptcy of Taiwan due to the massive increase of the senior population. To solve the problems facing aging societies, many studies have been done, but have focused on the limitations of older adults and primarily considered their functional decline and dependency. One study pointed out that older adults have more significant limitations and obstacles in learning new knowledge or new technologies when compared to young people (Park et al., 1996).

The elderly face higher barriers to participating in learning activities due to limited physiological and physical function. Factors may include ‘physical and mental limitations and obstacles’, ‘information processing limitations and obstacles’, and so on (Park, 1997, 1999), because the elderly lack experience with complex operation of digital tools. Studies by Schieber and Baldwin (1996) and Salthouse (1991) pointed out that perception and cognitive abilities decline with age, and negative age-related cognitive results have
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been confirmed by numerous studies. Aging people’s perceptive ability, strength, flexibility, mobility, memory, and learning ability are reduced (Fisk and Rogers, 1997). Park (1997, 1999) found that age-related cognitive experiments mainly showed effects in the following areas: memory, learning ability, language skills, visual-spatial function, attention, and mental speed; being in an unfamiliar environment also affected performance. Craik et al. (1987) found that when performing division of attention work, older people can develop the ability to reduce annualised performance difference more than young people. Kline and Scialfa (1996) found that older people were not similar to young people in visual operation, stable resolution, and approximate visual stimulation. Studies had shown that such a result was attributed to older people needing more time to obtain information. Different human cognitive functions, such as cognitive aging faster memory which is an element of vary the speed of aging, that (Craik and Byrd, 1982). Memory is also affected by aging, with the main example that it is difficult to remember to go to complete tasks; on the other hand, increasing age and accumulating experience can solve complex ethical and social issues (Hummert et al., 1994). Paas et al. (2005) have pointed out that well-designed learning materials can compensate for the adverse effects of cognitive aging, enhance learning outcomes, and shorten the gap between the performance of the elderly and the young. Many researchers who have studied cognitive-oriented learning found that older adults do have the capability to learn (Fisher, 1998; Wolf, 1998). Some older adults prefer to learn the related e-courses more than others; because they can feel they are of the same generation with young people (MOE, 2016).

However, the majority of related research always focuses on the adults’ learning; the instructional design of the effectiveness of learning for the elderly is still less studied than other aspects. There are four related studies regarding the instructional design of learning for the elderly in Taiwan’s central library from 2014 to 2016. This is why the current study focuses on this topic. Mayer’s (2003) study concluded that learning efficiency and training content are affected by different digital media. If future elderly citizens cannot rely on government assistance, it is important to design effective learning content to help the elderly to learn new skills (Park, 2000). Therefore, other businesses and scholars also advocated for the concept of designing a suitable assisted system for elderly learning depending on their physical and mental condition. For example, Montavista Software Inc. gave developers who developed the mobile operating system a portable and scalable platform; this lets developers create their own differentiated feature phones or smart phones for the elderly to use. Chen et al. (2003) also designed an operating system in smartphones for aging adults. It is likely that more electronic products with assisted instruction systems will be created, and the products using them will be better marketed because the technology will be simple and easy to access.

2 Literature review

Nakagami-Yamaguchi et al. (2016) indicated that the frequency of patients’ falls significantly decreased from 15.6 to 8.6 % (p < 0.05) through the use of an animation movie guide. In 65-year-old patients, the ratio of frequency of falls significantly decreased from 19.0 to 7.6 % (p < 0.01). However, Wolf et al. (1998) indicated that older adults still have sufficient learning ability, according to many studies in cognition and aging relative research. However, this study further explored the impact of cognitive
aging on the learning of elderly, and how multimedia learning could improve cognitive performance of the elderly with cognitive aging.

The current study first discusses the phenomenon of cognitive aging of the elderly, then analyses the causes of cognitive aging of the elderly, and finally proposes suitable multimedia design materials for elderly with cognitive aging. Human cognition is obtained through the application of knowledge from a variety of things and phenomena in the world; this can also be called information processing. Wickens (1984) created a human information processing (HIP) model (Figure 1), which describes human information processing and composition.

Figure 1  Structure of human information processing (HIP) model (see online version for colours)

Humans’ ways of receiving inputs from the external environment can be divided into five paths: vision, hearing, touch, smell, and taste. Therefore, a multimedia information processing system works through using multimedia presentation forms such as text, pictures, and sounds to transmit various messages. This study hypothesises that it is easier to learn training content through additional multimedia text and images than through written instructions alone. Multimedia instruction will help to improve memory encoding. Most multimedia is composed of audio, video, text, and other media and hypermedia objects (Maresca and Guercio, 2000). Therefore, the computer integrated treatment of a variety of media information (audio, video, and text), works so that a variety of information establishes a logical connection. This builds a system with a purpose in education and training, and the learner can take a multi-sensory stimulation to enhance learning effect. A computer-assisted guide (CAG) is one way to learn in current widespread use. Aimed at teaching, multimedia computer assisted instruction uses text, graphics, sound, animation, video, and other material integrated together to form teaching elements to make teaching more substantial, more intuitive, and more attractive, thereby increasing the passion for learning and learning efficiency (Blakeney et al., 2011).

The ‘cognitive load’ in this study refers to the burden of mental ability for older learners who watch the multimedia learning materials. Sweller et al. (1998) indicated that
the cognitive load can be divided into intrinsic load and extraneous load, according to their sources. Park et al. (1996) assessed the difference in cognitive performance between older adults and young people for the four aspects of the information processing including speed, working memory, and sensory function as follows:

1 Processing speed

The old and young people were able to complete the tests within the same timeframe, but the elderly group had more errors in their work. There were also response of speed/accuracy trade-offs, implying that the ability of the elderly to work effectively was affected by time pressure. Therefore, this variable is also included in the current study to test the interaction of cognitive loading.

2 Working memory

Craik et al. (1987) described the pattern of short-term memory ‘processing resource’ as an instant information processor, temporary storage, and retrieval and conversion of messages. This means that mental capacity is connected with instantaneous operations. Short-term memory encoding can be divided into auditory encoding and visual encoding (Baddeley, 1992).

3 Sensory function

Mayer (2003) pointed out that learners would get different learning outcomes by using a diverse media system. Specifically, she found that the learning outcomes with the text and graphic media are better than those using just text. New teaching software uses flash combined with animation, text, and audio-visual effects. Mayer (1987) described cognitive models in multimedia learning (see the following chart), showing how elderly learn or process information.

Figure 2 The cognitive models in multimedia learning

Additionally, socioeconomic status will affect the learning outcome. Tsai and Liu (2013) indicated that the family’s socioeconomic status and academic achievement is directly related. Because a higher socioeconomic status will allow a person more resources, it is likely she or he also could have more experiences with technology products than others. Therefore, socioeconomic and age variables do act as moderators for learning outcomes, but are difficult to manipulate in this study.
3 Specific aims

This study focuses on finding an interface to boost the efficiency of the elderly for learning outcomes. For example, when learning how to operate the functions of digital cameras, learners can control the display speed of multimedia in accordance with their cognitive loading. This study aims to explore the effects in learning outcomes and cognitive load of the elderly through a multimedia teaching system (MTS), through the new technology and teaching model to increase the performance and cognitive loading of elderly learning.

3.1 Research questions

This study uses the special functions of multimedia, and finds ways to stimulate the learning outcomes of the elderly. The research questions are summarised as follows:

1. Are the elderly learning outcomes affected by the MTS?
2. Does the presented speed of MTS affect the elderly learning outcomes?

3.2 Hypotheses

By exploring these issues, the hypotheses in this study are as follows:

H1 Elderly who are in the treatment group will gain a higher learning test score via receiving the intervention of MTS than the comparison group.

H2 Elderly who are in the treatment group will gain a higher learning test score through receiving the MTS and playing speed-controlled instruction by themselves, compared to those only receiving the MTS.

H3 The playing of speed-controlled of MTS will affect the elderly’s cognitive load.

4 Research design

This study uses the quasi-experimental design method, pre-test and post-test with nonequivalent groups. The study examines the learning outcomes for the treatment group and the comparison group, the participants having been non-randomly assigned to each. The treatment group received the computer-assisted teaching system which uses a combined model of media and speed-controlled multimedia to teach the elderly the related photographic knowledge of the digital camera as the intervention content. The comparison group did not participate in the intervention programme, but both groups read the simplest guide, which included the text and static graphics, in the limited time before the pre-test beginning, meaning that they got the basic photographic knowledge. This intervention programme is MTS. Both of the treatments are MTS, one played automatically by a computer, and the other speed-controlled by learners; these are the independent variables for this study. The learning outcome test is the dependent variable. This programme lasted for one week. There were 79 older adults (aged between 65 to 75 years old) as the participants, who were divided into two main groups. The comparison
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group was 39 people; the treatment group was 40 people who were then divided into two sub-groups (meaning 20 subjects in the treatment group received the MTS played automatically by computer, and the other 20 subjects received the MTS, speed-controlled by themselves). The subjects’ eligibility by ages was determined due to consideration of their physical and psychological function. Eligible subjects had to have their vision corrected to normal vision before testing in this experiment. Because of the small samples recruited, the quasi-experimental design was used as within-subjects design. Although this study is designed to decrease threats to internal validity as much as possible, limitations remain. In particular, the elderly like to form into small groups according to their interests. This experiment only can match similar demographics as much as possible in the comparison and treatment groups in order to reduce the between-subject differences. Participants were given a $10 incentive upon the completion of the pre-test and post-test study. The assisted-teaching contents are related to a digital camera’s operation function and knowledge on photography.

4.1 Outcome measures

The learning outcomes utilise the paper and pen test, which contains three parts: one is a rote learning effectiveness test, the second is a meaningful effectiveness test, and the third part is a cognitive load test. The rote learning effectiveness test consists of text-level problems to test the elderly learning content. The meaningful effectiveness test is a situation model, to test the elderly’s inferential understanding of learning materials, and how they integrate the original knowledge to new situations. The test requires learners to fill in blanks with the numbers shown on the computer screen while playing the MTS. The aim is to examine the elderly cognitive load. The learning testing utilises the PISA (programme for international student assessment) test scale. A PISA test is a logic test tool, to measure a group of students on information, mathematics, natural science, reading, and problem solving ability. PISA draws mainly from three levels to measure students’ ability: the ability to access the message, the ability to understand the message, and the ability to think and judge. The PISA test assesses the learners’ ability to access information, to obtain information, analyse information, evaluate information, integrate information, and express information, as well as their personal ability to think independently. Therefore, it is suitable to examine the elderly learning outcome. The PISA test is used for the students of 28 OECD (Organization for Economic Cooperation and Development) countries and four non-OECD countries, and it is currently used broadly in Taiwan’s schools; this implies good internal validity. The mission of OECD is to promote policies that will improve the economic and social well-being of people around the world. There are six levels of scoring on this scale, worst = (F) under 50, bad = (E) 51–60, general = (D) 61–70, good = (C) 71–80, better = (B) 81–90, excellent = (A) 91–100. If the subjects in this study accept the whole intervention programme, they will know how to take a photograph with a digital camera and have related knowledge, thus scoring at least C, and possibly up to A. The paper and pen test has 30 questions, including 15 questions for the rote learning effectiveness test, and 15 questions for the meaningful effectiveness test. Additionally, there are 3 numeric ‘fill in the blank’ questions for cognitive load testing, which are measured only for the experimental group.
4.2 Sampling plan

The ‘purposive sampling’ method is used in this study, which recruited 79 older adults who aged between 65 to 75 years old from senior centres in Keelung City, all of which are under the charge of Keelung City Government in Taiwan. The reason for this choice is that the researcher is the director of the department of education in Keelung City Government; the researcher could get effective assistance because of this geographical location and occupation. The study is limited to the elderly who are literate and with normal (or corrected to normal) hearing and vision. There are four senior centres in Ann Lela District, Keelung City, and a total of 220 older adults are between 65 to 75 years old. According to the Ministry of Education of Taiwan, a previous study for satisfaction from senior centre in 2015 showed that only one-third of all the older adults participated in the experiment. Therefore, the experiment for this study uses a nonrandom sample of one-third of all the elderly. Due to the limitations of manpower and material resources, this study uses a ‘purposive sampling’ method to get the required sample size based on the inclusion criteria. All of the senior citizens are now retired. As stated above, the experiment required the subjects have normal-level vision and hearing. In consideration for the elderly persons who may have hearing difficulties, the volume of sound was adjustable to correct for the hearing ability of the subject before the experimental testing. In addition, all elderly subjects in this study for the content of training gave their consent and met the following common criteria:

1. have little or no contact with and/or practical use of the multimedia function;
2. have little or no experience with digital cameras; and
3. can identify and comprehend Chinese text and sound.

In addition, the sampling in this study focuses on the elderly, so the instructor was also recruited from the senior centres of Taiwan. The instructor has at least five years’ experience in teaching the elderly.

5 Conclusions and suggestions for future research

The completion of this study provides specific empirical data, and further informs the design principles of multimedia learning materials in order to address the elderly’s cognitive aging, and improve the quality of research on the elderly. Table 1 shows that most of the normality test at 5% of the general conditions because the p-value is not smaller than 0.05; it can’t reject the null hypothesis of normality data, and sample data for all levels of treatment combinations show the treatment groups meet the normal distribution.

<table>
<thead>
<tr>
<th>Normality test</th>
<th>Comparison group</th>
<th>Treatment group who receive the intervention of MTS</th>
<th>Treatment group who receive the intervention of MTS and playing speed controlled instruction by themselves</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>0.891</td>
<td>0.861</td>
<td>0.873</td>
</tr>
<tr>
<td>p-value</td>
<td>&gt;0.100</td>
<td>&gt;0.100</td>
<td>&gt;0.100</td>
</tr>
</tbody>
</table>
In addition, the test results show that the learning outcome of the treatment group was better than the control group, and the treatment group followed by MTS and speed controlled by subject was more efficient than those being controlled automatically, as shown in Figure 3 and Figure 4.

**Figure 3** Outcome between two groups (see online version for colours)

![Figure 3](image)

**Figure 4** Outcome between the two treatment groups (see online version for colours)

![Figure 4](image)

**Table 2** Variance analysis of the effect of learning style and speed control mode of elderly

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning styles</td>
<td>0.025</td>
<td>1</td>
<td>0.025</td>
<td>0.821</td>
</tr>
<tr>
<td>Speed control method</td>
<td>0.268</td>
<td>1</td>
<td>0.268</td>
<td>8.875**</td>
</tr>
<tr>
<td>Interactions</td>
<td>0.126</td>
<td>1</td>
<td>0.126</td>
<td>4.169*</td>
</tr>
<tr>
<td>Error</td>
<td>2.355</td>
<td>78</td>
<td>0.030</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.777</td>
<td>81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * p < 0.05; ** p < 0.01

Meanwhile, it is shown that the interaction between different learning patterns and a speed control method is significantly different, as shown in Table 2. From Table 2, we can see that the interaction between different learning patterns and speed control methods is significantly different, F (1, 78) = 4.17, MSE = .030, p = .045. This indicates that the
significantly different effect of the presentation pattern on the performance of the participants in the overall learning performance will vary depending on the speed control mode.

In addition, ANOVA results show that two variables factor in this experiment for elderly. Multimedia-assisted learning different complexity of operational tasks, and the resistance of multimedia has significant effect (F (2, 18) = 4.30, p < 0.03). Elderly persons in using different multimedia assisted teaching times to learn the guide, and the operations tasks which is in the complexity varies also have a significant impact (F (2, 36) = 182.66, p < 0.0001); that is, the more complex procedures are, the longer time the operation takes, so the complexity of the operation defined in this study is a significant difference. In addition, media presentation and operation tasks have significant interaction between the two (F (4, 36) = 4.33, p < 0.006). This means that the elderly who are in the treatment group will gain a higher learning test score via receiving the intervention of MTS than the comparison group. The elderly who are in the treatment group will gain a higher learning test score through receiving the MTS and playing speed-controlled instruction by themselves than those only receiving the MTS. There are some limitations to this study, such as the subjects whose physiological and psychological function are worse than younger subjects’, and that the duration time of MTS’s design is limited. The other limitation is that the different outcomes may have been affected by the subjects’ socio-economic background.

This study’s greatest contribution is the substantive content that promotes teachers and designers of multimedia learning materials to address the phenomenon of elderly cognitive aging, and to understand the design principles of cognitive load theory-oriented learning materials, so they can make and propagate suitable material for senior citizens to learn. This study focuses on learning-related knowledge of multimedia and digital camera operation by the elderly, and cannot ensure the same solution will suit the operation of other digital products, and doesn’t compare the performance between elderly and younger subjects. It is recommended that future research can expand the age range of the subjects and enrich the content of MTS to explore these issues.

References


