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Trends and research issues of mobile learning studies in nursing education: A review of academic publications from 1971 to 2016



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ABSTRACT

In the past decades, the issues related to mobile learning have been widely discussed around the globe; however, the development and trends of applying mobile technologies in nursing education still lack systematic analysis. In this study, a meta review of the studies published in academic journals from 1971 to 2016 was conducted to analyze the application domains, subjects, adopted learning strategies, investigated research issues and findings of mobile technology-supported nursing education. From the review results, it was found that the use of mobile technologies in nursing education and training have made great progress in the past decades. In addition to the changes in mobile technologies and the increasing number of mobile learning studies in nursing education, the subjects and research issues have also become more diverse in recent years. It was also found that mobile learning has mainly been applied to the training of basic nursing concepts and skills as well as to long-term care and obstetrics and gynecology, while few or even no studies are related to other nursing education domains. In addition, several widely adopted mobile learning strategies, such as inquiry-based learning, contextual mobile learning, synchronous sharing, Mindtools, project-based learning and peer assessment, have seldom been adopted in mobile nursing education. This also reflects the fact that most of these studies focused on skills training and basic knowledge comprehension, while few were conducted in the domains aimed at fostering learners' higher order thinking competences, such as problem solving or critical thinking. On the other hand, it was found that the number of studies using an experimental design has increased in recent years; moreover, most studies reported the learners' cognitive performance and perceptions, while their learning behaviors were seldom analyzed. Accordingly, the research trends and potential research issues of mobile nursing education are proposed as a reference for researchers, instructors and policy makers.

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1. Introduction

The advancements in wireless Internet, sensing technology, and mobile technology have boosted the transformation of education and learning conceptions. [Hwang, Wu, and Chen \(2007\)](#) indicated that the development of wireless

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communication and sensing technologies provides researchers and instructors with new thinking perspectives. In particular, the portability and accessibility of digital learning content supported with mobile technology provide the opportunity for learners to link the textbook knowledge with real life environments; for instance, Vogel, Kurti, Milrad, Johansson, and Muller (2014) applied mobile technology in an ecology learning activity to guide students to observe and collect data in the real environment. Such a learning approach enables learners to have real-world problem-solving experience using the knowledge learned from textbooks.

These advancements in technologies have brought a tremendous change to the education of all subjects in the 21st century. Besides leading in mobile learning in normal subjects, implementing mobile technology in nursing education is also an issue worth discussing. Not only can the integration of innovative techniques help students or trainees learn effectively within limited clinical learning time, but it can also help nursing staff conduct training and reinforcement of professional skills. For instance, Wu, Hwang, Tsai, Chen, and Huang (2011) developed a mobile guiding system for a clinical nursing course; through the mobility of the mobile devices, learners were guided to interact with simulated standard patients in real scenarios. The sensing technology can lower the obstacle of entering information into mobile devices during the learning process, and can guide students to identify the abnormal symptoms by observation; the results showed that the students using the mobile guiding system outperformed those using conventional ways in disease identification learning achievement, which confirmed that mobile learning can effectively increase nursing students' learning results. Applying the function of instant information of mobile technology can control examinees' inspection progress and movements, while also providing them with health education services and correct identification of patients (Athilingam et al., 2016). Furthermore, mobile technology can help nurses take control of the medical golden treatment time and let them deliver and record medical information to increase clinical efficiency (Colton & Hunt, 2016; Hwang et al., 2007; Lee & Daugherty, 2016). For instance, Wang and Kim (2015) applied mobile phones and the Internet system to let midwives, pregnant women, and other health professionals have two-directional interaction, easy operation, instant medical messages, and feedback.

It was found that digital learning platforms in mobile technology can support nursing students' learning in clinical medical environments (Lai & Wu, 2016). However, as with the innovations in technology, instant and accurate medical and nursing professional knowledge must also be accumulated by clinical learning and experience to avoid any abnormal event or medical malpractice. Through relevant research development and discussion, professional medical groups can be cultivated to improve the quality of medical practice. To understand the application and trends of mobile technology in nursing, literature on mobile devices in nursing from 1971 to 2016 was analyzed in this study. From the analysis results, some research issues are proposed for nursing education which can serve as relevant research for mobile technology in nursing education for medical education institutes or researchers.

2. Literature review

There are various definitions of mobile learning. One frequently adopted definition is the teaching mode that employs mobile technologies to provide learning materials, guidance or supports to learners (Sharples, Milrad, Arnedillo Sánchez, & Vavoula, 2009). Another, which is a broad-sense definition, refers to the learning mode that is not constrained by physical locations (Hwang, Tsai, & Yang, 2008). The former emphasizes the use of mobile technologies, while the latter emphasizes the mobility of learners or learning equipment. With the portability of mobile devices, learners can read teaching materials, practice, and collect data at any time; meanwhile, with the help of sensing technologies, learning systems can detect learners' location and provide learning guidance and supports based on their needs in real-world contexts (Phillippi & Wyatt, 2011; Wu et al., 2011). This is of great help for promoting learning results (Wu & Sung, 2014; Wu, 2014a, 2014b).

There have been many successful examples of applying mobile technology in medical education. For instance, clinical teachers applied iPads to help midwives simulate the clinical learning environment (Brown & McCrorie, 2015); health professionals applied smart phones and QR codes to cultivate students' rapid learning (Jamu, Lowi-Jones, & Mitchell, 2016). Meanwhile, mobile technology in nursing education has received emphasis. For instance, Wu (2014a, 2014b) adopted mobile devices to enhance nursing students' professional knowledge and skills. With the facilitation of mobile technology, learning of nursing professional knowledge can be effectively enhanced. Furthermore, scholars have also indicated that nursing education with mobile technology can enhance the interaction among peers and teachers, and has received strong affirmation from students (Wu & Sung, 2014).

Another important goal of applying mobile technology in nursing education is to facilitate students' skills training or on-the-job training (Ashby, Snodgrass, Rivett, & Russell, 2016; Tower, Cooke, Watson, Buys, & Wilson, 2015). For instance, Lai and Wu (2012, 2016) adopted mobile devices to guide students to operate systems to help them connect theories with practice in order to improve the records, evaluation, and feedback of the e-system.

In addition to skills training, mobile technologies also have good potential in terms of benefiting learners in other dimensions of nursing education. For instance, Ashby et al. (2016) as well as Tower et al. (2015) discussed the application of mobile synchronous feedback systems and their effect on learning perceptions. Athilingam et al. (2016) indicated that the mobile learning mode can increase patients' cognition of heart failure knowledge and improve their confidence in health education knowledge. Wu et al. (2011) also confirmed that leading mobile learning in the respiratory and circulatory system in nursing education allowed students to use personalized instruction and supplement teaching materials to learn professional knowledge. It was found that most students showed a positive attitude toward using mobile learning systems and participating in the training program.

According to the literature, an increasing number of researchers are attempting to apply mobile technology to improve students' learning results, help educators prepare the learning activities suitable for students, and provide safety, quality, and professionalism in nursing education (Billings, 2005, 2012; Billings, Kowalski, Shatto, & Erwin, 2016). To enable the research and development in nursing to become more sophisticated, analyzing previous application and research trends in mobile technology in nursing education has become important. By way of a profound literature review and investigation of different aspects, the improvements in research and education can be understood by researchers and educational institutes alike (Chiang et al., 2016; Hwang & Wu, 2014). However, in much of the published literature, there is no research trend analysis of the application of mobile technology in nursing education. The greatest feature of nursing education is to combine the textbook knowledge with clinical practice and application. To provide a more detailed mobile learning literature analysis, the literature was analyzed to understand the findings of mobile technology in nursing in the past; possible research trends and issues are then proposed.

3. Research methods

3.1. Resources

The journal papers related to mobile learning in nursing education between 1971 and 2016 were searched in the Scopus database on December 31st, 2016. There were 24,353 papers including “mobile learning” or “ubiquitous learning” in the paper title, abstract, or keywords list. Among them, 130 were related to nursing. By removing 28 non-journal papers and 5 redundant journal papers, a total of 97 were selected in the final list for analysis, as shown in Fig. 1. Two experienced researchers then read and categorized the papers based on the coding scheme. During the coding process, if there were inconsistent coding values, the researchers were asked to discuss until agreement was reached.

3.2. Data distribution

Fig. 2 shows the publication situation of mobile learning in nursing education papers from 1971 to 2016. The earliest paper was written by Porth and May (1971), and investigated the mobile library cart in nursing education. There was no relevant research on mobile learning in nursing between 1971 and 1981. Fewer than five papers were published each year from 1982 to 2004 in which mobile learning in nursing education was discussed (Bomberger & Kern, 1982). It was not until 2005 that it started to receive more attention from researchers. In Fig. 2, it can be seen that 17 papers were published in the nursing domain in 2016. Such a finding is reasonable since, due to the advancements in technology, nursing students needed to practice learning repeatedly anytime and anywhere to gain nursing knowledge more effectively. In particular, in recent years, the rapid growth in the use of mobile devices around the globe has encouraged schools and institutes to employ mobile technologies in learning and training (Song & Kong, 2017). Meanwhile, the application of mobile devices offers learning equipment which satisfies the needs of nursing education, and apparently mobile learning technology started to be applied in formal and informal education at about this time.

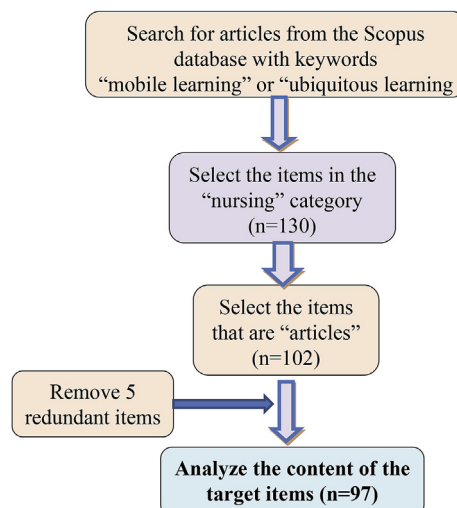


Fig. 1. Scopus database searching steps.

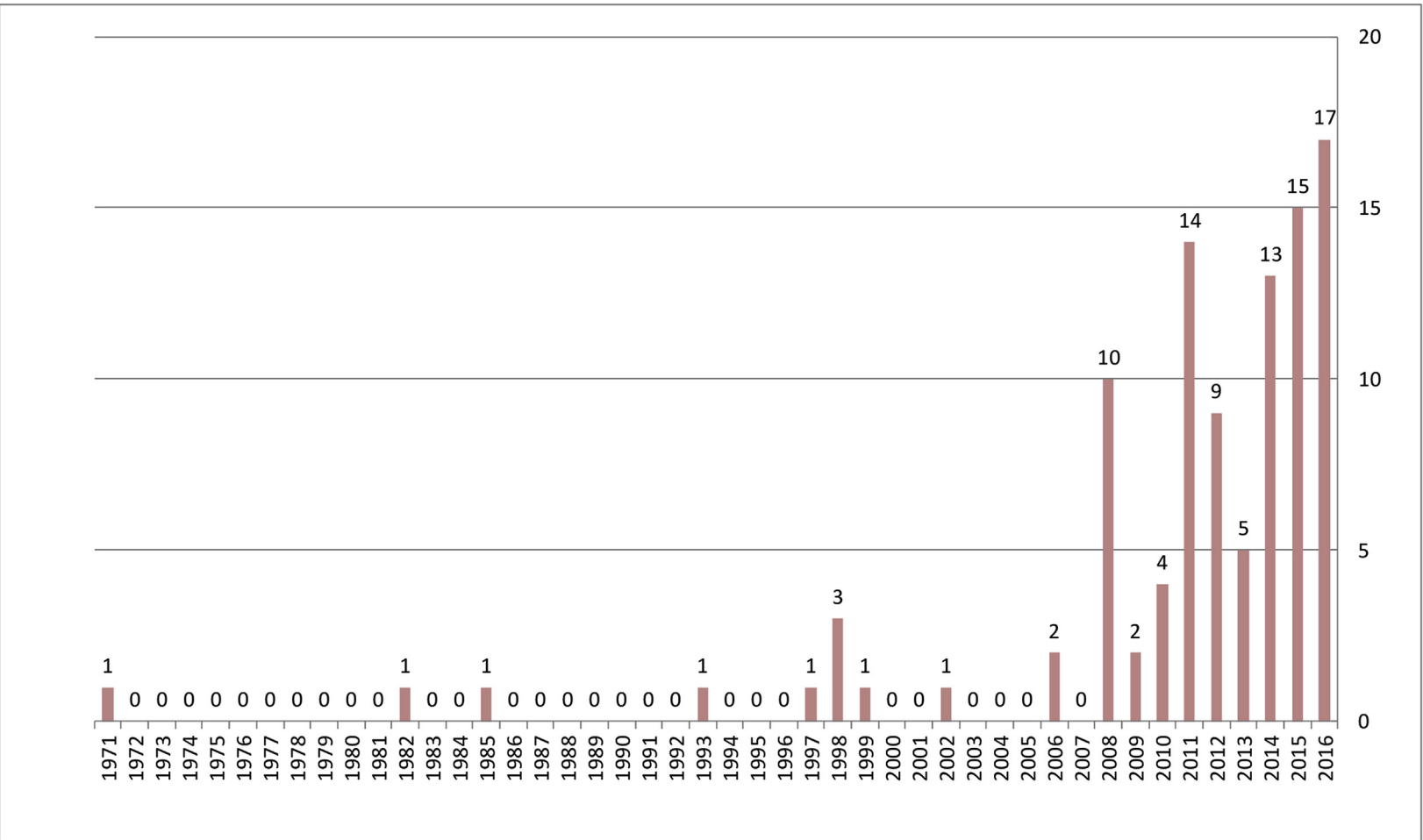


Fig. 2. Published papers applying mobile learning in nursing education from 1971 to 2016.

Table 1
Categories and explanations of the 11 mobile learning activities in nursing education adopted in this study.

Strategy	Explanation
(1) Guided learning	Through the supplementary learning materials, websites, and software, students are helped to collect, organize information, or practice.
(2) Peer assessment	Students are guided to grade and comment on peers' performance and works, based on the rubrics provided by teachers. In the activity, students play not only the roles of learners or interviewees but also the roles of teachers or interviewers.
(3) Video sharing	Students are guided to interpret, practice, and apply the learning contents by recording videos.
(4) Synchronous sharing	Students are guided to have in-time interaction through mobile technology, including discussion, sharing, and joint problem-solving.
(5) Issue-based learning	Students are guided to have data collection and online discussion, based on the assigned topics.
(6) Computers as Mindtools	Students are guided to use Mindtools (Computer-assisted learning tools) to summarize, organize, connect, and infer the knowledge.
(7) Project-based learning	Students are guided to complete the projects, based on the assigned topics, including reports or other forms of work.
(8) Inquiry-based learning	Students are guided to discover problems, to find the solutions, and to organize the knowledge.
(9) Contextual mobile learning	Students are guided to apply, observe, discuss the textbook knowledge, collect data, and solve problems in the real-world environment.
(10) Game-based learning	Gaming competition strategy is combined with mobile learning activities.
(11) Community service training	Learn by serving the patients on sites.

3.3. Coding schemes

Previous coding schemes served as a reference to analyze the contents in this study, including the nationality, authors, journals, adopted types of mobile devices, application subjects and forms, learning strategies, research methods, participants, and research issues (Hwang & Tsai, 2011; Hwang & Wu, 2014). The following items explain the coding schemes of each dimension:

- (1). Nationalities, authors, and journals: The basic information of those published papers is discussed, including authors, nationality, and journals. The aim is to understand who and which countries have more frequently published papers about mobile nursing education. Relevant journals for publishing mobile nursing education are also provided.
- (2). Adopted types of mobile devices: Ozdamli and Uzunboylu's categories of mobile devices (2015) served as a reference in this study, and the traditional mobile equipment adopted in nursing education was also included. Consequently, the categories of mobile devices in this study included wearable devices, smart phones, tablet computers, traditional portable computers or devices (e.g., notebooks or Personal Digital Assistants), mobile medical or teaching equipment, mixed, and no use of devices. The category "mixed" means using two or more different types of devices; no use of devices means that the research was conducted by document analysis or questionnaire survey.
- (3). Application domains: Nursing specialist fields include information technology training, basic nursing concepts and skills, long-term care, chest, critical care units/emergency health, cardiology, family medicine, neurology, pharmacology, evidence-based care, obstetrics & gynecology, orthopedics, pediatrics, psychiatric nursing, surgical ward, and geriatric medicine.
- (4). Learning strategies: The category of learning strategies was based on the 10 common mobile learning strategies proposed by Lai and Hwang (2015), that is, guided learning, peer assessment, video sharing, synchronous sharing, issue-based learning, computers as mindtools, project-based learning, inquiry-based learning, contextual mobile learning, and game-based learning. Furthermore, community service training is another commonly used strategy in nursing education. Table 1 provides the detailed explanations of these 11 strategies.
- (5). Research methods, participants, and research issues: This study reviewed the research methods, participants, and researched issues adopted in mobile nursing education studies. The research method categories are based on those proposed by Johnson and Christensen (2000), including experimental design method, questionnaire survey, qualitative research method, system development, and document analysis.
- (6). The participants included in nursing education are categorized into students, employees, patients, the general public, and no participants involved (e.g., studies aimed at reviewing the literature or developing mobile learning systems) (Brown & McCrorie, 2015; Zayim & Ozel, 2015).
- (7). The study categorized the research issues into the following aspects: cognition, affect, psychomotor, learning behaviors, and causal analysis. The cognition aspect means acquiring knowledge from learning, while the affect aspect indicates the participants' feelings about learning. The psychomotor domain refers to the professional skills for nursing, and was used to examine if the students were capable of operating the devices and applying knowledge to physical objects. The aspect of learning behaviors represents that the research investigated participants' actual behaviors in the real world or in the virtual world. Finally, causal analysis means the discussion of the relationship or effectiveness of participants' perceptions of the nursing education.

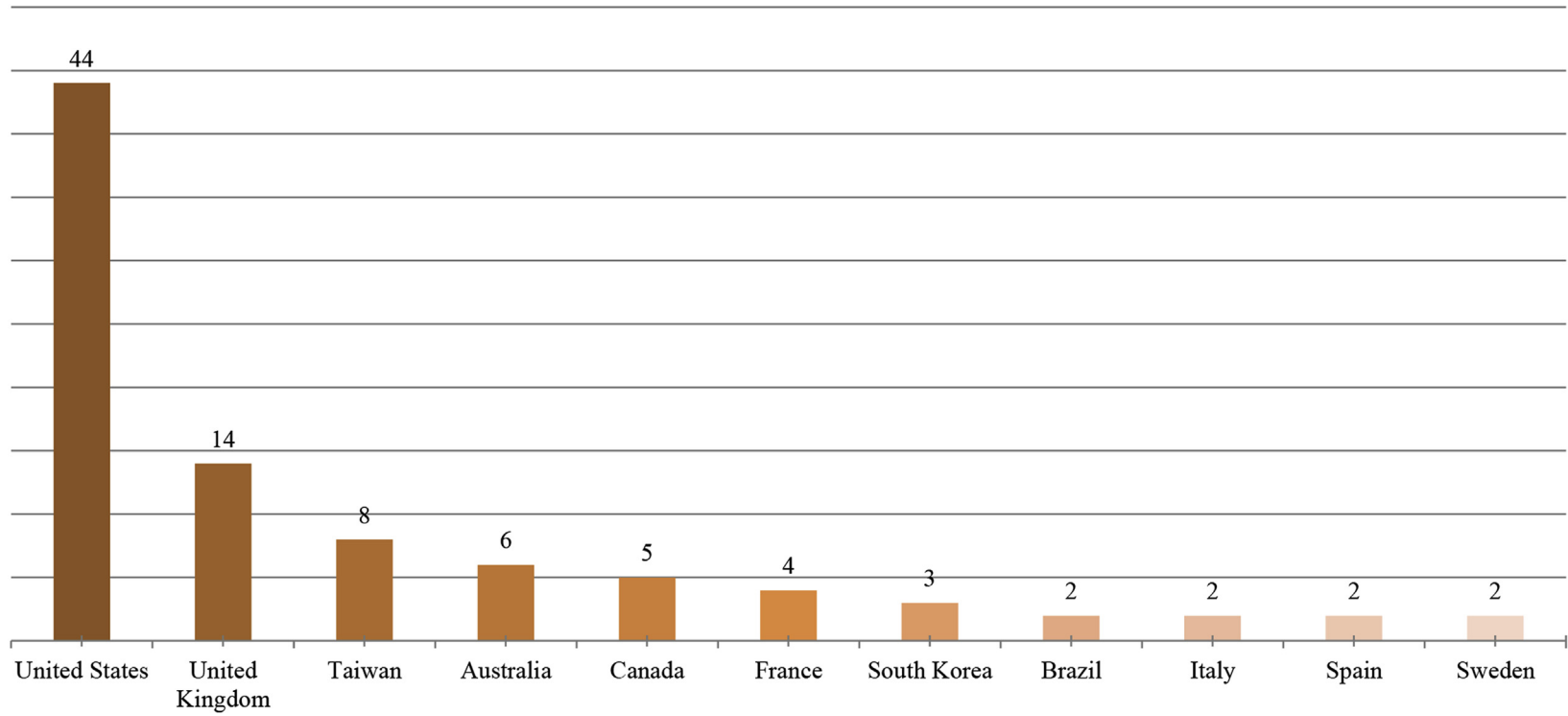


Fig. 3. Top ten countries publishing papers on mobile technology in nursing education during 1971–2016.

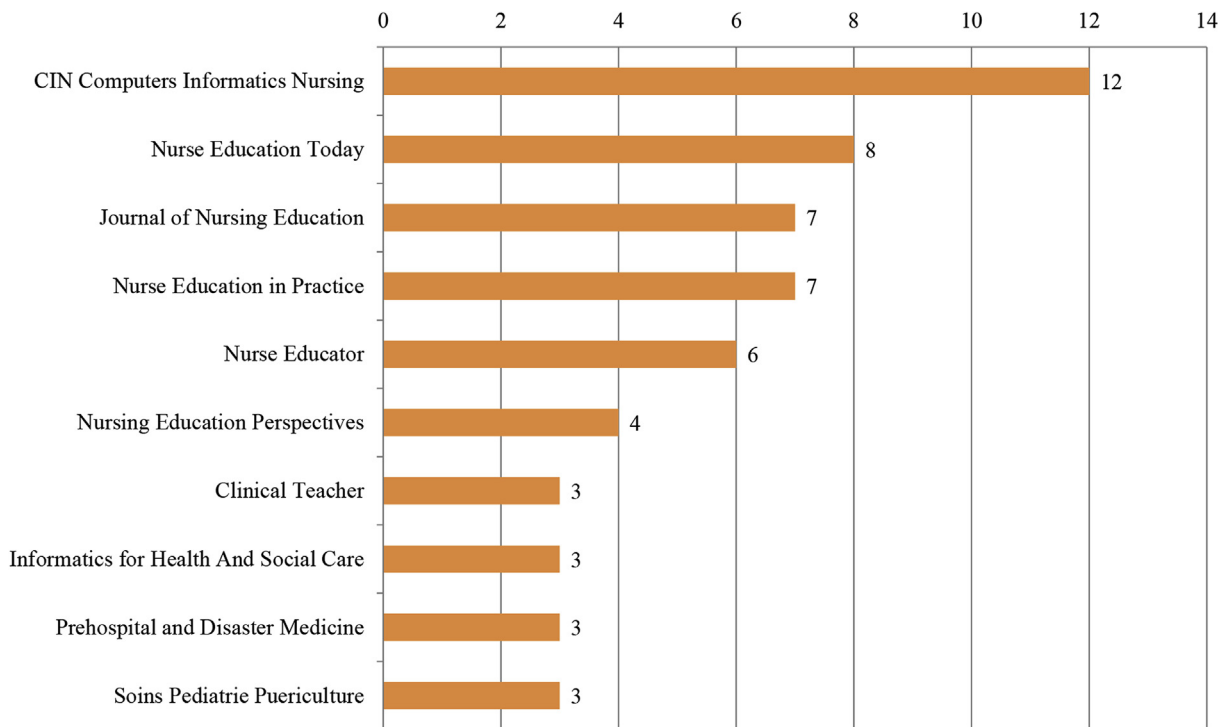


Fig. 4. Journals publishing more than 2 papers on mobile learning in nursing education from 1971 to 2016.

4. Research results

4.1. Nationalities, authors, and journals

Only the nationalities of the first authors of the published papers of mobile technology in nursing education were counted in this study. From the results, it can be found that there were many researchers from different countries attempting to apply mobile technology in nursing education. Fig. 3 shows the distribution of the top 10 countries and areas. The top three countries and areas are the United States (44), the United Kingdom (14), and Taiwan (8).

Furthermore, those institutes publishing more than two papers on mobile technology in nursing education from 1971 to 2016 were calculated. The schools with the greatest number of published papers (3) are Indiana University School of Nursing Indianapolis (IUSON), Universidade de Sao Paulo (USP), and Duke University (Duke), while two papers were published by National Taiwan Normal University (NTNU) and National Taichung University Taiwan (NTCU).

Fig. 4 shows the 10 journals with the greatest number of published papers from 1971 to 2016, including CIN Computers Informatics Nursing, Nurse Education Today, Journal of Nursing Education, Nurse Education in Practice, Nurse Educator, Nursing Education Perspectives, Clinical Teacher, Informatics for Health and Social Care, Prehospital and Disaster Medicine, and Soins Pediatrie Puericulture. The journal with the greatest number of published papers is CIN Computers Informatics Nursing, with a total of 12 papers, and the second is Nurse Education Today, with a total of 8 papers, followed by the Journal of Nurse Education and Nurse Education In Practice, with a total of 7 papers each.

4.2. Adopted types of mobile devices

The portability and functionality of mobile devices have great impacts on their acceptance by users. From 1971 to 2016, mobile technology changed greatly. Fig. 5 shows the distribution of the mobile devices adopted in each study; among them, there are 40 papers adopting smart phones, 3 using tablet computers, 16 using traditional portable devices, 10 using mobile medical or teaching equipment, 5 using mixed mobile devices, and 23 not using any mobile device. In addition, none of the studies employed wearable devices.

Furthermore, the 97 papers from 1971 to 2016 were divided into three periods by taking the fluctuations of mobile technologies into account. Accordingly, the first fluctuation was around 2000–2001 and the second was around 2010–2011 (Hwang & Wu, 2014; Zheng, Liang, Huang, & Liu, 2016). Therefore, the three time periods were 1971–2000, 2001 to 2010, and 2011 to 2016. Fig. 6 shows the application situation of mobile devices in each period. From the figure, it can be seen that from

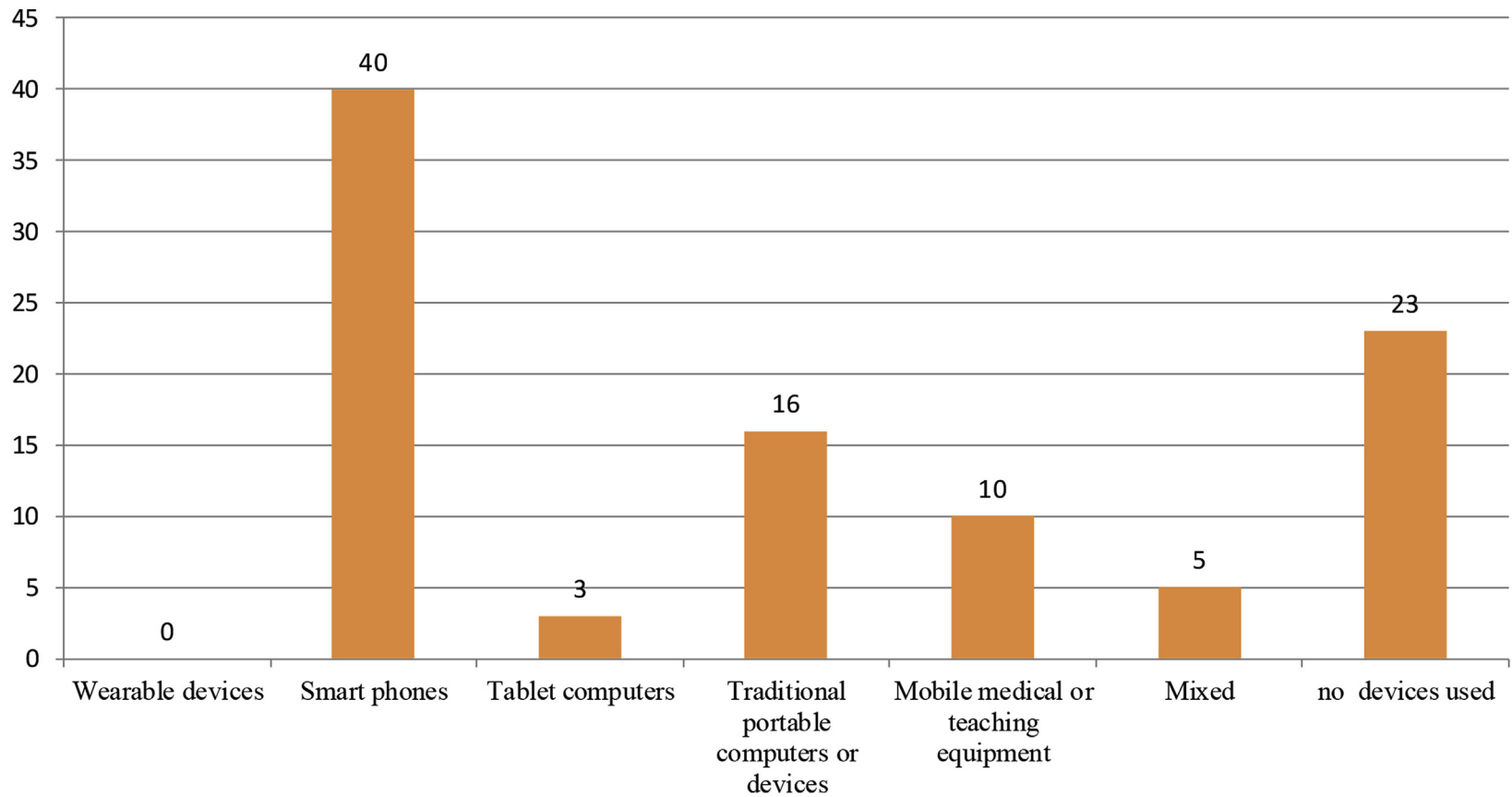


Fig. 5. Technologies adopted in mobile learning studies for nursing education from 1971 to 2016.

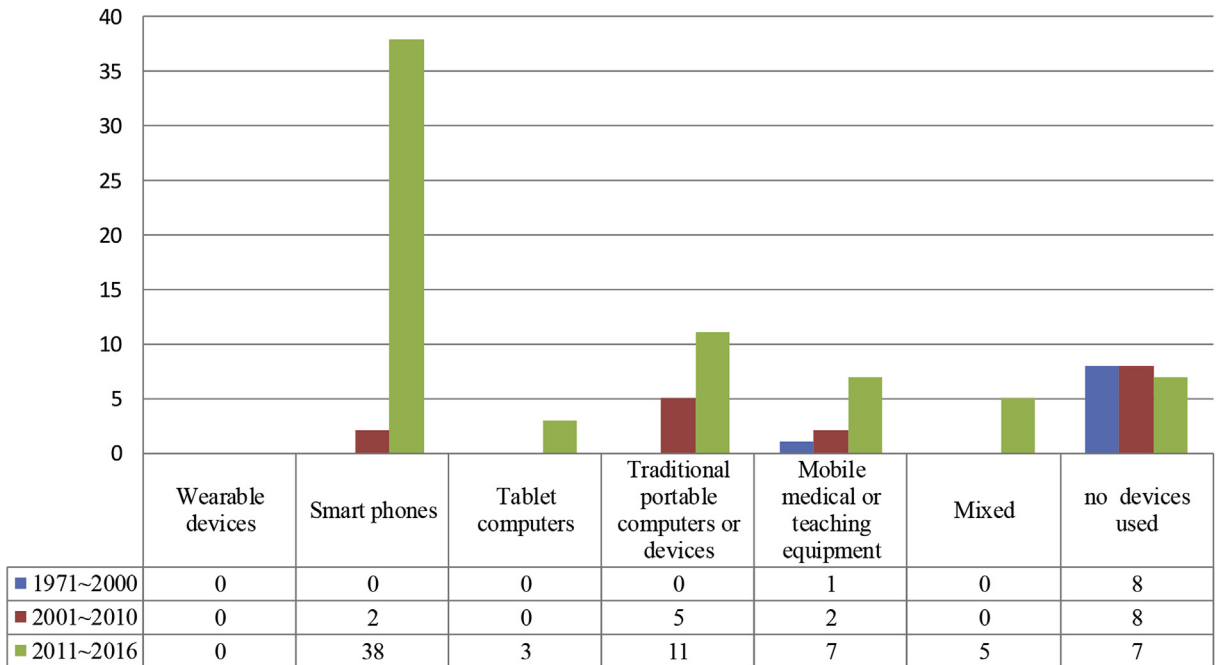


Fig. 6. Technologies adopted in mobile nursing education studies in each period.

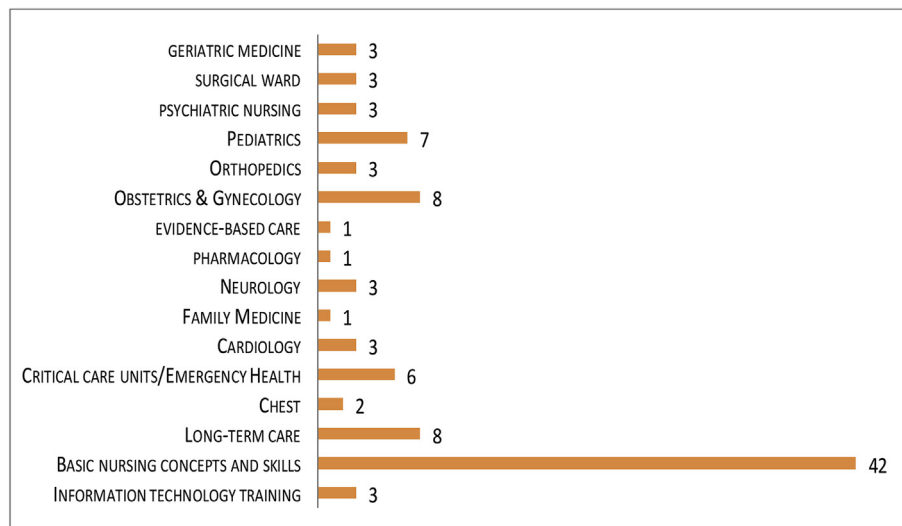


Fig. 7. Number of mobile nursing education studies for each application domain from 1971 to 2016.

1971 to 2000, the mobile technology was not yet well-developed and the research was mainly conducted by literature review or questionnaire investigation.

From 2001 to 2010, the research was mainly conducted by conventional portable computer devices, but there was some research using smart phones. For instance, [Garrett and Jackson \(2006\)](#) applied the wireless personal digital assistant tool (PDA) to develop and conduct assessment to improve the working environment of health professionals and to enhance the reflection of medical professionals. They developed a PDA e-portfolio tool to analyze students' learning process, and found that mobile technology can improve students' reflection on the process of learning practice and improve the learning results.

From 2011 to 2016, smart phones and tablet devices became the main devices for mobile learning; other types of mobile learning devices were also included in the teaching activities. For instance, [Phillippi and Wyatt \(2011\)](#) adopted smart phones

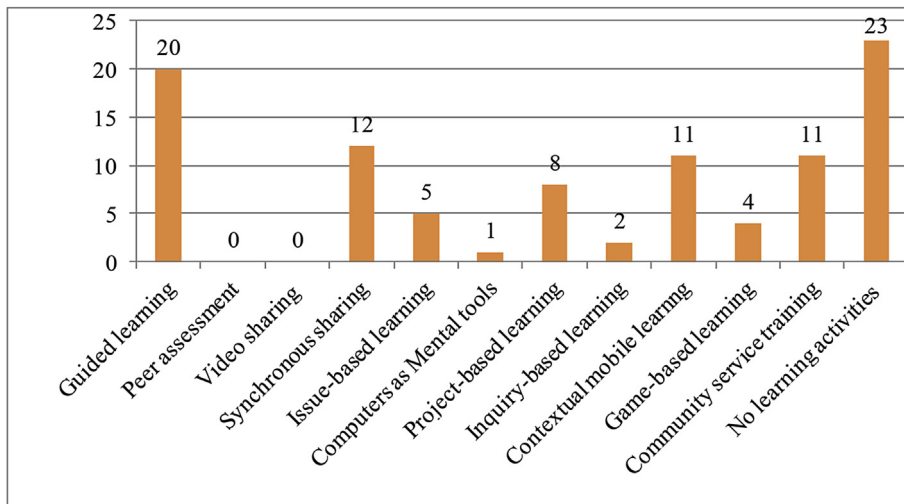


Fig. 8. Learning strategies adopted in mobile nursing education from 1971 to 2016.

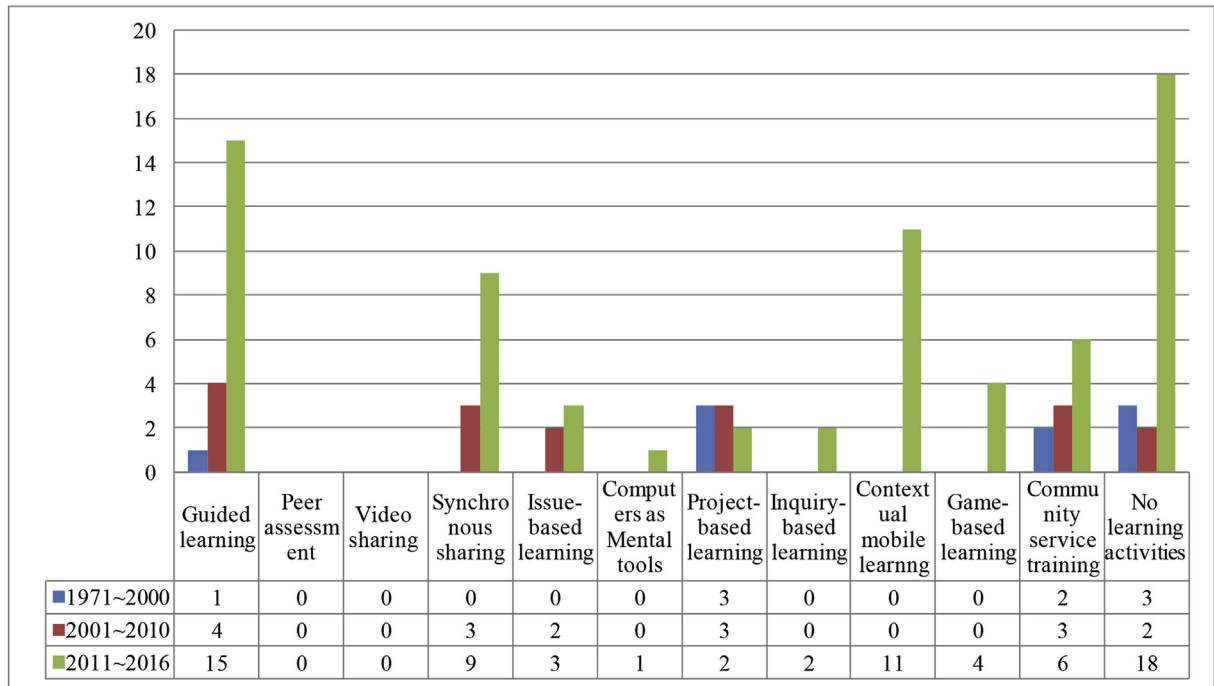


Fig. 9. Learning strategies adopted in mobile nursing education in each period.

in nursing education and found that they could guide the students to enhance their learning at anytime and anywhere. [Jamu et al. \(2016\)](#) adopted smartphones in clinical practice to help students engage in diverse forms of professional learning. Meanwhile, tablet computers started to be applied in nursing education. [Fletcher-Watson, Crompton, Hutchison, and Lu \(2016\)](#) used digital tablet computers in a digital literacy course for the elderly. [Brown and McCrorie \(2015\)](#) used tablet computers to support the learning for nurses and midwife students, while [Ashby et al. \(2016\)](#) used tablet computers as a testing tool for students' clinical practice. Many scholars indicated that using smart phones and tablet computers as an innovative teaching tool for nursing education is a trend worth emphasizing ([Hochberg et al., 2016](#); [Jamu et al., 2016](#); [Lee & Shin, 2016](#)).

On the other hand, no combinations of Global Positioning Systems, Augmented Reality, Bluetooth, Internet positioning, infrared rays, or the Internet of Things in nursing education were found in the literature.

4.3. Application domains

Fig. 7 shows the application domains of mobile devices in nursing education by reviewing the literature from 1971 to 2016. There are 97 papers of which the greatest number (i.e., 42) are about basic nursing concepts and skills. The second greatest number (8) are related to long-term care and obstetrics and gynecology.

From Fig. 7, it can be seen that the investigation of the nursing domains from 1971 to 2016 focused primarily on basic nursing concepts and skills. Terry, Moloney, Bowtell, and Terry (2016) taught the skills of intravenous infusion online, and the results showed that the students' preparation and management of intravenous infusion skills improved. Stephens and Gunther (2016) used Twitter to increase the involvement of teachers and nursing students, and to improve students' critical thinking and social interaction. Hardy, Mushore, and Goddard (2016) investigated using online video conferencing as a facilitation of the nursing students' training process, and the findings confirmed that through applying mobile technology in nursing education, students expressed positive learning results and gained rich nursing clinical learning experience (Colton & Hunt, 2016; Forbes et al., 2016; Hardy et al., 2016).

4.4. Learning strategies

In the mobile nursing activities, distribution of the adopted learning strategies is shown in Fig. 8. The greatest proportion is no learning activities, with a total of 23 papers, while the second greatest is guided learning, with a total of 20 papers. The third greatest is shared by both synchronous sharing and community service training, each with a total of 12 papers. This was followed by contextual mobile learning and community service training, with 11 papers each. It can be found that besides the more frequently adopted strategies, guided learning and highly-interactive synchronous sharing, nursing education places more emphasis on usage in the real environment, meaning using contextual learning and service learning to increase students' chances of actual practice.

The 97 papers were then divided into three periods, 1971 to 2000, 2001 to 2010, and 2011 to 2016. Fig. 9 presents that in the earliest stage (1971–2000), there were three project-based learning and two community service training papers. In the middle stage (2001–2010), more papers used guided learning, synchronous sharing, project-based learning, and community service training. In the most recent stage (2011–2016), the main strategy used is guided learning (15), followed by 9 papers using synchronous sharing, 11 using contextual mobile learning, and 6 using community service training. Lin (2013) used mobile technology in nursing courses to conduct peer assessment and interaction. This development may be linked with the increasing popularity of mobile devices and wireless Internet.

4.5. Research methods

The research method means the method used to collect and analyze data for answering the research questions, such as the experimental design method, questionnaire survey, qualitative research method, system development, and document analysis. Fig. 10 shows that among the 97 chosen papers, 48 (49.8%) adopted the experimental design method, meaning to investigate the effects of the proposed system or learning strategy on the participants, while 17 papers (17.4%) used the questionnaire survey method, meaning to explore participants' preferences regarding the commonly used tools or technologies in nursing education. There are 10 papers using the qualitative research method, which included a focus group interview, case study, or other qualitative methods. Besides, 9 papers (9.2%) mainly focused on the development of mobile

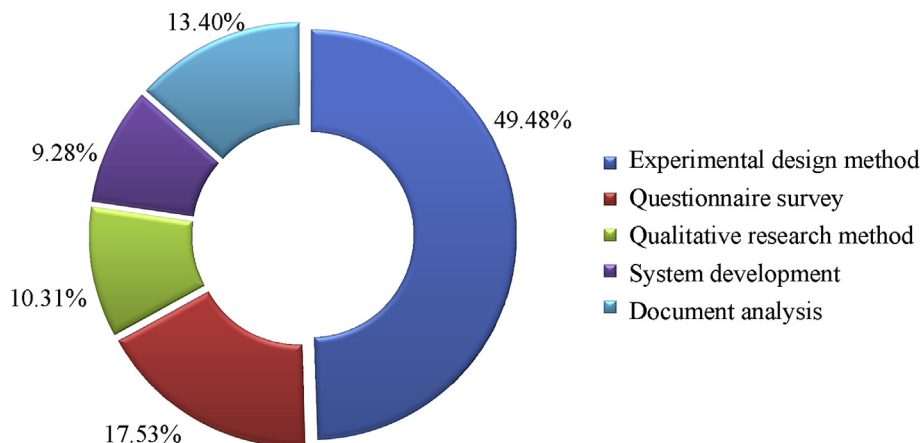


Fig. 10. Proportion of major research methods adopted in mobile nursing education from 1971 to 2016.

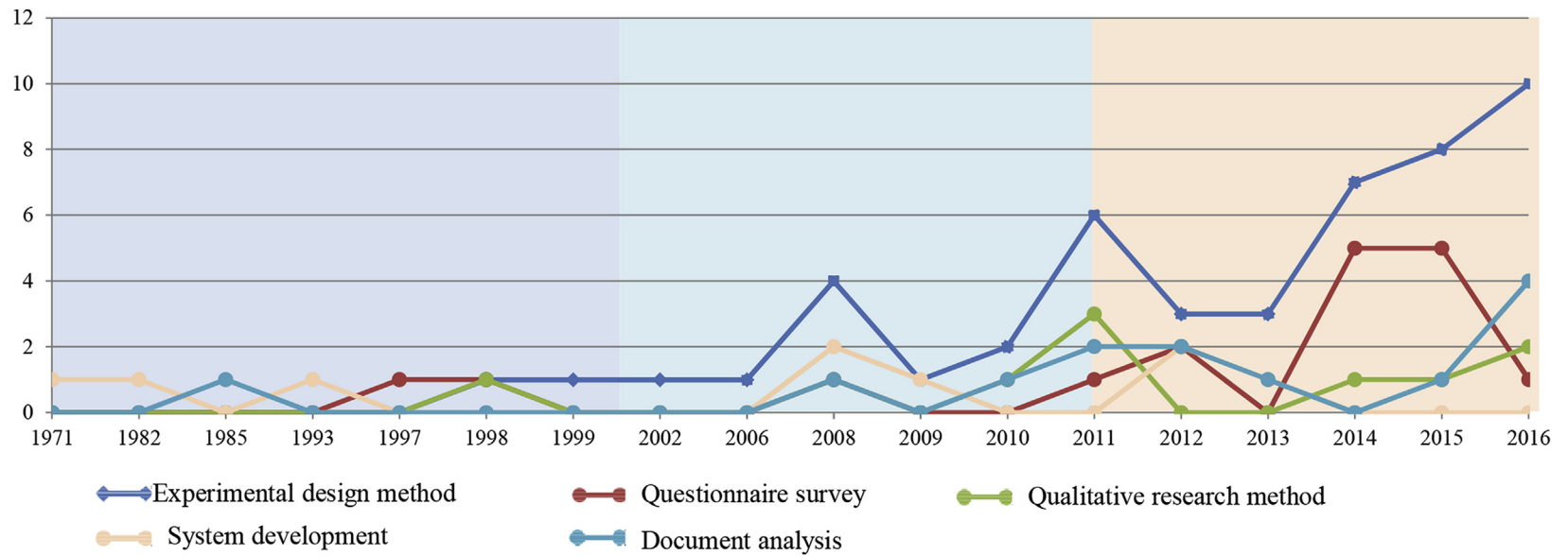


Fig. 11. Distribution of research methods between 1971 and 2016.

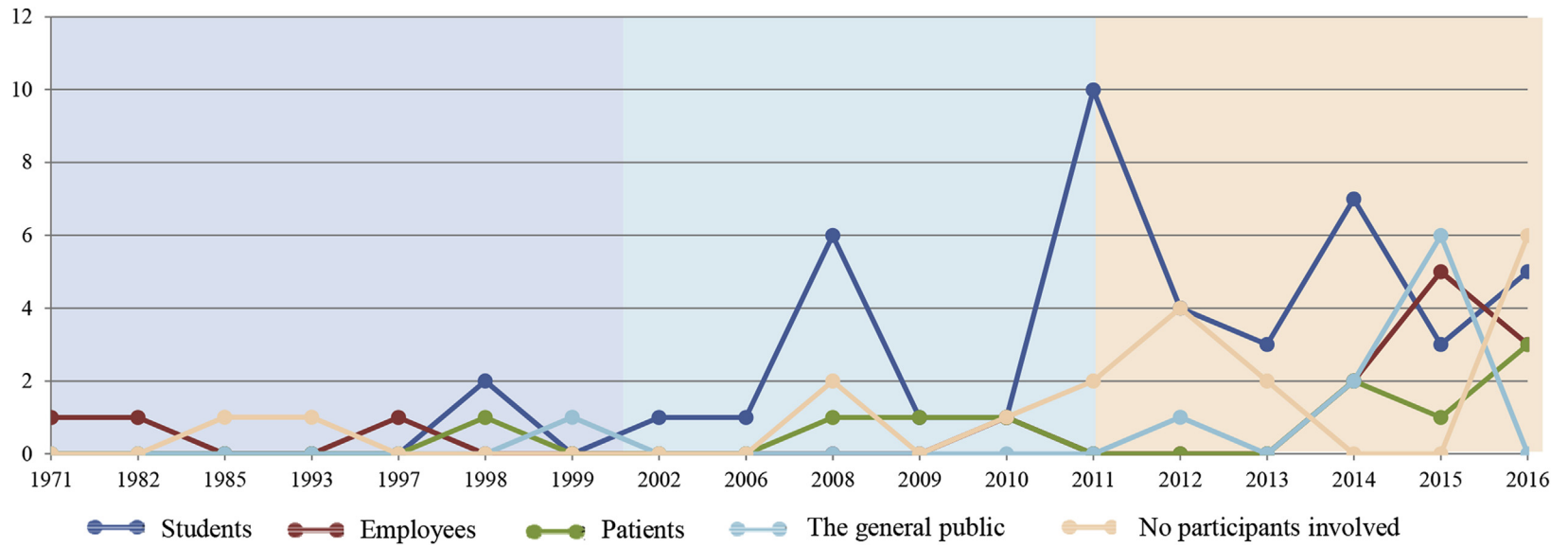


Fig. 12. Distribution of research participants from 1971 to 2016.

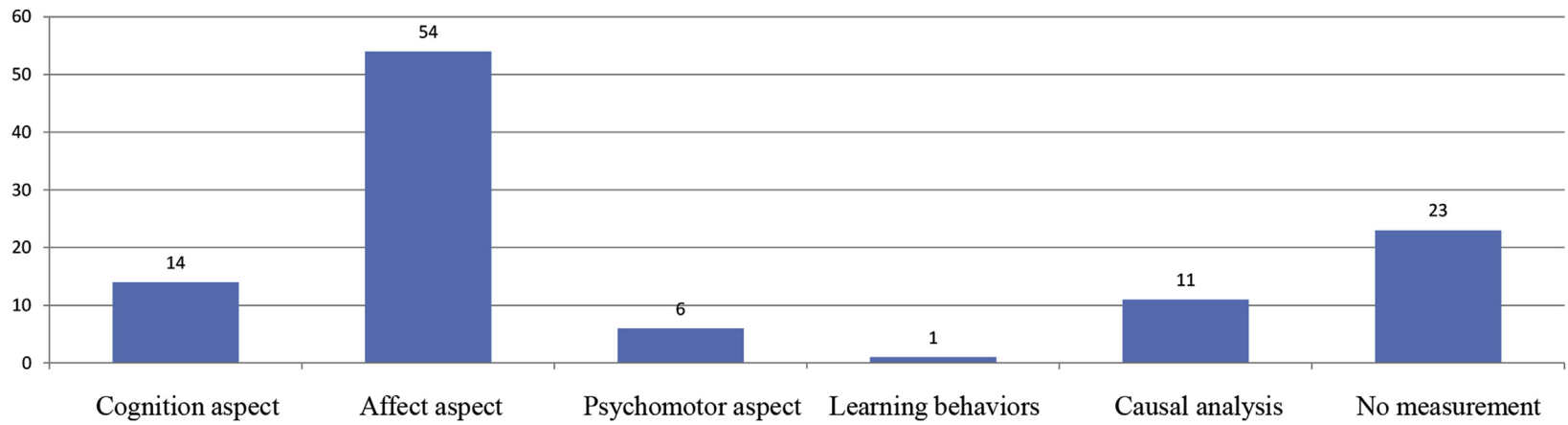


Fig. 13. The research issues conducted in mobile nursing education from 1971 to 2016.

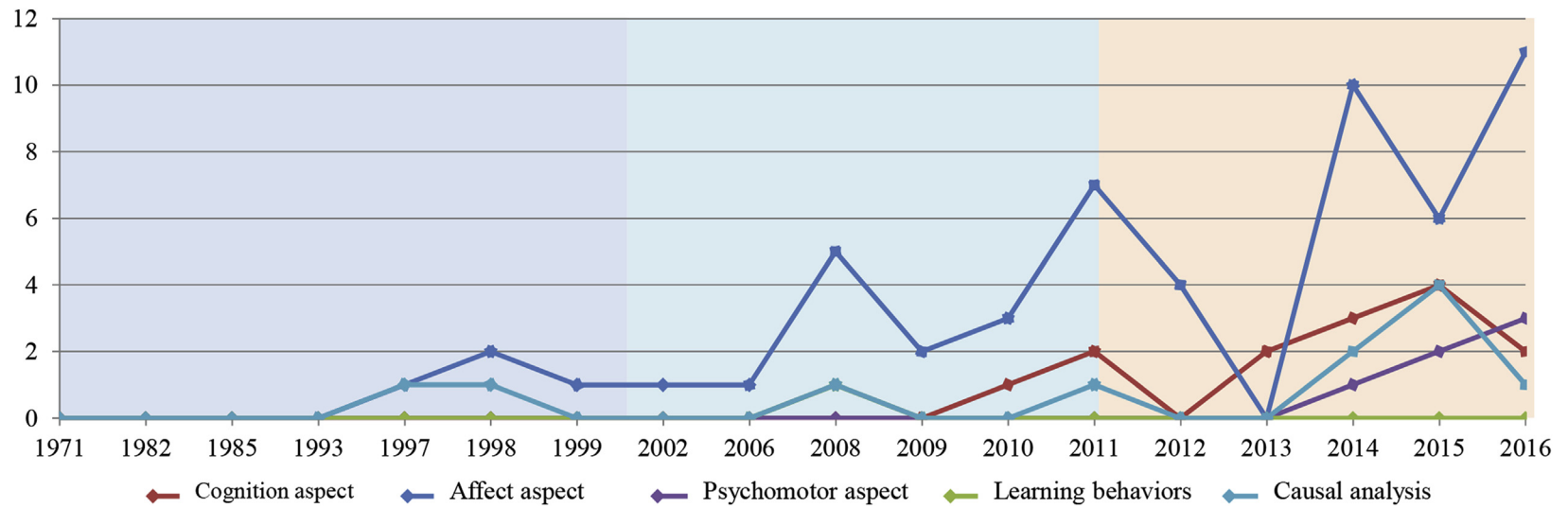


Fig. 14. Distribution of research topics in each period between 1971 and 2016.

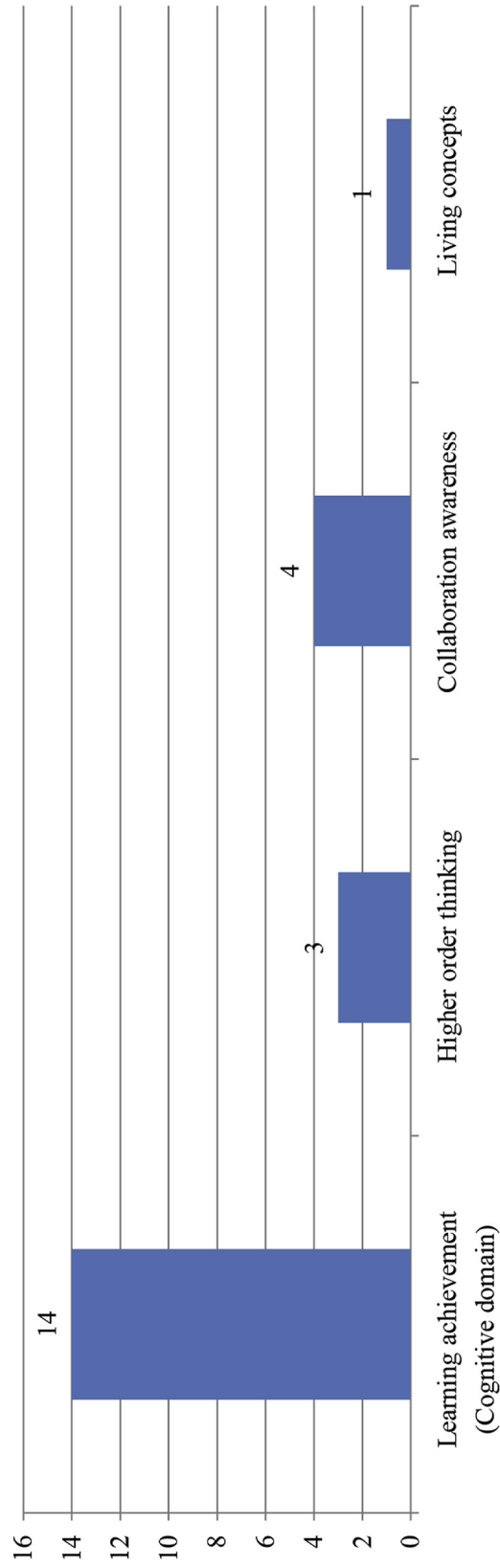


Fig. 15. Research issues in the cognition aspect.

learning systems rather than on investigating issues or evaluating subjects' performance or perceptions. In addition, 13 papers (13.4%) adopted document analysis to investigate educational issues in leading mobile technologies in nursing education.

Fig. 11 presents the number of publications for each research method every year. From the figure, it can be seen that from 1971 to 2000, the number of each research method was almost the same. However, from 2001 to 2010, experimental designs were more frequently adopted, while the second most common research method was system development. In the last period, 2011 to 2016, the number of papers using an experimental design was still increasing, but the number using system development decreased. Instead, more questionnaire investigations, qualitative research, and literature reviews were used. From this, it can be seen that in the period between 2000 and 2010, researchers emphasized the usage of systems in nursing-related issues, while from 2010 to 2016, they put a greater focus on the participants' acceptance and degree of affect regarding issues, systems, and strategies (see Fig. 12).

4.6. Subjects

The subjects of the studies were categorized into students, employees, patients, the general public, and no participants involved. The number of studies targeting each group was 44 for students, 14 for employees, 10 for patients, 10 for the general public, and 19 for no participants involved. In the early period (1971–2000), the frequency of different types of participants appearing in the research was quite similar. From 2001 to 2010, the number of studies targeting students increased. Furthermore, the research focusing on patients or having no participants involved (e.g. system development or literature review) also increased. In the later period (2011–2016), the participants became more diverse. Besides students, the training of employees was emphasized, which coincides with the results of the research methods; researchers in this period aimed to understand users' perceptions of systems or certain issues. Therefore, besides discussing employees or systems in mobilized training, mobile learning of nursing-related knowledge for the public and patients was also included in the investigation. A greater diversity of participants and implementation of technology in nursing education can be expected in the future.

4.7. Research issues

The research issues investigated in the mobile nursing education studies were also analyzed, including the aspects of cognition, affect, psychomotor, learning behaviors, and causal analysis. Fig. 13 shows the number of each issue discussed in the literature. It can be seen that studies on the cognition aspect (14 papers) and on the affect aspect (54 papers) constitute the majority of the studies. On the other hand, the research issues of the psychomotor aspect (6 papers), learning behaviors (1 paper) and causal analysis (11 papers) were rarely discussed throughout the period from 1971 to 2016 in mobile nursing education. Only one study investigated participants' learning behaviors (Bott et al., 2008).

The extent to which each topic was discussed each year is shown in Fig. 14. In the early stage (1971–2000), the causal analysis and affect aspect constituted the majority of the studies. Until 2010, the study cognition aspect, which is constantly used to explore learning effects, became adopted more constantly. In the later stage (2011–2016), research issues became more diverse, including cognition, affect, and psychomotor aspects, as well as causal analysis. With the increasing number of papers, the chances of each topic being discussed also increased, except for learning behaviors. There was only one paper regarding learning behaviors found (2008); not much inference can be drawn from this. To sum up, cognition aspect was the main concern of most of the mobile learning studies in the three stages. Many researchers intended to investigate the impacts of the proposed mobile learning approach on students' learning achievement since it was a convincing way to show whether the approach could achieve the educational objective of the target courses.

The cognition aspect was divided into learning achievement (cognitive domain), higher order thinking, collaboration awareness, and living concepts. Learning achievement (cognitive domain) means students' knowledge achievement. Higher order thinking means students' critical thinking ability, creativity, and problem-solving ability. Collaboration awareness means the degree of peers' interaction and engagement in collaborating to complete projects during the learning process. The living concepts include and discuss the participants' perspectives on crime, obesity, and others. As Fig. 15 shows, of all the literature reviewed, 14 papers discussed learning achievement (cognitive domain). On the other hand, there were 3, 4, and 1 papers mentioning the effects on learners' learning for the aspects of higher order thinking, collaboration as well as communication, and living concepts, respectively.

The affect aspect included technology acceptance, academic attitude/motivation, academic self-efficacy, learning interests, practical works self-efficacy, general medical care self-efficacy, self-management, and peer-interaction encouragement, as shown in Fig. 16. Technology acceptance includes the users' perceptions of the ease of use and usefulness of the technology-enhanced system. Academic attitude/motivation refers to the participants' attitude/motivation toward learning. Academic self-efficacy refers to the participants' confidence in their academic cognitive understanding. Academic learning interests refers to the participants' interest in learning medical or nursing knowledge. Practical works self-efficacy refers to the participants' confidence in conducting medical diagnosis or providing suggestions to patients. General medical care self-efficacy refers to the participants' confidence in conducting basic medical care. Self-regulation refers to the participants' awareness of making learning plans and managing learning time. Peer-interaction encouragement refers to the participants' awareness of using mobile technologies to facilitate peer interactions, such as collaboration, communication and competition, in learning activities. There were 54 papers discussing affect, of which 17 indicated that mobile nursing education is beneficial for students' technology acceptance, 6 expressed that the approach can help students' academic learning attitude and

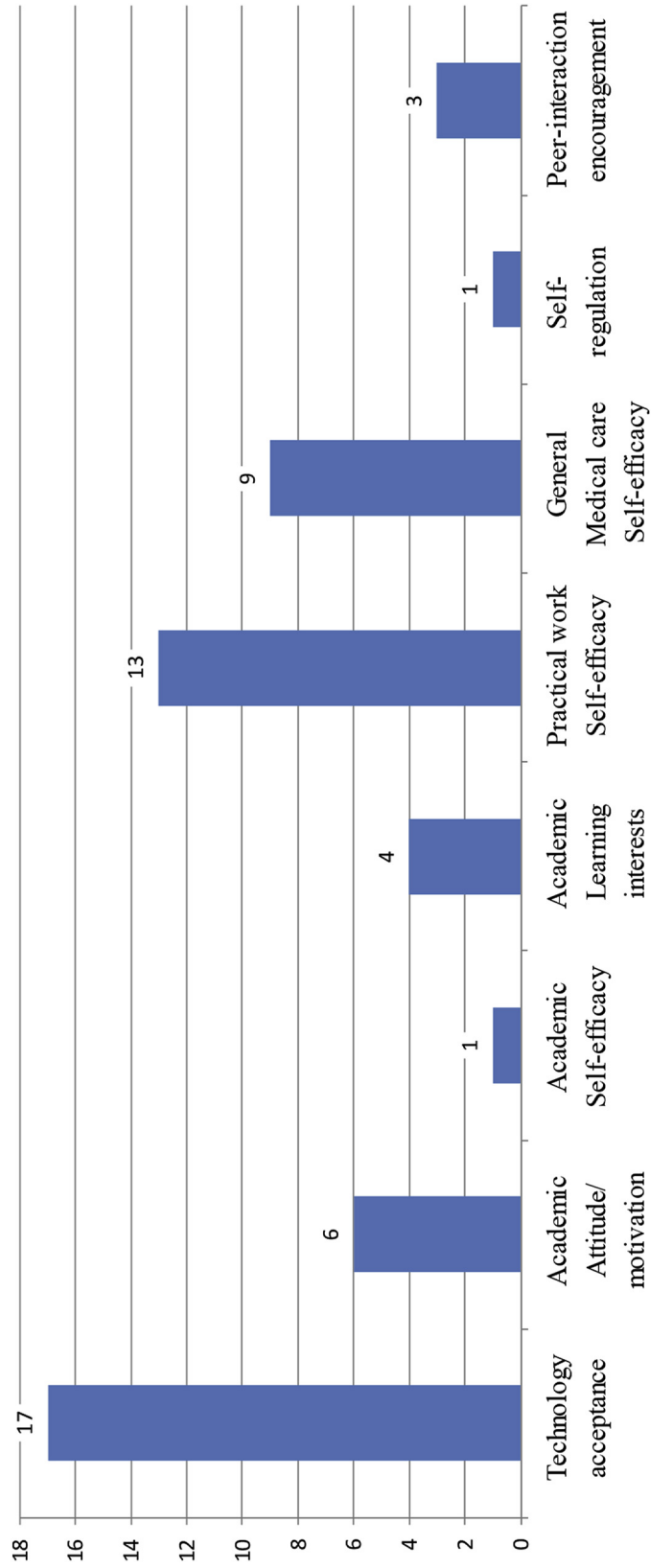


Fig. 16. Research issues in the affect aspect.

motivation, 1 showed the benefits of students' academic self-efficacy, and 4 conveyed that the approach can stimulate students' academic learning interest. In addition, 13 papers showed that mobile learning improved learners' practical work self-efficacy, and 9 reported that the approach improved learners' general medical care self-efficacy. In addition, 1 paper was related to self-regulation and 3 were related to peer-interaction encouragement.

5. Conclusion and discussion

In this study, a meta-review was conducted by analyzing the mobile learning studies in nursing education published in academic journals from 1971 to 2016. It was found that the number of studies greatly increased over the decades. It was also found that many studies reported the positive impacts of mobile learning on participants' performance or perceptions in nursing education (e.g., Green, Comer, Elliott, & Neubrandner, 2011; Keegan et al., 2016; Lee et al., 2016; Nguyen, Irizarry, Garrett, & Downing, 2015; Zayim & Ozel, 2015), showing the potential of using mobile technologies for improving learners' performance in nursing training courses.

In the meantime, it was found that issues related to "learning behavior" were seldom investigated. Most studies used achievement tests, skills tests and questionnaires to measure the participants' performance or perceptions from the cognition, affect, or psychomotor aspects, or they analyzed the relationships among these factors. This reveals that more studies are required to analyze learners' behaviors recorded during the learning process. As for the aspect of cognition, a total of 14 studies evaluated the participants' learning achievements, while only 3 of the 14 evaluated their higher order thinking performances, such as critical thinking skills (e.g., Carpenter, Theeke, & Smothers, 2013; Wu, 2014a,b). This implies that investigating the impacts of mobile learning approaches on learners' higher order thinking in nursing education remains a challenging and important issue. Moreover, in the aspect of affect, the most frequently investigated issue was the participants' technology acceptance, while other affective perceptions, such as self-efficacy and learning anxiety, were seldom discussed.

In addition, from the statistics, it was found that mobile learning was seldom conducted for many nursing education domains, such as infection, medicine, gastroenterology, metabolism & endocrinology, hematology & oncology, rheumatology, reproductive endocrinology and infertility, genetics, neonatology, pain management, otolaryngology, ophthalmology, division of rehabilitation medicine, division of urology, and dermatology. For example, "disease prevention" means using health education and regular health examinations to prevent dangerous factors; successful health education can not only improve the health of individuals and their families, but can also save significant medical expenses and lead to better life quality (Colton & Hunt, 2016; Wang & Kim, 2015). Therefore, it is worth investigating the impacts of mobile technologies on learners' performance in these nursing education domains.

On the other hand, it can be found that several learning strategies, such as inquiry-based learning, contextual mobile learning, synchronous sharing, computers as Mindtools, project-based learning, peer assessment, game-based learning and video sharing, were seldom adopted in mobile nursing education. In the past decade, many studies have reported the effectiveness of using those learning strategies in mobile learning applications (Hwang & Wu, 2014); therefore, it is worth trying to investigate the possibility of applying them to mobile learning for nursing education. In particular, inquiry-based learning, contextual mobile learning, Mindtools, project-based learning and peer assessment could be beneficial to the learners in terms of their higher order thinking, such as problem-solving and critical thinking performance.

From the above discussion, suggestions for the application of mobile technology in nursing education in the future are listed as follows.

- (1) Applying mobile technologies to the training in those seldom applied nursing domains. For example, in the specialized female and pediatric division, the training of several skills can be considered, such as incandescent lamps for infants, heel sticks, making formula, umbilical cord care, bathing for infants, hand-operated milking, and the skills of breast-feeding.
- (2) Applying the rarely adopted learning strategies to mobile nursing education, such as computers as Mindtools, peer assessment, game-based learning, and video sharing. Meanwhile, possible ways to implement these learning activity strategies and the application domains in nursing education can be considered, such as applying Mindtools to teach nurses to have the abilities of haemodynamics assessment in intensive care units, applying peer assessment to teach nurses to keep nursing records; applying game-based learning in geriatric medicine to teach nurses to be more sympathetic and caring to the elderly, and improving the professional image of nursing.
- (3) Designing effective mobile learning activities for promoting learners' higher order thinking in nursing education, such as problem-solving ability, creativity, and critical thinking ability.
- (4) Analyzing learners' behaviors and interactive patterns in mobile learning activities for nursing education to understand the relations between their behavioral patterns and learning achievement.
- (5) Investigating the effects of teachers', students', and other groups' personal factors, teaching experience, technology self-efficacy for mobile technology acceptance while using mobile learning in nursing education.
- (6) Proposing more effective mobile learning modes and strategies for nursing education. For instance, applying a combination of mobile technology and the flipped learning mode to nursing employee training and evaluating the effects of learners' nursing knowledge, skills, and self-learning performances.

- (7) Analyzing the possibilities of implementing different types of technologies for nursing education. For instance, the benefits of applying the Global Positioning System (GPS) in regional nursing education and the new research issues; RFID and QR-code can help nursing staff to identify the patients, understand the nursing environment and devices, and learn the nursing skills; wearable devices and IOT might expand the nursing education modes, learning strategies, or investigating issues.

On the other hand, some aspects of nursing education might not be suited to mobile learning, in particular, for those training programs conducted in a fixed location using large equipment or a number of tools. The training in surgery skills is such a program, in which the nursing staff need to work in the surgery and operate a number of surgical tools. At present, it is not suitable to use mobile devices in such a training context. However, the situation might change if wearable and augmented reality technologies advance and become popular in the future.

The main purposes and contribution of this study were to review and analyze relevant research on mobile learning in nursing and caring, and possible future research topics have been proposed. Due to the rapid development of technology, health care methods are becoming increasingly diverse. Through mobile technology and Internet communication, 24-hour medical and nursing service is being provided to increase the quality of medical care. Mobile technology can change the medical caring modes and allow professionals to use their time to provide information on cases, consultation for health education, and supports for those who require special care. This technology also provides another way to exchange messages and a support channel for society in general. Besides the problems of budgets and techniques, effective educational modes and learning strategies in mobile learning applied in health care are important factors determining the learning results. Therefore, how to examine the strategies in digital and mobile learning, and how to develop mobile learning strategies and modes more suitable for medical and nursing education are worth investigating.

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