A Context-Aware Mobile Learning System for Supporting Cognitive Apprenticeships in Nursing Skills Training

Po-Han Wu[1], Gwo-Jen Hwang[2*], Liang-Hao Su[3] and Yueh-Min Huang[1]
[1]Department of Engineering Science, National Cheng Kung University No.1, University Rd., Tainan city, Taiwan // [2]Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology No. 43, Sec.4, Keelung Rd., Taipei, Taiwan // [3]Department of Information and Learning Technology, National University of Tainan No. 33, Sec. 2, Shulin St., Tainan city, Taiwan // cincowu@gmail.com // gjhwang.academic@gmail.com // verylikeapig@gmail.com // huang@mail.ncku.edu.tw
*Corresponding author

ABSTRACT

The aim of nursing education is to foster in students the competence of applying integrated knowledge with clinical skills to the application domains. In the traditional approach, in-class knowledge learning and clinical skills training are usually conducted separately, such that the students might not be able to integrate the knowledge and the skills in performing standard nursing procedures. Therefore, it is important to develop an integrated curriculum for teaching standard operating procedures in physical assessment courses. In this study, a context-aware mobile learning system is developed for nursing training courses. During the learning activities, each student is equipped with a mobile device; moreover, sensing devices are used to detect whether the student has conducted the operations on the correct location of the dummy patient's body for assessing the physical status of the specified disease. The learning system not only guides individual students to perform each operation of the physical assessment procedure on dummy patients, but also provides instant feedback and supplementary materials to them if the operations or the operating sequence is incorrect. The experimental results show that the students' learning outcomes are notably improved by utilizing the mobile learning system for nursing training.

Keywords

Mobile and ubiquitous learning, Sensing technology, Nursing education, Cognitive apprenticeship, Mastery learning theory

Background and Motivation

In traditional nursing education, apprenticeship is usually adopted. Michele (2008) further proposed cognitive apprenticeship teaching to conduct clinical nursing. The experimental results show that cognitive apprenticeship can help promote nursing skills and exploration as well as reflection during learning processes. In such learning activities, demonstration-providing, exercise-leading and feedback-giving are done by experienced nursing staff or experts; meanwhile, the abilities of the nursing students to work independently are evaluated (Woolley & Jarvis, 2007).

Although a one-on-one teaching mode brings better learning achievements for students, the actual number of teachers is usually insufficient to support this teaching mode. Instead, a one-to-many teaching approach is commonly used in actual teaching activities. Such an approach to learning often affects the students' learning efficiency and effectiveness (Stalmeijer, Dolmans, Wolfhagen, & Scherpbier, 2009). Moreover, in traditional classes, although dummy patients are used to help the students to learn to identify and collect the life signs of each body part, the effect is not satisfying since the operations of the students cannot be recorded and no instant feedback or supplementary materials can be provided.

To cope with these problems, some scholars have attempted to implement information technology in nursing activities. For example, Chang, Sheen, Chang, and Lee (2008) used online media as supplementary material for nursing learning. With an increasing demand for nursing professionals, how to promote the quality and effectiveness of nursing education has become an important issue. Facing this issue, researchers must take into account the design of teaching materials, tools and modes, and how to efficiently and effectively share nursing knowledge and practical experience to equip students with better abilities to deal with unexpected clinical situations (Guo, Chong, & Chang, 2007). In order to adopt diverse learning methods to increase students' learning motivation, in addition to online teaching, mobile devices, such as cell phones or Personal Digital Assistants (PDA), are also used in nursing activities (Mansour, Poyser, McGregor, Franklin, 1990; Young, Moore, Griffiths, Raine, Stewart, Cownie, & Frutos-Perez, 2009; Bernard & Cathryn, 2006) or provided as teaching support (Chen, Hwang, Yang, Chen, & Huang, 2009). Using mobile devices as a learning tool for nursing education can provide abundant clinical teaching materials; in addition, the learning process of using mobile devices can be used as a basis for evaluating students' learning achievement (Dearnley, Haigh, & Fairhall, 2008; Hung, Lin, & Hwang, 2010; McKinney, & Karen, 2009). From related research, it has been found that mobile devices are often used as a knowledge acquisition tool in clinical nursing. Such a learning mode provides feasibility, but lacks functions of interaction and exercise. Hence, in the nursing programs that emphasize actual practice, how to establish a learning environment that provides personalized guidance and feedback for students to practice skills and apply knowledge in clinical situations is worth exploring.

Recently, due to the rapid development of sensing technology, combining real-world contexts with digital systems has become an important learning mode. Many researchers have attempted to combine sensing technology with mobile technology to build up context-aware ubiquitous learning, and have applied this technology to teaching activities in different subjects, such as natural science (Chiou, Tseng, Hwang, , & Heller, 2010; Chu, Hwang, Tsai, & Tseng, 2010; Hwang, Tsai, & Yang, 2008; Peng, Chuang, Hwang, Chu, Wu, & Huang, 2009), math (Zurita & Nussbaum, 2004), language (Chen & Chung, 2008) and social science learning (Hwang & Chang, 2011; Shih, Chuang, & Hwang, 2010). Some researchers further established digital libraries for supporting context-aware ubiquitous learning activities (Chu, Hwang, & Tseng, 2010). In this learning environment, the system can detect real-world situations via sensing technology, and guide students to learn through mobile devices in actual contexts (Uden, 2007; Hwang, Tsai, & Yang, 2008); the sensing equipment includes Bluetooth Technology (González-Castaño, García-Reinoso, Gil-Castiñeira, Costa-Montenegro, & Pousada-Carballo, 2005) Radio Frequency Identification (RFID) (Hwang, Kuo, Yin, & Chuang, 2010) and Global Positioning Systems (GPS) (Huang, Lin, & Cheng, 2010). The major benefit of context-aware ubiquitous learning is to provide personalized scaffolding and support for students to observe and experience real-world situations so as to construct personal knowledge (Hwang, Yang, Tsai & Yang, 2009). The students, as a result of interaction with real contexts and learning systems, can conduct independent thinking and enhance their learning motivation to further promote learning achievement (Chu, Hwang, & Tsai, 2010).

Present research concerning context-aware ubiquitous learning is mostly outdoor ecological learning (Hwang, Tsai, & Yang, 2008; Hwang, Yang, Tsai, & Yang, 2009; Ng & Nicholas, 2009; Hwang, Kuo, Yin, & Chuang, 2010; Chu, Hwang, & Tsai, 2010). Skills training has not attracted scholars' attention until recently. For example, Hwang, Yang, Tsai and Yang (2009) developed a context-aware ubiquitous learning environment for guiding inexperienced researchers to practice single-crystal X-ray diffraction operations with step-by-step guidance and feedback. The experimental results showed that the context-aware ubiquitous learning mechanism is beneficial for cultivating students' problem-solving abilities and operational skills.

In this study, we attempt to develop a nursing skills training system based on mobile and sensing technology for guiding students to practice the standard operating processes of respiratory assessment. Through a combination of the cognitive apprenticeship strategy and a context-aware ubiquitous learning environment, the students are not only provided with personalized guidance to strengthen their nursing skills, but are also offered prompt feedback and review to enhance their nursing knowledge.

Mobile System with Cognitive Apprenticeship Strategy for Physical Assessment

This study attempts to establish a nursing skills training system via mobile devices for students to learn the standard operating processes of physical assessment in a context-aware ubiquitous learning environment. The standard operating processes include collecting life sign information, physical assessment of patients, identifying diseases, and giving immediate nursing treatment. The framework of the learning system is shown in Figure 1.

The learning environment is a simulated sickroom, in which the dummy patients exhibiting physical symptoms are located. When the students approach a dummy patient (i.e., the learning target), the RFID reader on the mobile device detects the tag on the patient and provides relevant information, including the patient's name, symptoms (e.g., having a fever and having much sputum in the past week), and case history (e.g., having had a stroke five years ago). Afterward, the learning system guides the students to observe the dummy patient and collect data following the standard process of physical assessment. When the students finish the physical assessment procedure, the learning system immediately calculates their degree of mastery (DM), which represents the time needed to correctly complete the physical assessment procedure in comparison with the expected completion time of an expert level learner. The DM of Student Si is calculated using the following formula (Barsuk, Ahya, Cohen, McGaghie, & Wayne, 2009; Block, 1971; Carroll, 1963):

$$\mathrm{DM(Si)} = \frac{\text{(expected completion time)}}{\text{(student completion time)}} \times 100\%$$

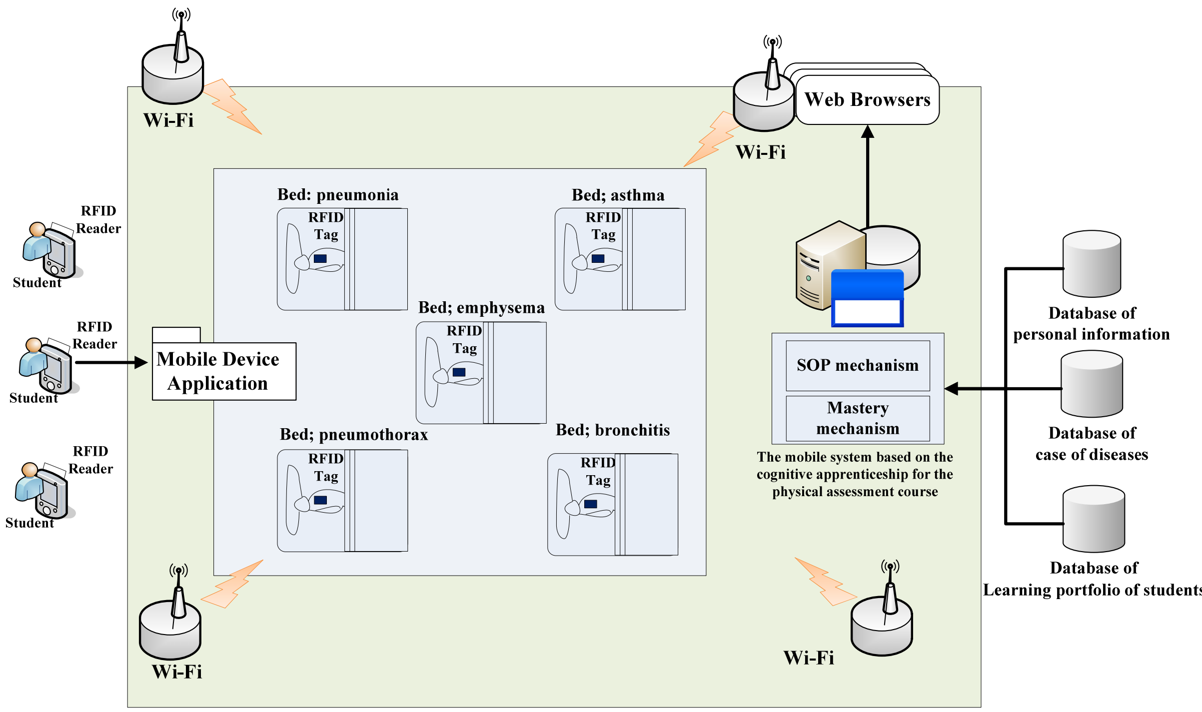

Figure 1. System framework

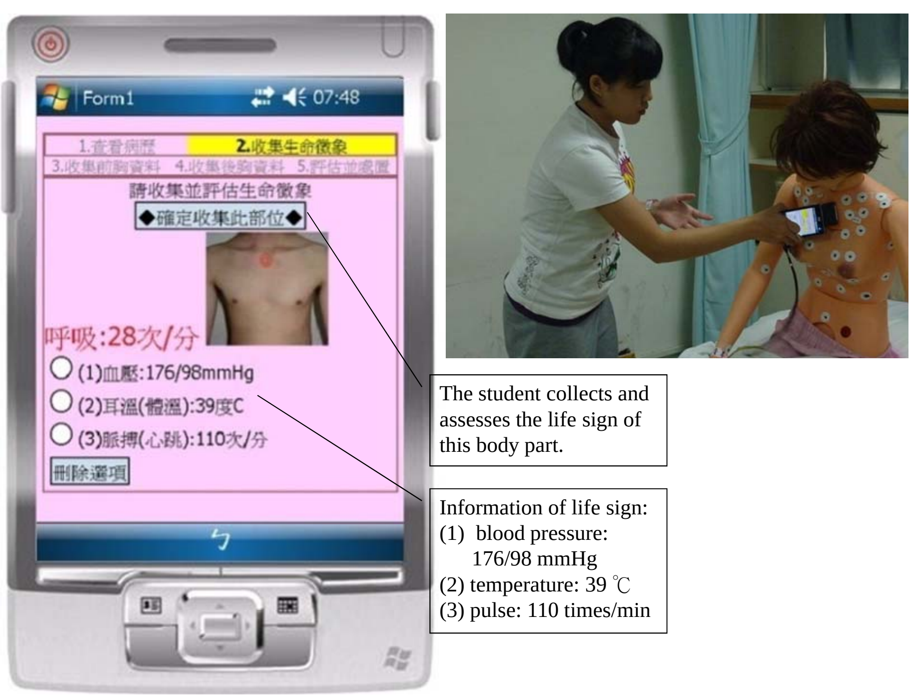

Figure 2. Interface for detecting pathological signs

In this study, the focus of the instruction is the “respiratory system.” The student first logs onto the learning system and chooses a case from the scenario case database for practicing physical assessment. The student is guided through the standard operating process of physical assessment. In the “demonstration and guidance” stage, the student has to diagnose a dummy patient according to the case history offered by the system and the hints given by the sensing technology to answer questions. During the examination, the student gathers physiological information about the patient via an RFID reader on the mobile device. The system will give life signs corresponding to different positions. For example, after the student detects the RFID tag on the chest via the mobile device, the system will give information of breathing frequency (times/second). Other physiological information includes temperature, pulse and blood pressure, as shown in Figure 2. Through the life signs detection exercise, the student is able to familiarize him/herself with visual examination, palpation, percussion and auscultation, and determine the treatment of the patient according to the given information.

When the student conducts the standard operating process for physical assessment, the learning system compares the information retrieved from the case database with that provided by the student to ensure the correctness of each step. If the operation is incorrect, missing or overlooked, the system will give feedback to the student, as shown in Figure 3.

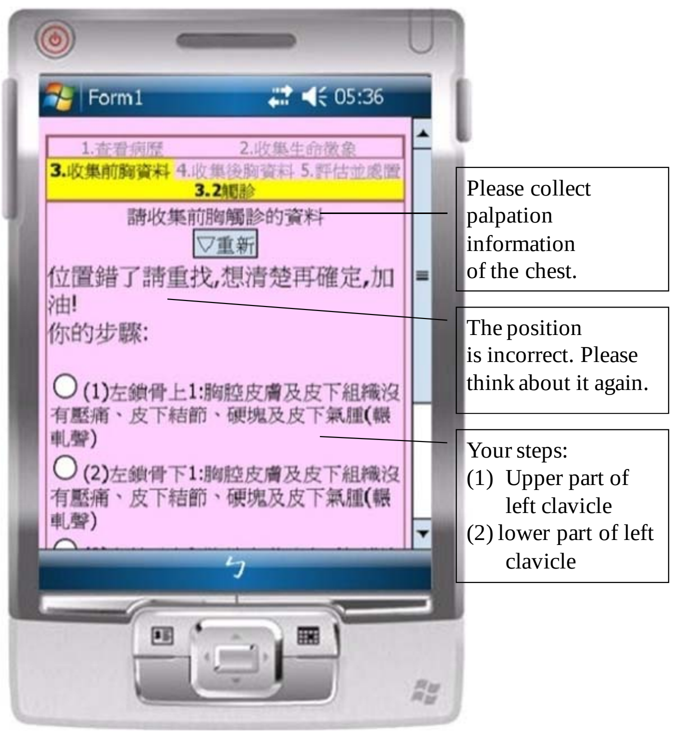

Figure 3. Interface for giving hints for mistakes or missing steps

During the learning process, the student can view personal mistakes or missing steps, and repeat the exercise to reach a degree of mastery through “observation and reflection”, as shown in Figure 4.

For example, during the process of practicing palpation, the student detects vibration information caused by the voice of the dummy patient, breath movement and the position of the diaphragm, among which the tags of the left and right paths represent the patient’s expansion situation. In addition to palpation, visual examination information, percussion and auscultation are also collected based on the tags in the standard operating process. The final step of the standard operating process is to examine the patient’s blood test report, as shown in Figure 5. Afterward, the system presents some similar diseases for the student to identify and fill in according to the gathered symptoms.

After the student completes a practice of the physical assessment procedure, the learning system presents the current degree of mastery, as shown in Figure 6. For the first case of this illustrative example, the patient is suffering from pneumonia. Assuming that the student has spent 25 minutes correctly completing the physical assessment procedure and the expected completion time is 20 minutes, we have DM = (20 ÷ 25) × 100%=80%. Usually the teachers would define a higher standard for degree of mastery, such as 90%; therefore, the learning system will guide the student to spend more time practicing the procedure of checking the pneumonia case.

Figure 4. Interface for providing the correct steps

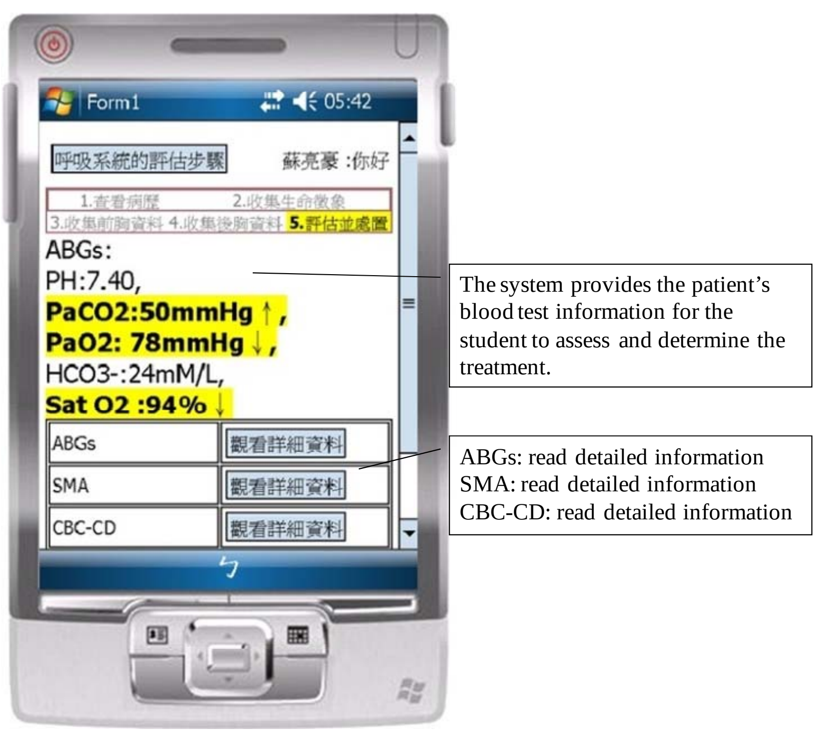

Figure 5. Interface for showing the patient's blood test information

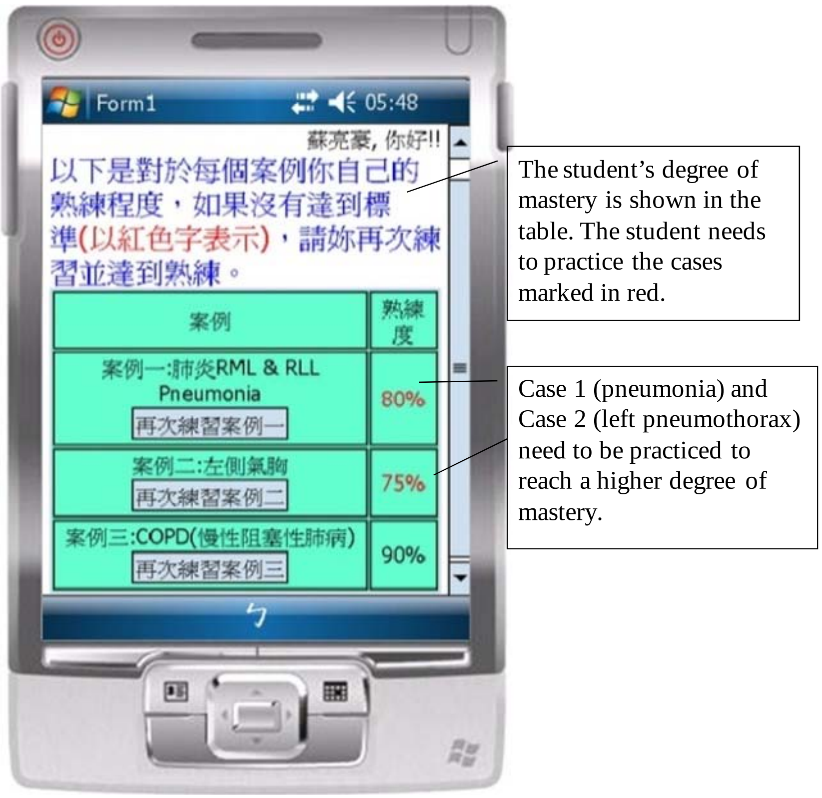

Figure 6. Interface for showing the student’s degree of familiarity with the standard operating process for the disease

As a result of repeated exercise, the student’s standard operating process skills gradually become immediate responses, reaching a degree of mastery. When the frequency of making mistakes reduces, the system will gradually lessen the hint-giving to assist the student to independently complete the physical assessment standard operating process. The student can thus achieve a degree of mastery through repeated practice. When the student correctly answers the same question three times consecutively, the system will determine and present the student’s degree of mastery based on his/her operation time. The flow chart for the mobile nursing training system is shown as Figure 7.

Experiment Design

The study aims to adopt cognitive apprenticeship teaching as a framework to train the students in learning physical assessment standard operating processes via a mastery mechanism in a context-aware mobile learning environment for mastering the procedures as experts.

Subjects

The subjects included two classes of fourth graders of the Nursing Department at a Science and Technology University in Kaohsiung County in Taiwan. A total of forty-six students voluntarily participated in the study. One class was assigned to be the experimental group and the other was the control group. The experimental group, including twenty-two students, was guided by the mobile supported system with cognitive apprenticeship to conduct physical assessment courses, while the control group with twenty-four students was guided by the traditional approach with learning sheets. All of the students were taught by the same instructor who had taught that particular nursing course for more than ten years. The standard respiratory system physical assessment operating process was constructed by two experienced teachers in the Nursing Department.

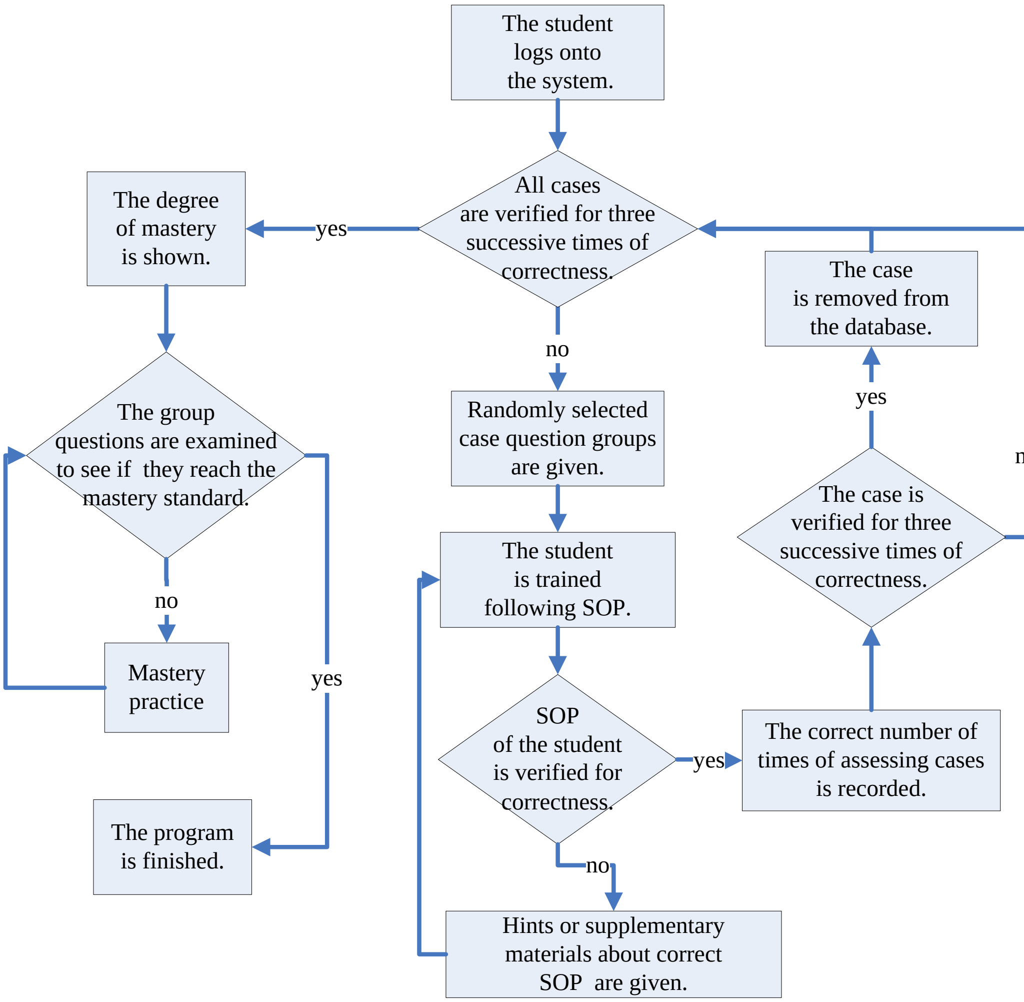

Figure 7. Flow chart for the mobile nursing training system

Research Tools

The research tools in this study included learning achievement test sheets, mid-term exams (written and skill tests), questionnaires of learning attitude, questionnaires of cognitive load, and questionnaires for the acceptance of the mobile learning system. The test sheets were developed by two experienced teachers. The pre-test sheets consisted of two groups of questions about physical assessment (each group has four to six short-answer questions) and two short-answer questions about blood tests; the post-test sheets included ten multiple-choice questions (40%), seven multi-select questions (42%), and eight matching questions (18%). For the mid-term exam, the questions about the physical assessment of the respiratory system were extracted (42.5%). These questions included multiple choice (32.5%) and situational questions (10%). The skill tests evaluated the degree of accuracy (100%) and degree of smoothness (100%) of the actual operation.

The questionnaires of learning perceptions, cognitive load and reception of the mobile learning system were compiled by the researchers and revised by four experienced experts. Those questionnaires were presented using a six-point Likert scale, where “6” represented “strongly agree” and “1” represented “strongly disagree”.

The questionnaire of learning perceptions consisted of twelve items. Its Cronbach's alpha value was 0.925. The questionnaire of cognitive load consisted of four questions. Its Cronbach's alpha value was 0.897. The students in both groups were asked to complete the questionnaires after the learning activity.

The questionnaire for the acceptance of using the mobile learning system included two scales; that is, four items about "the ease of use of the mobile learning system" and three items about "the usefulness of the mobile learning system". The Cronbach's alpha values for these two scales were 0.906 and 0.923, respectively; and the Cronbach's alpha of the entire questionnaire was 0.964.

Experiment Procedures

The flow chart of the experiment is shown in Figure 8. Before the experiment, the two groups of students took a two-week course about the basic knowledge of the respiratory system, which is a part of the formal nursing curriculum. After the course, a pre-test was conducted to evaluate the background knowledge of the two groups of students before participating in the learning activity.

In the beginning of the learning activity, the students in the experimental group first received a 30-minute instruction concerning the operation of the mobile learning system and the learning mission. Afterward, they were guided by the learning system to find each dummy patient and collect physical data for each case from the patient following the standard operating procedure. At the start, the learning system shows plenty of hints and supplementary materials to the students. After several practices, the system gradually reduces the amount of support to the students if they have achieved a higher DM.

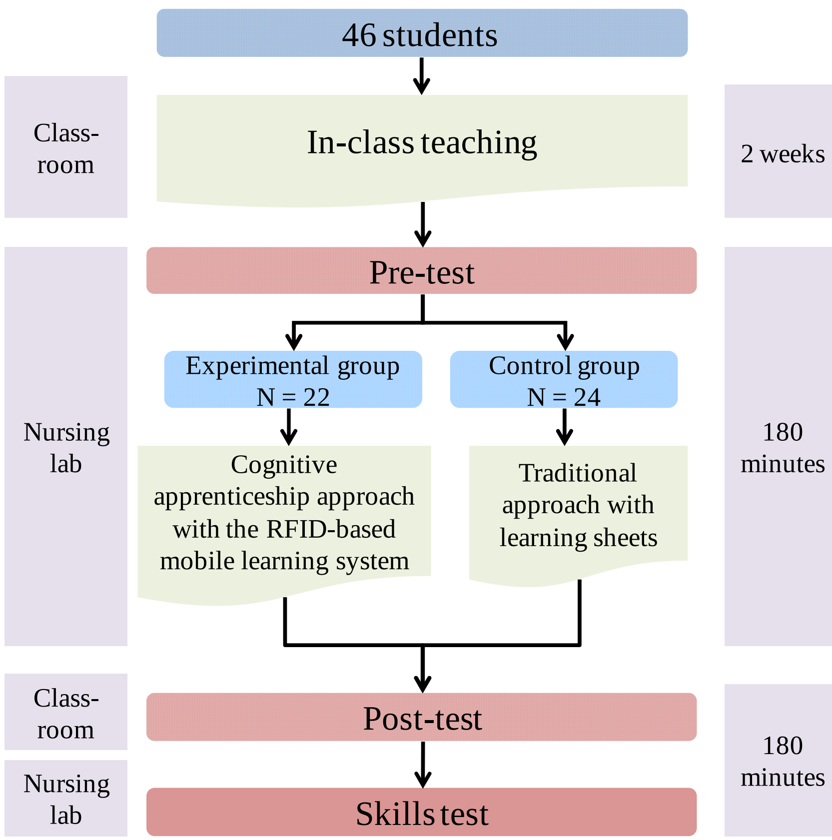

Figure 8. Diagram of experiment design

On the other hand, the students in the control group learned with the traditional approach; that is, they were guided by the teaching assistant and were provided with a learning sheet, on which the learning missions and the situational questions were described. During the learning activity, the control group students were also guided to collect physical data from the dummy patients, for which printed instructions about the patients' information (e.g., the patient's name, symptoms and case history) were provided. The students were asked to follow the instructions on the learning sheet to practice nursing operations and answer the questions; moreover, they could repeatedly practice the standard operating process skills by themselves on the dummy patients after watching the demonstration of the teaching assistant.

The activity lasted for one hundred and eighty minutes. After the learning activity, the students received a post-test and the post-questionnaires for measuring their learning attitudes, cognitive load and their acceptance of the mobile learning system. From the results of the pre- and post-tests, the effectiveness of the guiding system for the physical assessment course in assisting the learning of the students could be evaluated. Moreover, through the feedback collected via the questionnaires, their learning attitudes, cognitive loads and the perceptions of the use of the mobile learning system could be analyzed. Some of the students were further interviewed. In the week after the learning activity, the students took a mid-term exam which included a written test and an operation test.

Results and Discussion

The study proposes a guidance system for the standard operating process of a physical assessment course based on the cognitive apprenticeship approach, and examines the effect of such a model on the learning achievements of the students in the experiment. In this section, the experimental results are discussed in terms of the dimensions of learning achievement, learning attitude, cognitive load, and reception of the mobile learning system.

Analysis of Learning Achievements

The study aims to examine the effectiveness of the mobile system using standard operating processes based on the cognitive apprenticeship approach for improving the learning achievement of the students. The mean value and standard deviation of the pre-test scores are 53.50 and 10.43 for the control group, and 70.14 and 12.71 for the experimental group. According to the *t*-test result (t=4.87, p=0.00<.05), a significant difference is found between the two groups. It is evident that the two groups of students did not have equivalent abilities prior to taking this unit, as shown in Table 1. In order to explore the effectiveness of the mobile system using standard operating processes based on the cognitive apprenticeship approach for improving the learning achievement of the students, an analysis of covariance (ANCOVA) is used to exclude this difference between the prior knowledge of the two groups.

Table 1. *t*-test result of the pre-test scores

		N	Mean	S.D.	t
Pre-test	experimental group	22	70.14	12.71	4.87^{*}
	control group	24	53.50	10.43	

$^{*}p$<.05

Table 2 summarizes the results of the post-test scores. The mean value and standard deviation of the post-test scores are 53.13 and 8.48 for the control group, and 78.14 and 9.4 for the experimental group. The analysis of covariance (ANCOVA) is used to test the difference between the two groups by using the pre-test scores as covariate and the post-test scores as dependent variables. The adjusted mean value and standard error of the post-test scores are 54.89 and 1.98 for the control group, and 76.2 and 2.09 for the experimental group. According to the results (F=45.26, p=0.00<.05), a significant difference exists between the two groups. After excluding the influence of the pre-test results, the post-test results of the mobile system for the physical assessment course showed a significant difference. That is, the mobile learning approach had significant and positive effects on the learning achievements of the students for the physical assessment course.

Table 2. Descriptive data and ANCOVA of the post-test results

		N	Mean	S.D.	Adjusted Mean	Std.Error.	F
Post-test	experimental group	22	78.14	9.40	76.2	2.09	45.26^{*}
	control group	24	53.13	8.48	54.89	1.98	

$^{*}p$<.05

Table 3 presents the *t*-test results of the scores of the skills test. It is noticeable that the scores of accuracy and smoothness are 87.32 and 87.75 for the experimental group, and 77.83 and 75.21 for the control group. According to the *t*-test result, it is found that the level of accuracy (t=2.20, p=0.03<0.05) and the level of smoothness (t=2.41, p=0.02<0.05) show a significant difference between the two groups. Hence, the mobile system with the standard operating process for the physical assessment course was effective in improving the learning achievements of the students.

Table 3. *t*-test result of the skills test scores

		Group	Mean	S.D.	N	t
Skills test	Accuracy	experimental	87.32	10.26	22	2.20*
		control	77.83	17.72	24	
	Smoothness	experimental	87.75	10.55	22	2.41*
		control	75.21	22.38	24	

*p<.05

Analysis of Learning Log

The learning log of this study is analyzed and presented as well. The analysis of the learning log can further explain that the mobile system with the cognitive apprenticeship strategy for physical assessment helps improve the students' learning efficiency. The standard physical assessment procedure consists of 134 operations. In the traditional approach, the students are asked to complete the procedure (i.e., the 134 operations) within three hours. Through the mastery mechanism of the mobile learning design with instant feedback, the number of times a student can practice for each case is far more than that of a student who learns with the traditional approach, as shown in Figure 9. Owing to the personalized learning guidance and the instant feedback provided by the mobile learning system, it is found that the frequency of practicing the standard operating procedure for physical assessment was significantly increased for each case, implying that the students had more practice opportunities. For example, the students in the experimental group performed about 445 operations (i.e., 3.32 practices) on average for the first case within three hours, while those in the control group only performed 134 operations (i.e., 1 practice) within the same time.

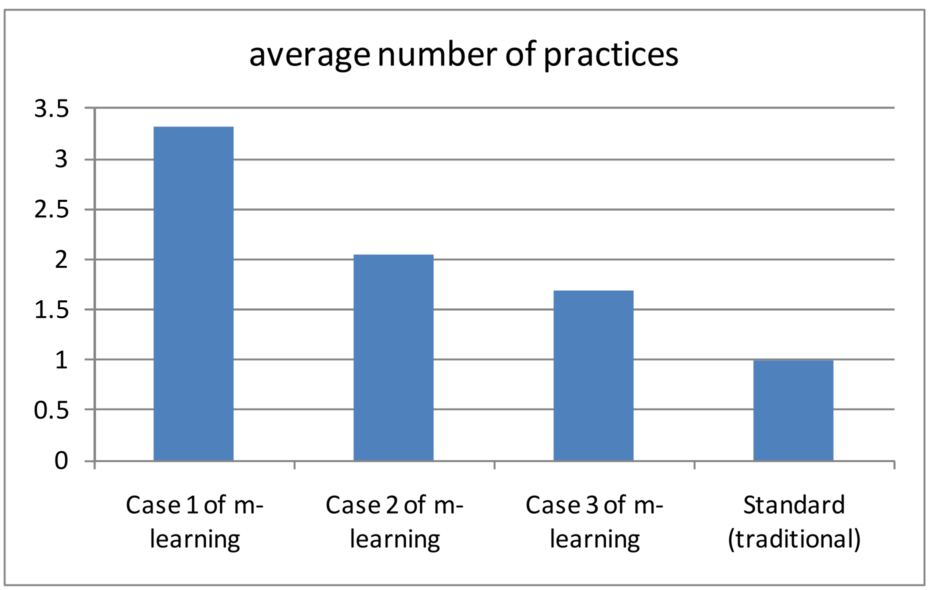

Figure 9. Mean of the students' average number of practices

Analysis of Learning Attitude

The study analyzed the learning situations of the students guided by the mobile system with standard operating processes for the physical assessment course based on the cognitive apprenticeship approach and guided by the learning portfolios in order to understand the learning preferences and learning attitudes of the students in the experiment. As shown in Table 4, both of the scores that exceed four reveal that the two groups gave higher evaluation for self-learning. The mean scores for learning attitude are 5.23 for the experimental group and 4.58 for the control group. It is noticeable that a significant difference exists between the two groups (t=4.14, p=0.00<0.05). Accordingly, the mobile system proposed by the study better assists the students in understanding, and in evaluating themselves.

Table 4. *t*-test result of learning attitude

		N	Mean	S.D.	t
Learning attitude	experimental group	22	5.23	0.54	4.14^{*}
	control group	24	4.58	0.54	

$^{*}p$<.05

From the scores of the skills test, the levels of accuracy and smoothness of the experimental group are better than those of the control group. This suggests that the control group was overoptimistic concerning its self-evaluation, leading to a longer time for completion of the standard operating process. The overall procedure of the control group is correct, but lack of familiarity results in a longer thinking time. In contrast, the levels of accuracy and smoothness of the experimental group are higher because the mobile learning system provides practice of the actual operating process to enable the students to digest the standard operating process for the evaluation of the respiratory system and to concentrate on disease assessment.

Analysis of Cognitive Load

The cognitive load questionnaire aimed at exploring the cognitive load situation faced by the students. Table 5 presents an analysis of the students' cognitive loads. The means are 3.43 for the experimental group and 4.33 for the control group. The *t*-test result (t=-2.74, p=0.01<0.05) shows a significant difference between the two groups. It is evident that the mobile learning system of the physical assessment course created no additional cognitive load for the experimental group students. It should also be noticed that nursing courses include not only instruction of nursing knowledge, but also a large proportion of internship programs. From the results of the analysis, the cognitive load of the control group is comparatively high. Therefore, using the mobile learning system as a teaching strategy can lower the trainee nurses' cognitive load while learning.

Table 5. *t*-test result of cognitive load

		N	Mean	S.D.	t
cognitive load	experimental group	22	3.43	1.41	-2.74^{*}
	control group	24	4.33	0.67	

$^{*}p$<.05

Analysis of the Acceptance of the Mobile Learning System

The analysis of the acceptance of the mobile learning system is shown in Table 6, from which it was found that most of the students gave positive evaluations. The four questions with a mean exceeding five are "It is easy to operate the PDA interfaces of the mobile learning system", "It is easy to read the information on the PDA screens of the mobile learning system", "The response speed of the mobile learning system is well-matched with the learning progress on the site" and "I think that PDA operation of the personal learning system is easy". This represents that the students evaluated the ease of use of the system positively. It was also observed during the experiment that the students, after being taught once or twice, were familiar with the PDA operations and learning contexts. However, from the standard deviation of the first item (i.e., 1.02), it was found that not all of the students highly accepted the interface of the PDA system, although most of them gave positive feedback (the mean is 5.23). This finding implies that more careful design of the user interface is needed in order to facilitate more students, in particular, those who have little experience in using computers or mobile devices.

For "Usefulness", the questions with a mean exceeding five include "The personal progress provided by the mobile learning system can benefit my learning achievement", "The guidance of the mobile learning system is quite clear and effectively assists me to understand the learning content and steps", and "Combining the mobile learning system and the real-world contexts is helpful to learning". This represents the positive evaluation given by the students.

Table 6. Degree of the acceptance to the mobile learning system

Scale	Questionnaire item	Mean	S.D.
Easiness	1. It is easy to operate the PDA interfaces of the mobile learning system.	5.23	1.02
	2. It is easy to read the information on the PDA screens of the mobile learning system.	5.45	0.67
	3. The response speed of the mobile learning system is well-matched with the learning progress on the site.	5.41	0.67
	4. I think that PDA operation of the personal learning system is easy.	5.27	0.70
Usefulness	5. The personal progress provided by the mobile learning system can benefit my learning achievement.	5.36	0.66
	6. The guidance of the mobile learning system is quite clear and effectively assists me to understand the learning content and steps.	5.36	0.73
	7. Combining the mobile learning system and the real-world contexts is helpful to learning.	5.23	0.61

Discussion and Conclusions

This study proposes a context-aware ubiquitous mastery learning strategy using the cognitive apprenticeship approach applied to the standard operating process of a physical assessment course that included collecting patients' life signs and physical assessment information, identifying diseases, and immediate nursing treatment. The students interacted with the learning system via mobile devices. Through repeated practice and feedback, the students learned visual examination, palpation, percussion, assessment and immediate nursing care of respiratory diseases. The experimental results showed that the learning achievement and learning attitude of the experimental students were significantly better than those of the control group students, revealing the potential of this innovative approach in nursing education. Moreover, students who used the mobile learning system showed lower cognitive load than those who learned with the traditional approach, implying that the personal guidance and immediate feedback mechanisms did ease the learning pressure of the students via showing them an effective way of learning.

Such a learning process conformed to the mastery learning theory proposed by Carroll (1963) that teachers, based on the learning targets, teach and assist students to repeatedly practice for a desired achievement of the final goal. In the past decades, the effectiveness of the mastery learning approach has been shown by many researchers (Lalley & Gentile, 2009; Horiuchi, Yaju, Koyo, Sakyo, & Nakayama, 2009; Johnson, Perry, & Shamir, 2010). Narciss and Huth (2006) showed that immediate feedback can significantly benefit students' learning achievement and learning motivation. Zimmerman and Dibenedetto (2008) further emphasized the effectiveness of using the mastery learning approach in the classroom.

Although mastery learning theory has been recognized as being effective, it is difficult to carry out since the cost of providing individual students with a personalized tutor in the real-world training environment is too high. The use of the context-aware u-learning approach has overcome this problem. It enables the students to understand and construct complete concepts of respiratory disease assessment and to further master the assessment skills. Experimental results show that not only the knowledge level but also the skill level of the students was effectively promoted as a result of the nursing training using the mastery strategy in context-aware ubiquitous learning.

On the other hand, from the interview results, it was found that the students in the experimental group showed different degrees of acceptance of the PDA system interface, which could be due to their different experiences of using mobile equipment. Consequently, arranging more operational practice using mobile devices at the beginning of the learning activity is necessary; moreover, it is worth investigating a better way of developing a user interface for inexperienced learners.

Acknowledgements

This study is supported in part by the National Science Council of the Republic of China under contract numbers NSC 98-2511-S-024-007-MY3 and NSC 98-2631-S-024-001.

References

Barab, S. A. & Krishner, D. (2001). Guest Editor's introduction: rethinking methodology in the learning sciences. *Journal of the Learning Sciences, 10*, 5-15.

Barsuk, J. H., Ahya, S. N., Cohen, E. R., McGaghie, W. C., & Wayne, D. B. (2009). Mastery learning of temporary hemodialysis catheter insertion by nephrology fellows using simulation technology and deliberate practice. *American Journal of Kidney Diseases, 54*(1), 70-76. doi: DOI: 10.1053/j.ajkd.2008.12.041

Bernard, M. G., & Cathryn, J. (2006). A mobile clinical e-portfolio for nursing and medical students, using wireless personal digital assistants (PDAs). *Nurse Education Today, 26*(8), 647-654.

Block, J. H. (1971). *Mastery Learning: Theory and Practice.* New York: Holt, Rinehart & Winston.

Bogossian, F. E., Kellett, S. E. M., & Mason, B. (2009). The use of tablet PCs to access an electronic portfolio in the clinical setting: A pilot study using undergraduate nursing students. *Nurse Education Today, 29*(2), 246-253.

Carroll, J. B. (1963). A model of school learning. *Teachers College Record, 64*, 723-733.

Chang, W. Y., Sheen, S. T., Chang, P. C., & Lee, P. H. (2008). Developing an E-learning education programme for staff nurses: processes and outcomes. *Nurse Education Today, 28*(7), 822-828.

Chen, C. H., Hwang, G. J., Yang, T. C., Chen, S. H., & Huang, S. Y. (2009). Analysis of a ubiquitous performance support system for teachers. *Innovations in Education and Teaching International, 46*(4), 421-433.

Chen, C. M. & Chung C. J. (2008). Personalized mobile English vocabulary learning system based on item response theory and learning memory cycle. *Computers & Education, 51*(2), 624-645.

Chiou, C. K., Tseng, Judy. C. R., Hwang, G. J., & Heller, S. (2010). An adaptive navigation support system for conducting context-aware ubiquitous learning in museums. *Computers & Education, 55*(2), 834-845.

Chu, H. C., Hwang, G. J., & Tsai, C. C. (2010). A knowledge engineering approach to developing mindtools for context-aware ubiquitous learning. *Computers & Education, 54*(1), 289-297.

Chu, H. C., Hwang, G. J., & Tseng, Judy. C. R. (2010). An innovative approach for developing and employing electronic libraries to support context-aware ubiquitous learning. *The Electronic Library, 28*(6), 873-890.

Chu, H. C., Hwang, G. J., Huang, S. X., & Wu, T. T. (2008). A Knowledge Engineering Approach to Developing E-Libraries for Mobile Learning. *The Electronic Library, 26*(3), 303-317.

Chu, H. C., Hwang, G. J., Tsai, C. C., & Tseng, J. C. R. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science course. *Computers & Education, 55*(4), 1618-1627.

Dearnley, C., Haigh, J., & Fairhall, J. (2008). Using mobile technologies for assessment and learning in practice settings: A case study. *Nurse Education in Practice, 8*(3), 197-204.

González-Castaño, F. J., García-Reinoso, J., Gil-Castiñeira, F., Costa-Montenegro, E., & Pousada-Carballo, J. M. (2005). Bluetooth-assisted context-awareness in educational data networks. *Computers & Education, 45*(1), 105-121.

Guo, S. H. M., Chong, P. P., & Chang, H. K. (2007). Mobile learning in nursing practical training: an applicability analysis. *International Journal of Mobile Learning and Organisation, 1*(4), 342-354.

Horiuchi, S., Yaju, Y., Koyo, M., Sakyo, Y., & Nakayama, K. (2009). Evaluation of a web-based graduate continuing nursing education program in Japan: A randomized controlled trial. *Nurse Education Today, 29*(2), 140-149.

Huang, Y. M., Lin, Y. T., & Cheng, S. C. (2010). Effectiveness of a Mobile Plant Learning System in a science curriculum in Taiwanese elementary education. *Computers & Education, 54*(1), 47-58.

Hung, P. H., Lin, Y. F., & Hwang, G. J. (2010). Formative assessment design for PDA integrated ecology observation. *Educational Technology & Society, 13*(3), 33-42.

Hwang , G. J., Kuo, F. R., Yin, P. Y., & Chuang, K. H. (2010). A Heuristic Algorithm for planning personalized learning paths for context-aware ubiquitous learning. *Computers & Education, 54*(2), 404-415.

Hwang, G. J. (2003). A conceptual map model for developing intelligent tutoring systems. *Computers & Education, 40*(3), 217-235.

Hwang, G. J., & Chang, H. F. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education, 56*(1), 1023-1031.

Hwang, G. J., Tsai, C. C., & Yang, S. J. H. (2008). Criteria, strategies and research issues of context-aware ubiquitous learning. *Educational Technology & Society, 11*(2), 81-91.

Hwang, G. J., Yang, T. C., Tsai, C. C., & Yang, S. J. H. (2009). A context-aware ubiquitous learning environment for conducting complex science experiments. *Computers & Education, 53*(2), 402-413.

Johnson, E. P., Perry, J., & Shamir, H. (2010). Variability in reading ability gains as a function of computer-assisted instruction method of presentation. *Computers & Education, 55*(1), 209-217.

Lalley, J., & Gentile, J. (2009). Classroom assessment and grading to assure mastery. *Theory into Practice, 48*, 28-35.

Mansour, A. A. H., Poyser, J., McGregor, J. J., & Franklin, M. E. (1990). An intelligent tutoring system for the instruction of medical students in techniques of general practice. *Computers & Education, 15*(1-3), 83-90.

McKinney, A. A. & Karen P. (2009). Podcasts and videostreaming: Useful tools to facilitate learning of pathophysiology in undergraduate nurse education? *Nurse Education in Practice, 9*(6), 372-376.

Mikkelsen, J., Reime, M. H., & Harris, A. K. (2008). Nursing students' learning of managing cross-infections: Scenario-based simulation training versus study groups. *Nurse Education Today, 28*(6), 664-671.

Narciss, S., & Huth, K. (2006). Fostering achievement and motivation with bug-related tutoring feedback in a computer-based training for written subtraction. *Learning and Instruction, 16*(4), 310-322.

Ng, W., & Nicholas, H. (2009). Introducing pocket PCs in schools: Attitudes and beliefs in the first year. *Computers & Education, 52*(2), 470-480.

Peng, H., Chuang, P. Y., Hwang, G. J., Chu, H. C., Wu, T. T., & Huang, S. X. (2009). Ubiquitous performance-support system as Mindtool: A case study of instructional decision making and learning assistant. *Educational Technology & Society, 12*(1), 107-120.

Shih, J. L., Chuang, C. W., & Hwang, G. J. (2010). An inquiry-based mobile learning approach to enhancing social science learning effectiveness. *Educational Technology & Society, 13*(4), 50-62.

Stalmeijer, R. E., Dolmans, D. H. J. M., Wolfhagen, I. H. A. P., & Scherpbier, A. J. J. A. (2009). Cognitive apprenticeship in clinical practice: can it stimulate learning in the opinion of students? *Advances in Health Sciences Education, 14*(4), 535-546.

Uden, L. (2007). Activity theory for designing mobile learning. *International Journal of Mobile Learning and Organisation, 1*(1), 81-102.

Woolley, N. N. & Jarvis, Y. (2007). Situated cognition and cognitive apprenticeship: A model for teaching and learning clinical skills in a technologically rich and authentic learning environment. *Nurse Education Today, 27*(1), 73-79.

Yang, S. J. H. (2006). Context Aware Ubiquitous Learning Environments for Peer-to-Peer Collaborative Learning. *Educational Technology & Society, 9*(1), 188-201.

Young P., Moore E., Griffiths G., Raine R., Stewart R., Cownie M., & Frutos-Perez M. (2009). Help is just a text away: The use of short message service texting to provide an additional means of support for health care students during practice placements. *Nurse Education Today, 30*(2), 118-123.

Zimmerman, B. J., & Dibenedetto, M. K. (2008). Mastery learning and assessment: Implications for students and teachers in an era of high-stakes testing. *Psychology in the Schools, 45*, 206-216.

Zurita, G., & Nussbaum, M. (2004). Computer supported collaborative learning using wirelessly interconnected handheld computers. *Computers & Education, 42*(3), 289-314.