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Examining the digital skills of nursing students: the power of information for problem-solving

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ABSTRACT

Our society is undergoing digital change. Dealing with digital technologies has become a daily practice. Many healthcare facilities are implementing digital technologies. Nurses are placed in a strategic position to be the leader of the digital healthcare workforce. Nursing students are more exposed to this technological advancement as they are future professional nurses. This study aimed to examine how information-processing and exchanging skills in digital spaces affect digital problem-solving skills among nursing students. The Bayesian mindsponge framework (BMF) was used as a conceptual framework. This quantitative study utilized a cross-sectional design. The population was all nursing students in two private nursing institutions located in Bangkok, Thailand (n=476) and Surabaya, Indonesia (n=179). Samples were the total population. Self-developed instrument was used in data collection. Data analysis used BMF analytics. The majority were females aged 20-22 years old who use smartphones and tablets daily. The information-processing and information-exchanging skills in digital spaces were positively associated with digital problem-solving skills among nursing students ($M_{\text{InformationProcess}}=0.30$ and $SD_{\text{InformationProcess}}=0.05$; $M_{\text{InformationExchange}}=0.37$, and $SD_{\text{InformationExchange}}=0.05$). More efforts are needed to improve nursing students' problem-solving skills by using digital content, for instance, by modifying the information-processing and information-exchanging skills in digital spaces. Collaborative learning methods should be promoted in order to support the creation of conducive environment for supporting knowledge or information-exchanging behavior among nursing students by using digital technology.

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1. INTRODUCTION

"The value of information is very real when it comes to sorting out similar problems" [1]. Digital change is happening in our society. Digital technologies are implemented in our daily practice [2]. In the digital era, efficiency means connecting people and technology seamlessly. Digital technology means any software, hardware, or network solutions that construct, support, and expand business activities. The rate of digital innovation is growing every year [3], but its application to improve our health and health service remains largely untapped potential to augment and extend care [4], and there is immense scope for the use of digital health solutions especially to address the needs during and after the pandemic [5]. Digital health can

increase nurses' ability to deliver high-quality nursing care to their clients. Nurses are placed in a strategic position to be the leader of the digital healthcare workforce. Therefore, nurses need to accept health-related digital technology personally, use it and get benefits from it, so that the healthcare workforce can evolve, adapt, and develop digital competency [6].

The 73rd World Health Assembly (WHA) has made a roadmap for 2020-2025 for supporting the global strategy on digital health aiming at supporting all countries in strengthening their health systems by using digital technologies to achieve their health vision [7]. World Health Organization (WHO) is using the strength of digital technologies and health innovation to catalyze the global achievement of health and well-being. The implementation of digital healthcare technologies worldwide consequently raises the disruption of analog or manual practices in the healthcare delivery system which may be seen as opportunities or threats, thus nurses need to develop new digital skills [8]. Nowadays, nurses need to master various digital skills related to education and inter-professional health communication, improve their fluency in using smart devices and software, manage issues of digital regulation and compliance, operate telenursing and promote products of nursing services [9].

Nursing students are future professional nurses. Nursing digital skills are the key to digital transformation in nursing. Therefore, nursing students are encouraged to have at least the basic digital skills to do smart nursing and deliver high-quality nursing care in the future. The current study has three objectives, such as: i) compare the basic digital skills of nursing students between Bangkok and Surabaya, ii) examine how information-processing skills in digital spaces affect the digital problem-solving skills among nursing students, and iii) examine how information-exchanging skills in digital spaces affect the digital problem-solving skills among nursing students. Findings from this study will be beneficial for developing a basic strategic course, e.g., digital health or digital nursing in digitally adjusted nursing education curriculum, which is promising for the implementation of future digital nursing in a digital environment of healthcare delivery system.

2. METHOD

The mindsponge theory (MT) was used as the theoretical foundation [10], while Bayesian mindsponge framework (BMF) was used as the theoretical framework of this study [11]. MT considers the importance of the human mind's information-processing ability by filtering new information or values using the subjective cost-benefit judgment. The human mind ejects unsuitable information and absorbs mindset-compatible new information [10]. A digital mindset is a way of thinking or a set of beliefs consisting of various core values-oriented in digital solutions adoption by using new technologies in individual work and activities. Individual's beliefs in technology may affect their openness or skepticism in initiatives of digital environment transformation [12]. Digital technology acceptance may not be seen in digital behavior only, but also in digital mentality determining positive attitude towards digital technology. A nurse who accept the digital technology needs to have internet, digital media, and information literacy to be digitally competitive in a multiprofessional working environment.

This cross-sectional study targetted the population of all nursing students in two private nursing institutions located in Bangkok, Thailand (N=520) and Surabaya, Indonesia (N=179) in the academic year of 2022/2023. Samples were the total population (Bangkok: N=476; Surabaya: N=179). Inclusion criteria were active students in the even semester of the 2022/2023 academic year. Exclusion criteria were denied informed consent, unable to provide the required information, and being respondents in try-out questionnaire testing (Bangkok: N=44). Discontinuation criteria were incomplete answers to questionnaires.

In this study, the basic digital skills in nursing students referred to six aspects, namely: i) fluency in using digital devices (computer, tablet, and smartphone use for simple, personal, and work tasks); ii) skills in receiving and managing digital information and content by using search engines or digital information-processing skills; iii) safe and legal online self-protection (in data storage-sharing, updating-keeping-securing passwords, and taking precautions against viruses); iv) digital communication socially and professionally (by using email, messaging services, and social media) or digital information-exchanging skills, v) digital problem-solving skills by using digital content (FAQs/tutorials/fact sheets/scientific articles); and vi) skills in online shopping (setting up an account, filling in online forms, and using different secure payment methods). All aspects were translated into a six-item self-developed instrument to assess the basic nursing skills among nursing students, which was content-validated by three experts in nursing education in Thailand. A five-point Likert scale ranging from 1 to 5, 1 for less confidence and 5 for strongly confident, was used to differentiate responses among respondents. Each response was categorized into less (scale 1 and 2), moderate (scale 3), and high skills (scale 4 and 5) for determining the degree of basic digital skills per item. This study protocol has been reviewed by the Ethical Committee of Saint Louis College, Bangkok, Thailand, with an ethical clearance registered certificate of E. 017/2565. Informed consent was given to all respondents initially.

This study instrument was tested on 44 nursing students in Bangkok. Results of the Pearson Product Moment correlation test showed that all items were valid ($r=0.734-0.812$) and the results of Cronbach Alpha test showed high reliability ($\alpha=0.865$). Mean and frequency analyses was used to compare the basic digital skills of nursing students between sites. To examine how information-processing and exchanging skills in digital spaces affect the digital problem-solving skills among nursing students, an analytical model was constructed based on MT. The formula of the analytical model is as:

$$\begin{aligned} DigitalProblemSolving &\sim normal(\mu, \sigma) \\ \mu_i &= \beta_{DigitalInformationProcess} * DigitalInformationProcess_i + \beta_{DigitalInformationExchange} \\ &\quad * DigitalInformationExchange_i + a_{Country}[Country] \\ \beta &\sim normal(M, S) \end{aligned}$$

The probability around μ is determined by the form of normal distribution, with the standard deviation σ . The digital problem-solving skills of respondent i are indicated by μ_i . The model has coefficients of $\beta_{DigitalInformationProcess}$ and $\beta_{DigitalInformationExchange}$. The values of coefficients β are also in the form of normal distribution.

The BMF analytics were used to examine how the information-processing skills (item 2) and information-exchanging skills (item 4) in digital spaces affect the digital problem-solving skills (item 5) among nursing students [11]. The bayesvl R package, aided by the Markov chain Monte Carlo (MCMC) algorithm, was employed for statistical analyses in BMF analytics [13]. To make the data more transparent and reduce the reproduction cost at the same time, all data and code snippets of this study were deposited onto an open science framework (OSF) server: <https://osf.io/6vztr/> [14].

3. RESULTS AND DISCUSSION

There were 476 and 179 nursing students from Bangkok and Surabaya who participated in this study respectively. Table 1 explains the respondents' demography characteristics and personal information. Most respondents were females aged 20-22 years old which is nursing freshmen. Bangkok respondents had more monthly pocket money and a frequent users of tablets, while Surabaya respondents preferred to use smartphones for daily usage. Table 2 explains the basic digital skills among nursing students between Bangkok (BKK) and Surabaya (SBY).

Table 1. Basic information

General characteristic	Bangkok/BKK (n=476)		Surabaya/SBY (n=179)	
	F	%	F	%
Sex				
Male	22	4.6	30	16.8
Female	454	95.4	149	83.2
Age				
<17-19	149	31.3	62	34.6
>20-22	250	52.5	91	50.8
>23-25	43	9.1	24	13.5
>26-28	20	4.2	2	1.1
>29-32	11	2.3	0	0
>33-35	3	.4	0	0
Nursing education level				
1 st year	132	27.7	47	26.3
2 nd year	123	25.8	33	18.4
3 rd year	119	25	27	15.1
4 th year	102	21.4	38	21.2
5 th year (interns)	0	0	34	19.0
Pocket money/month (USD)				
<27	0	0	41	22.9
27-80	49	10.3	101	56.4
>80-160	279	58.6	27	15.1
>160-240	82	27.5	10	5.6
>240-320	41	8.6	0	0
>320-400	16	3.4	0	0
>400-480	1	0.2	0	0
>480-560	6	1.3	0	0
>560-640	0	0	0	0
>640	2	0.4	0	0
Daily use digital device				
- Tablet	249	52.3	1	0.6
- Smartphone	156	32.8	162	90.5
- Computer/laptop	68	14.3	16	8.9
- Others	3	0.6	0	0

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Table 2. Basic digital skills

Basic digital skills	Less				Moderate				High			
	BKK		SBY		BKK		SBY		BKK		SBY	
	F	%	F	%	F	%	F	%	F	%	F	%
Item 1	1	0.2	4	2.2	221	46.4	27	15.1	254	53.4	148	82.7
Item 2	3	0.6	3	1.7	325	68.3	40	22.3	148	31.1	136	76.0
Item 3	3	0.6	11	6.1	317	66.6	42	23.5	156	32.8	126	70.4
Item 4	1	0.2	3	1.7	299	62.8	35	19.6	176	37.0	141	78.8
Item 5	11	2.3	26	14.5	369	77.5	65	36.3	96	20.2	88	49.2
Item 6	6	1.3	10	5.6	317	66.6	35	19.6	153	32.1	134	74.9

The average score of basic digital skills was higher in Bangkok than in Surabaya (Mean=4.11 vs. 4.01) but still in the same high level. The skills were relatively more similar among Surabaya respondents than Bangkok (SD=0.63 vs. 0.74). Overall, the basic digital skills were not different significantly among nursing students between Bangkok and Surabaya. Most respondents in both sites reported high skills fluency level in using digital devices for simple, personal, and work tasks (Bangkok vs. Surabaya=53.4% vs. 82.7%), and the most difficult basic digital skills to master were the digital problem-solving skills by using digital content (Bangkok vs. Surabaya=2.3% vs. 14.5%). These two items only which were identified to be significantly different between study sites. It is indicated that the daily use of digital devices can support the fluency level in using it. In the other hand, despite the many types of information available on the internet, nursing students still need to master the attribute skills related to problem-solving by using digital content.

The latest model fitting run was on October 20, 2023, R version 4.3.1, Windows 11. The total elapsed time was 223.8 seconds. The model convergence was proved by all n_{eff} values being above 1,000, and all $Rhat$ values were equal to 1. The Markov chains convergence was validated by trace plots as shown in Figure 1, which showed that the chains fluctuate around central equilibriums after the warm-up period.

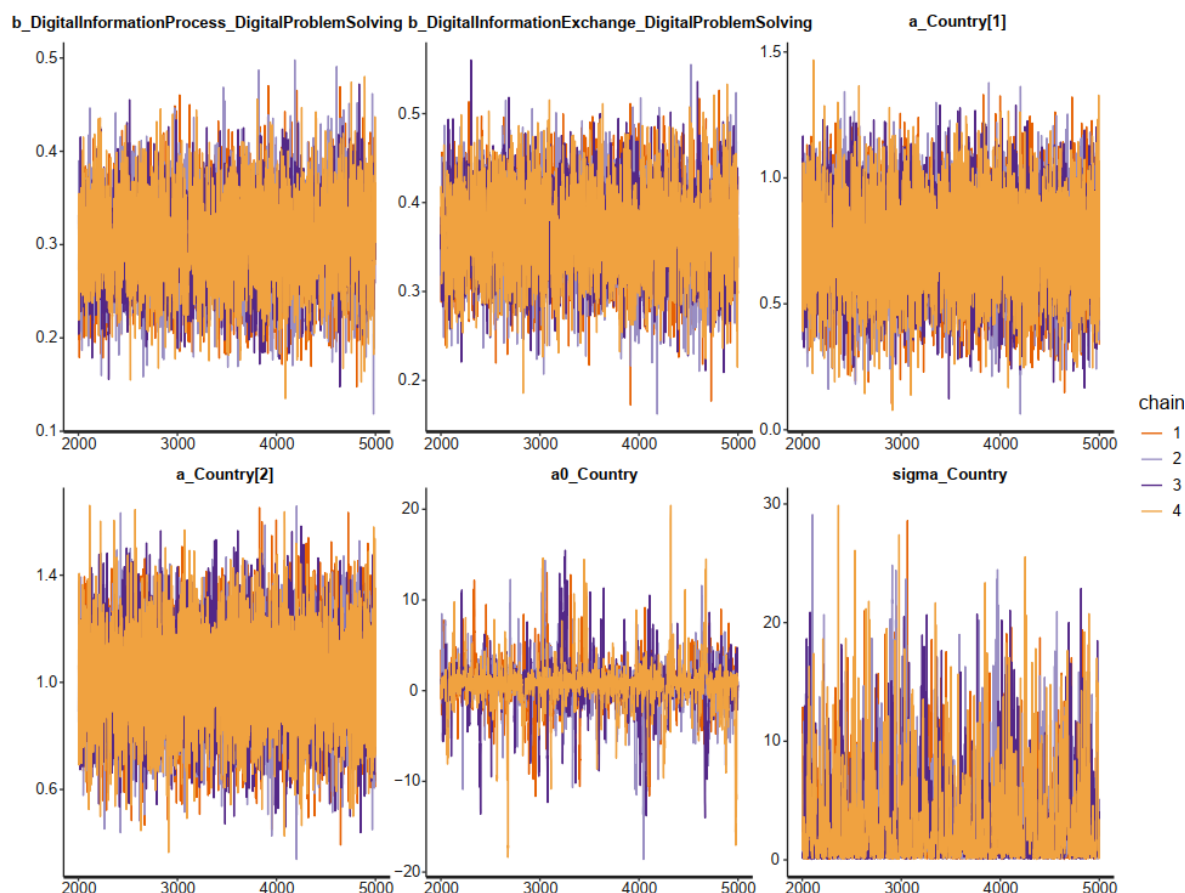


Figure 1. Trace plots for the model

Analysis results from BMF analytics considered a linear relationship. The information-processing and information-exchanging skills in digital spaces were positively associated with digital problem-solving skills among nursing students ($M_{\text{InformationProcess_DigitalProblemSolving}}=0.30$ and $SD_{\text{InformationProcess}}=0.05$; $M_{\text{InformationExchange_DigitalProblemSolving}}=0.37$ and $SD_{\text{InformationExchange}}=0.05$). This means that information-processing and exchanging skills in digital spaces positively affected problem-solving capabilities by using digital content among nursing students. Table 3 shows the estimated posteriors of the analytical model's parameters.

Table 3. Estimated posteriors

Parameters	Mean	SD	n_eff	Rhat
b_DigitalInformationProcess_DigitalProblemSolving	0.30	0.05	5167	1
b_DigitalInformationExchange_DigitalProblemSolving	0.37	0.05	4708	1
a_Country[1]: Surabaya	0.73	0.18	11109	1
a_Country[2]: Bangkok	1.01	0.18	11150	1
a0_Country	0.72	2.49	1092	1

Figure 2 shows the posterior distribution with highest posterior density intervals (HPDIs) at 95%. The found effects are clear, which suggests that the results are reliable. Figure 3 shows the posterior distribution of the intercept representing samples in Bangkok (Thailand) was slightly better/higher than that representing Surabaya (Indonesia) nursing students. In other words, Bangkok nursing students tend to have higher problem-solving skills, but the difference with Surabaya nursing students was not significant.

Daily life functional literacy is associated with basic digital skills important for accomplishing personal and professional tasks in the digital environment [15]. Nursing students' digital competencies are important for supporting their academic performance, both variables were mediated by digital informal learning demanding consideration from nursing educators and curriculum designers [16]. Both study sites conduct digital courses in a different name, but the thing is both sites' nursing curriculum has applied the adjustment of curriculum due to digitalization. There is a high possibility that the age of the respondents (mostly 20-22 years old) plays an important role in determining this high fluency level. Individual who was more than 20 years old were found to be better at using digital devices. People who were born between 1995-2010 are called Generation Z, or Gen Z, having a unique characteristic compared to millennials and the preceding generation [17]. Generation Z is widely known for their fluency in using digital media. They have tended to use digital technology, the internet, and social media since very young.

Another reason may be due to all respondents using the digital devices in everyday life, mostly using smartphones in Surabaya and tablets in Bangkok, making their fluency level high. This is supported by a study of 384 students in Central Java, Indonesia, which found that most students used smartphones for more than 6-7 hours per day for purpose of searching for learning materials or other information, and perceived many benefits from smartphone usage [18]. Another study of 277 students in Southern Thailand showed that tablet computers and smartphones were relatively easily accessible for students and useful for supporting online learning, but there was a significant difference in access between urban and rural residents due to policy issues [19]. The Thai government initiated the program of "one student, one tablet" firstly in 2011 under the governance of former prime minister Yingluck Shinawatra with spending of over two billion Thai Baht (THB) [20]. There was huge support from the Thai government to catalyze the digital learning.

Results also showed that the most difficult basic digital skills to master were the digital problem-solving skills by using digital content. This finding is supported by a study of 817 pedagogy freshmen in three Chilean public universities which showed that the lowest level of digital competence was found in the area of problem-solving, information & digital literacy, and digital content creation [21]. Digital literacy application in education, work, and social environments allows people to build and share useful digital content to be used in communication and problem-solving activities [15]. Collaboration through communication should be the primary method in nursing education by using digital technologies implementation [22].

BMF analytics have shown results of a highly reliable positive association of study sites with digital problem-solving skills. We found more Surabaya nursing students who had difficulties solving problems by using digital content. There is a possibility that this phenomenon was caused by the inadequate implementation of digital learning methods in nursing education institutions in Indonesia. In a digital learning environment for nursing students, the digital problem-solving skills were proved to be enhanced by the application of the digital collaborative learning method [23]. Collaborative learning methods should be promoted to support the creation of conducive environment for supporting knowledge-exchanging behavior among nursing students. In another study that applying direct problem-based learning (DPBL) for educating pre-registered health professionals, it was found that DPBL was better than the traditional PBL method for improving knowledge, skills, and learning outcomes [24]. Results from a Q-methodology study of 47 fourth-year nursing students showed that simulation-

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based learning by using a standardized patient may boost nursing students' self-confidence, enhance critical thinking, improve problem-solving skills, and promote competency [25].

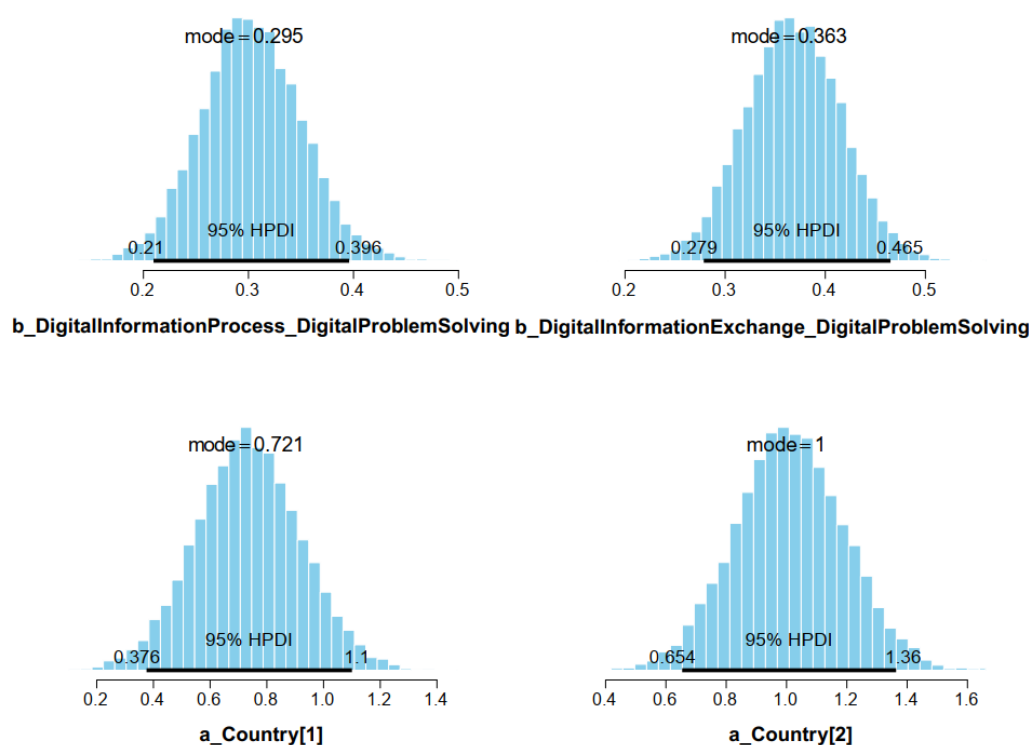


Figure 2. Distributions of posterior coefficients with HPDI at 95%

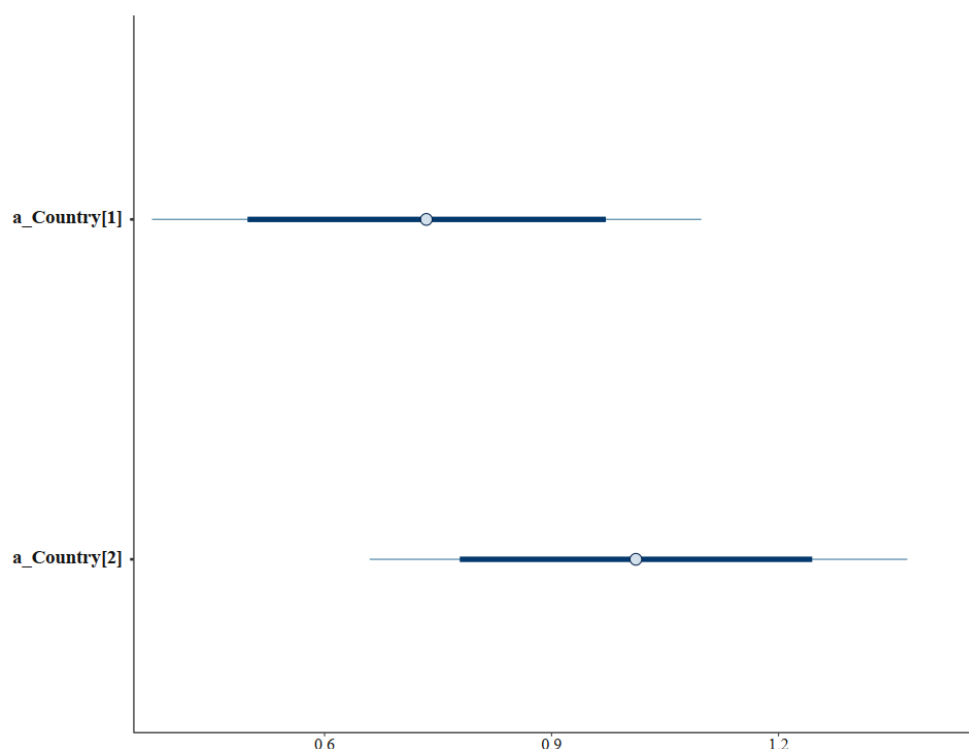


Figure 3. Estimated intercepts reflecting the level of problem-solving skills among nursing students in Bangkok (`a_Country[2]`) and in Surabaya (`a_Country[1]`)

Other than the digital learning method, many other factors may play a role in determining the digital problem-solving skills of nursing students. A study of Spanish university freshmen showed that male students thought that they were information and communication technology (ICT) competent, capable of managing information and collaborating by using digital media, and confident in problem-solving with digital devices. Female students, on the other hand, reported more mobile phone usage for engaging in social media activities and image-text and graphic design processing [26]. Oppositely, another study towards 155 Greek university students did not find any digital skills gap between male and female students because both groups had equal Mean scores, while differences in age and educational level influenced some digital skills components, age and gender correlated with social media use frequency [27]. Another study of 1,160 university students in Ghana showed that there was a significant correlation between pocket money and subjective well-being in which digital health literacy mediated this relationship [28].

We found that the information-processing and information-exchanging skills in digital spaces positively affect the problem-solving capabilities using digital content among nursing students. Information-processing skills can support information-exchanging skills, but both skills will be used after information-seeking skills. A mixed studies review of 51 empirical studies found seven types of influencing factors of collaborative information seeking and five types of outcomes that will be useful to researchers, practitioners, team leaders, and system designers implementing and evaluating collaborative information projects [29]. Information seeking is individual behavior to seek a sense of information sufficiency which makes him put his effort or practice required to achieve his goals e.g., for problem-solving [30]. Those who view themselves as capable of gathering information are more likely to seek information [31]. After seeking, information processing is the core of human performance because it affects environmental perception and actions. Information processes and transformations are related to human performance because they determine our memory, cognition, attention, perception, action selection, and multiple-task performance [32]. After seeking and processing, individuals will share or exchange the information, especially the credible one, which rely on trust-based evaluation [10], mostly to fulfill social expectations [31].

In a digital environment, the information provided by digital content should be processed carefully with respect to reliable digital resources. Based on mindsponge mechanism, after being exposed to new digital information then humans will multi-filtering it by using subjective cost-benefit judgment and assessing its compatibility with the existing mindset [33]. Trust in the information provider may be a bypass of the multi-filter human mind's information processing which is essential for public resources in ensuring effective communication [34]. The presence or absence of trust affects information absorption after moving to the multi-filtering system stage. While getting varied information through digital content, the public judges its value with a trust-based subjective evaluation [21].

The six-step problem-solving model developed by Schein proposes six steps addressing the many challenges or problems that arise in many settings [35]. Step 2 focus on determining the underlying causes of the problem. Step 3 involves creating a variety of solutions. The digital information-processing and information-exchanging skills are relevantly used in the second and third steps. In step 4, the subjective judgment or evaluation of cost-benefit sollutive information available is the most important part. Digital problem-solving skills is highly relevant to this fourth step. By using the selected solution, individuals then behave to implement it and finally evaluate the success based on data. In this case, the six-step cycle will continue from the start again.

The goal of the continuous improvement process is not to solve but to evolve. To evolve, improving the absorptive ability of the human mind towards new values or information and information-processing skills is the key. Due to each individual's mindset or pool of knowledge, sharing, discussing, and collaborating with others may result in knowledge or information exchange requiring a certain level of information-exchanging skills. Thus, the collaborative learning method is highly recommended in nursing education. Students with higher digital skills tend to be more digitally creative because they can use digital technologies to implement and test their solutions to a particular problem. Information processing and exchanging skills may support digital competency, and together with digital openness may result in digital problem-solving creativity among students. Digital information-processing and exchanging skills can help improve digital problem-solving skills by enhancing digital creativity. The creative solution can be used as input for the later problem-solving creativity processes. Higher digital skills or capability may facilitate the information-seeking behavior important for generating creative solutions more effectively [36].

This study is not without limitations. Firstly, the newly developed instrument was content-validated only before usage in the data collection process. The psychometric property of this instrument has not tested yet. The instrument testing procedure involved item validity and reliability tests only based on in-campus instrument testing with a small sample size. Secondly, the nature of the cross-sectional study makes it hard to monitor the changes in digital skills value over time. The continuous assessment of nursing students' digital skills, especially problem-solving skills by using digital content, is highly recommended.

4. CONCLUSION

Overall, the basic digital skills are not different significantly between Bangkok and Surabaya nursing students. There is a significant difference in the fluency level in using digital devices and the digital problem-solving skills by using digital content between sites. The information-processing and information-exchanging skills in digital spaces positively affect digital problem-solving capabilities by using digital content among nursing students. Bangkok nursing students tend to have higher problem-solving skills, but the difference with Surabaya nursing students was not significant. More efforts are needed to improve nursing students' problem-solving skills by using digital content, for instance by modifying the information-processing and information-exchanging skills in digital spaces. Collaborative learning methods should be promoted to support the creation of conducive environment for supporting knowledge or information-exchanging behavior among nursing students by using digital technology.

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