



A Computer-based Clinical Simulation System Based on Constructivist Learning Environments for Undergraduate Nursing Students in the Field of Geriatric Emergencies

Dai Young Kwon¹, Su Jung Lee², Yong Cheon Kim³,
Se Hyun Lim⁴, Won Hee Park² and Mi So Kim^{2*}

¹Center for Curriculum and Instruction Studies,
Korea University, Seoul, 02841, Republic of Korea

²College of Nursing, Korea University,
Seoul, 02841, Republic of Korea

³Department of Computer Science Education,
Korea University, Seoul, 02841, Republic of Korea

⁴Department of Nursing, Far-East University,
Chungbuk, 27601, Republic of Korea

Abstract

Background/Objectives: This study proposes to develop a computer-based clinical simulation learning system based on Constructivist Learning Environments (CLEs) to enhance nursing students' clinical reasoning skills for geriatric emergencies.

Methods/Statistical analysis: We designed the system to implement problem-based learning as a problem-solving process by providing nursing process through simulations. The system was piloted to 88 nursing students, which presented three emergency scenarios of the elderly in nursing facilities.

Findings: For this study, we developed a computer-based simulation system that can evaluate patients' conditions in problem scenarios that can occur in real situations, according to the nursing process. And the pilot study result shows that upper-year students were more confident in using the system for learning compared with the lower-year counterparts, and they exhibited greater satisfaction using the system for learning.

Improvements/Applications: Applying the learning system equipped with information resources and cognitive tools from CLEs will improve students' learning outcomes.

Key Words : Computer-based clinical simulation, Nursing education, Constructivist learning environments, Problem-based learning

1 INTRODUCTION

THE ELDERLY have become the core target population for public health and medical sectors as the elderly population increased worldwide (He, Goodkind, & Kowal, 2016). The number of elderly people using nursing facilities, alternative residential care places, or home care services was projected to increase from 15 million in 2000 to 27 million in 2050 (Center for Disease Control and Prevention, 2016). Such elderly people experience a decline in physical and mental functions, have multiple chronic illnesses, and are prone to emergency situations because of polypharmacy (Mortazavi et al., 2016). Frail and old residents in nursing facilities have a particularly poor prognosis if they do not rapidly receive appropriate treatment in emergencies, because nursing facilities have fewer physicians participating in direct care, with a shortage of medical personnel and equipment for diagnoses and treatment (Kim et al., 2015; Shanley et al., 2011). Under these circumstances, nurses are the main healthcare providers, and their quality crucially affects the level of care for the elderly in the facilities. Therefore, nursing education for geriatric care has been recognized as critical (Spilsbury et al., 2011), and Berman et al (2005) suggested that it be implemented of the undergraduate curriculum. Such curriculum should integrate classroom knowledge and apply it to actual clinical settings. A clinical reasoning skill, a dynamic cognitive process, is

essential for identifying a patient's problem, interpreting and analyzing information, and coping with a patient's status. Therefore, education for nursing skills and knowledge improvement that can improve clinical reasoning skills is necessary (Lapkin et al., 2010).

Clinical simulation education is known to be effective in an educational setting as it does not harm actual subjects while allowing the learner to integrate theory and practice by utilizing multimedia data, patient simulators and computer simulations. Previous studies reported that simulation education used in a clinical practice entails improvement in the following areas: practical skills, knowledge, self-competence, and communication ability (Centrella-Nigro et al., 2016; Gotwals and Scholtz, 2016; Bambini, 2009). Research on clinical simulation education has recently been implemented using computers, which have no spatial and temporal limitations and can apply numerous learning strategies and individualized learning factors, in addition to inducing student interest (Cook et al., 2012). Specifically, adopting computer simulations strategically has the advantage of reducing the number of required personnel for training, as well as enhancing the ability to self-update information and retain techniques (Cook et al., 2012).

Problem-Based Learning (PBL) is another useful learning strategy that increases students' perceived learning effectiveness and satisfaction, problem solving ability, critical thinking ability, and clinical reasoning ability through group discussions and self-directed learning (Dolmans et al., 2016). Because the problem situation presented by the PBL provides authentic case, it can provide effective education when combined with simulation training (Kim and Choi, 2008). The recent development of information and communication technology has yielded web-based PBL, which is computer based and provides realistic scenarios and extremely fast access to diverse information, and has provided an environment where PBL can be implemented easily (Dolmans et al., 2016; Spinello and Fischbach, 2008). Therefore, the purpose of this study was to develop and pilot a computer-based PBL learning system using the simulation system to improve the clinical reasoning skills of the nursing students in the field of geriatric emergencies, who may not have practical experience. We have developed a computer-based simulation system that can evaluate patients' condition according to the nursing process by gathering and analyzing the information needed

for the geriatric nursing for the possible emergencies in the field.

2 MATERIALS AND METHODS

This study was composed of two parts: the development of computer-based clinical simulation education and its evaluation for possible application in nursing curricula.

A. Stage 1: Development of a computer-based clinical simulation system based on CLEs

1. Concepts for learning system (Constructivist Learning Environments)

The proposed system is based on Constructivist Learning Environments (CLEs), environments required for effective constructions in learning. A learner acquires knowledge through the interaction with the external world (environment) and constructs a meaning or knowledge for oneself (Yldz-Feyziolu et al., 2013). As shown in [Figure 1], the goal of the learning system in this study was to provide information resource and cognitive tools from the CLEs. The Information resources provides the information expected to be required during the problem-solving process and are prepared so that the learner can learn effectively. They are essential elements in self-directed learning such as textbooks, encyclopedias, and on-line resources. The web-links provides definitions to the medical terminology presented in the system, which are linked to Medical Library Engine as information resource. The Cognitive tools help learners effectively support cognitive processes to gain meaningful experiences in the process of building their own knowledge. In this study, the system provides feedback during a problem-solving process while comparing it to the expert rule as cognitive tools.

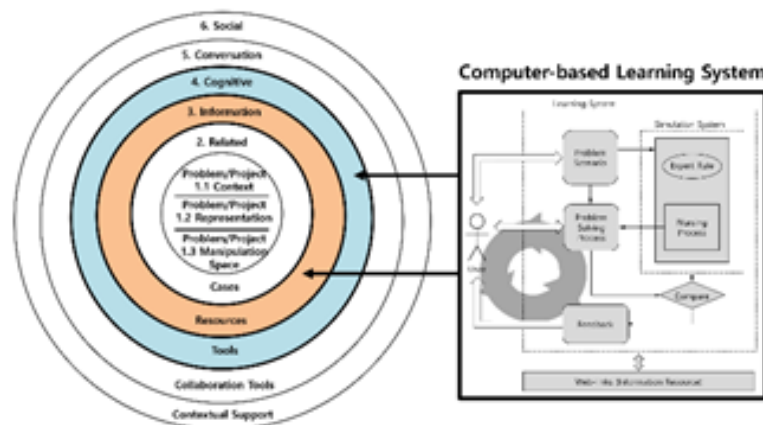


Figure 1: Constructivist Learning Environments (CLEs) for the Computer-based learning System.

2. System design

The proposed learning system is designed to perform PBL by re-constructing the nursing process in the system as a problem-solving process. As shown in [Figure 1], the computer-based clinical simulation system is composed of clinical problem scenarios, which present background information of an emergency and a patient's condition; the problem-solving process, which provides questions that require decision-makings; and feedback, which helps the learner solve the problems autonomously by comparing the learner's decision making with the expert rules in the system. The expert rules were based on the management principles for the elderly with chest pain, suggested by Kim et al (2017). The expert rules were verified by 15 experts consisting of (i.e., emergency medicine, neurology, and geriatrician specialists), six were nursing professors, and six were staff members in geriatric nursing facilities.

B. Stage 2: An evaluation of computer-based clinical simulation education based on CLEs for possible application in nursing curriculum

1. Participants

The participants in our study consisted of 88 college students in a 4-year nursing college in South Korea (28 first-year, 35 second-

year, 13 third-year, and 12 fourth-year students). We were approved by the Institutional Review Board (KU-IRB-10-15-A-2) of Korea University for developing expert rule based algorithm, which is the main part of the proposed learning system. However, Korea University does not require an IRB for a pilot test, so instead, a consent letter was received from all of the students.

2. Procedures

The system background, purpose and method of using the system were explained to the participants of each grade prior to the test, followed by a guidebook and the contact information of the responsible researchers. Each student was allowed to access the system through the Internet whenever they were personally available, and the average time required for problem-solving was 30 minutes. The students were required to solve three problem scenarios related to chest pain, a frequently occurring emergency in nursing facilities. All medical terms were linked to the medical search engine so that the user could check the unfamiliar words by clicks. Feedback was provided during the problem-solving process. The final feedback was provided to confirm the answers upon completing the problem-solving. Finally, the system was evaluated through a survey.

3 RESULTS AND DISCUSSION

A. Stage 1: Development of a computer-based clinical simulation system based on CLEs

For this study, we developed a computer-based simulation system that can evaluate patients' conditions in problem scenarios that can occur in real situations, according to the nursing process. [Figure 2] shows the system composition suggested in this study.

Problem posing

Select Question

Question #1 - Chest Pain Scenario

Question #2 - Airway Obstruction Scenario

Scenario

Mr. Lee (35/M) is complaining of chest pain and dyspnea, grasping his chest and dropping to the floor when he stand up to go to the restroom.

He feels a constriction in the chest. It is difficult to breathe.

Mr. Lee's blood pressure and pulse rate are 110/65mmHg, 100b/m, and the respiratory rate is 12/m after his chest pain. After 5 minutes, the vital signs are not changed, but he is complaining continuous chest pain for 7 minutes. He and his family have denied signing the written consent of DNR (Do not resuscitate) and he is usually taking medications as follows:

Diazepam 500mg p.o. bid
 Lisinatin 10mg p.o. q.d
 Codeine 200mg p.o. qid

Start

Diagnosis List

Chest pain

Stroke

Seizure

Hypoglycemia

Electrolyte disturbances

Airway obstruction (Airflow limitation)

Please Select Correct Symptoms

Problem solving & answer and explanation

Nursing Process Field

Please select all the visible appearance of the patient after reading a scenario (If you select a word, go to the search web-site)

Submit

Mental change

☐ Mental deterioration ☐ Loss of consciousness

☐ Stupor ☐ Altered mental status

Symptom of Cardio-Vascular System

☒ Chest discomfort ☒ Chest pain ☐ Palpitation ☐ Radiating pain

Symptom of Respiratory System

☒ Dyspnea ☐ Cyanosis ☐ Communication disorder

☐ Sputum ☐ Hemoptysis ☐ Cough

Symptom of Gastrointestinal System

☐ Nausea ☐ Vomiting ☐ Loss of appetite ☐ Acute pain ☐ Jaundice

☐ Weight loss ☐ Abdominal pain ☐ Reflux pain ☐ Rebound tenderness

☐ Tenderness ☐ Abdominal rigidity ☐ Abdominal distention ☐ Dyspepsia

☐ Diarrhea ☐ Constipation ☐ Reduced food intake ☐ Stool color change

Symptom of Neurologic System

☐ Headache ☐ Abnormal sense of equilibrium ☐ Quadrigia ☐ Hemiparesis

☐ Parosmia ☐ Anorexia ☐ Gait disturbance ☐ Anesthesia ☐ Edema

☐ Tingling sensation ☐ Visual disturbance ☐ Tetanus ☐ Mydriasis

☐ Convulsion ☐ Seizure ☐ Rigidity ☐ Aphasia

☐ Abnormal face movement ☐ Tremor ☐ Dysarthria ☐ Blurred vision

☐ Generalized convulsion

Symptom of Urinary System

☐ Incontinence ☐ Urinary frequency ☐ Low urine output

☐ Change of urine color ☐ Urine odor ☐ Pyuria ☐ Hematuria

☐ Urinary discharge ☐ Micturition pain ☐ Burning sensation ☐ Dysuria

Symptom of Endocrine System

☐ Tumor ☐ Dryness ☐ Cold sweat ☐ Dehydration ☐ Anemia

☐ Cold and clammy skin ☐ Fatigue ☐ Polydipsia ☐ Fatigue

☐ Weakness ☐ Dizziness ☐ Nervousness

No symptoms

☐ Lethargy ☐ Piloerection ☐ Frailty ☐ Pale ☐ Syncope ☐ Shock

☐ Anxiety ☐ Pain ☐ Arrhythmia ☐ Palpitation ☐ Sleep disturbance

☐ Pruritus ☐ Hand tremor ☐ Erythema ☐ Chills ☐ Heat rash

☐ Edema ☐ Pitting edema

Figure 2: System composition.

The problem scenario is presented on the upper-left side of the system, the diagnosis list on the bottom-left side, and problem-solving progress on the right, with the answer and explanation revealed upon solving the problem.

1. Presenting a problem scenario

The problem scenario presents information on the emergency background and the patient's current condition. Problem-solving begins in the problem scenario after the learner presses the "start" button.

2. Problem-solving according to nursing process

The problem-solving step presents to the learner decisions made from expert rules in the simulation system's nursing process in the

form of a questionnaire for the proposed learning system. The problem-solving step consists of four nursing processes: assessment, diagnosis, intervention, and evaluation; each process presents with three to four problems. The three types of content presented to the learner for decision making during the problem-solving step are as follows:

First, in the assessment step, learners select, from 101 appearances in nine categories, all the visible symptoms of the patient for a given scenario in the problem-solving process. Afterward, learners will select the most probable diagnosis from 15 symptoms and diseases (including chest pain) that occur frequently in nursing facilities. The third step involves general decision making for nursing intervention. This section is presented as multiple-choice and yes-or-no questions.

3. Problem explanation feedback

Problem explanation feedback is provided if the comparison between the choice (decision) of the learner and that of the expert rules in the simulation system reveals different answers. In the feedback section, a section of the scenario that the learner must focus on is underlined, and additional information required for problem solving is provided.

4. Answer, Explanations and Web link

Learners study by using the PBL format and moving back and forth between the problem-solving step and the feedback process in the learning system. Answers and explanations provide explanations with a suggestions page, which is offered in the problem-solving step. If the learner selects the correct answer, he or she is able to view the contents of the suggestions page, which are unavailable during the problem-solving process, and the learner can review the entire problem-solving process.

The proposed learning system provides information on jargon that is necessary during problem solving by providing hyperlinks for problem situations and scenarios, the problem-solving step, and during the feedback process. [Figure 3] shows the Medical Library Engine, an information resource provided by the system in this study.



Figure 3: Medical Library Engine (Web link).

B. Stage 2: An evaluation of computer-based clinical simulation education based on CLEs for possible application in nursing curriculum

For this study, we conducted the following survey to investigate whether the evidence-based simulation learning system was useful during the process of autonomously building techniques and knowledge required by learners for geriatric nursing. The questionnaire comprised sections of self-efficiency, satisfaction of system usage, effectiveness in learning, and usability, which presents questions on the ease of use [Table 1]. The average scores were not high, with an average of 3.55 for self-efficiency, 3.45 for satisfaction, 3.59 for effectiveness, and 3.66 for usability. This indicates that the user is unfamiliar with PBL, which provides a comparison in the diagnosis between the learner and an expert.

TABLE I
Questionnaires for system evaluation

Section	No.	Question	M	SD
Self-efficiency	Q1	I was interested to learn using this system	3.42	1.10
	Q2	I was eager to learn using this system.	4.01	0.75
	Q3	I am confident that I can learn using this system.	3.21	0.89
Satisfaction	Q4	I want to learn using this system again.	3.12	0.99
	Q5	I am satisfied with learning through this system.	3.25	0.96
M=3.55 SD=0.73				
M=3.45 SD=0.72				

Effectiveness M=3.59 SD=0.69	Q6	I want to introduce this system to my friends.	3.06	1.04
	Q7	I think the scenarios presented in this system are realistic.	4.05	0.90
	Q8	I think this system helps in the autonomous learning process.	3.75	0.85
	Q9	This system was helpful in teaching the ability to manage geriatric emergencies.	3.61	0.90
	Q10	The process of solving the problems based on the scenarios presented in this system was helpful for managing geriatric emergencies.	3.85	0.80
	Q11	The contents of the lesson learned using this system will be useful in real-life situations.	3.69	0.84
	Q12	This system is effective in teaching the information necessary for problem situations.	3.62	0.89
	Q13	This system is effective in systematically forming the knowledge necessary for problem situations.	3.57	0.87
	Q14	I have corrected my understanding using this system.	3.44	0.93
	Q15	I think this system is helpful for the critical thinking process.	3.33	0.98
Usability M=3.66 SD=0.78	Q16	This system has adequate functions to teach.	3.40	0.95
	Q17	Feedback provided when the answer was incorrect was helpful in problem-solving.	3.84	0.99
	Q18	The weblinks provided for the jargon in this system were helpful.	3.78	1.19
	Q19	It was easy to search related information using weblinks provided by the system.	3.61	1.19

[Figure 4] shows the analysis results of each category. The analysis of each category revealed that the average scores generally increased with each grade, from the first to the fourth. The following is the result of a detailed analysis of the survey on self-efficiency, satisfaction, effectiveness, and usability, and shows that for self-efficiency, first-year students scored the lowest (3.32), while fourth-year students scored the highest (3.83). For satisfaction, first-year students scored the lowest (3.19), while fourth-year students scored the highest (3.77). The effectiveness score, the purpose of which is to determine the degree of helpfulness, shows that first-year students obtained the lowest average score (3.40), while fourth-year students had the highest average score (3.80).

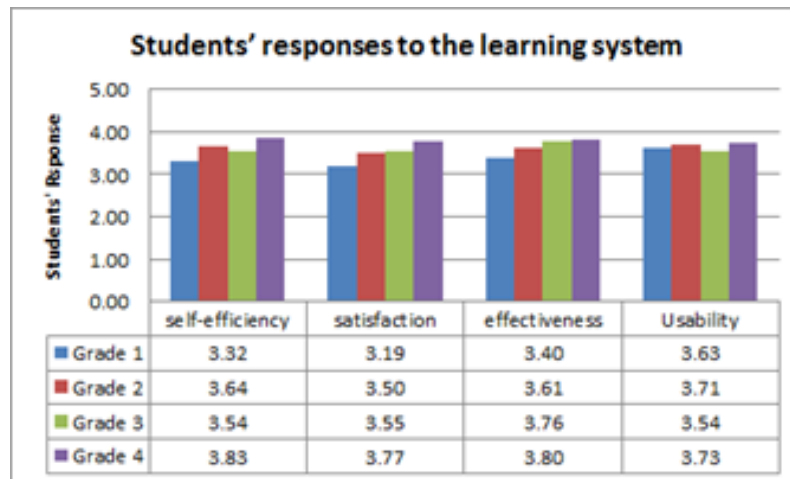


Figure 4: Student responses regarding the learning system.

Subjective comments included, "the web-links and feedback provided by the system was helpful for solving the problems" and "the scenario-based problem-solving process of the system was helpful for enhancing clinical reasoning skills and geriatric emergency management."

The pilot study result shows that upper-year students were more confident in using the system for learning compared with the lower-year counterparts, and they exhibited greater satisfaction using the system for learning. Subjective comments by upper-year students suggested that the problem-solving process based on a scenario was helpful for learning geriatric emergency management. This finding may be because they have more substantive theoretical background and practical experience, which is in line with a previous study result showing that those with more knowledge in the relevant area can utilize the system with greater confidence (Grbz and Birgin, 2012; Reed et al., 2010).

There are several limitations in this study. This study was based on data from one institution with small and unequally sized subgroups that the findings may not be generalizable. Ideally, a larger sample would be desirable for comprehensive data that can be generalized. Moreover, the conducted survey includes students' perceived improvement of clinical reasoning skills after using the sys-

tem. Further research would need to include both pre- and post-test data of using the system that shows statistical significance to learn if developed learning system has any increase on the overall student knowledge base and clinical reasoning skills.

4 CONCLUSION

In this study, the learning system was developed with the goal of enabling learners to solve problems autonomously by providing CLE information resources and cognitive tools. The students' responses demonstrated that the proposed learning system (web-links and feedback) provided by the system was helpful for learning. Applying the learning system equipped with information resources and cognitive tools from CLEs will improve students' learning outcomes and the quality of students' educational experience.

References

- [1] Bambini, D., Washburn, J. O. Y., & Perkins, R., 2009. *Outcomes of clinical simulation for novice nursing students: Communication, confidence, clinical judgment*. Nursing education perspectives, 30(2): 79-82.
- [2] Berman, A., Mezey, M., Kobayashi, M., Fulmer, T., Stanley, J., Thornlow, D., & Rosenfeld, P., 2005. *Gerontological nursing content in baccalaureate nursing programs: Comparison of findings from 1997 and 2003*. Journal of Professional Nursing, 21(5): 268-275.
- [3] Center for Disease Control and Prevention. 2016. *Long-Term Care Providers and Services Users in the United States State Estimates Supplement: National Study of Long-Term Care Providers*, 2013-2014..
- [4] Centrella-Nigro, A. M., Blackwell, B., Coughlin, A., & Voorhees, K. A., 2016. *The Effect of Human Patient Simulators on Knowledge and Self-Competence in Graduating Pre-licensure Nursing Students*. Nursing Education Perspectives, 37(6): 337-339.

- [5] Cook, N. F., McAloon, T., O'Neill, P., & Beggs, R., 2012. *Impact of a web based interactive simulation game (PULSE) on nursing students' experience and performance in life support training: a pilot study*. Nurse education today, 32(6): 714-720.
- [6] Dolmans, D. H., Loyens, S. M., Marcq, H., & Gijbels, D., 2016. *Deep and surface learning in problem-based learning: a review of the literature*. Advances in Health Sciences Education, 21(5): 1087-1112.
- [7] Gotwals, B. A., & Scholtz, S., 2016. *Video-Enhanced Simulation in Pediatric End-of-Life Care*. Nursing Education Perspectives, 37(6): 360-362.
- [8] Grbuz, R., & Birgin, O., 2012. *The effect of computer-assisted teaching on remedying misconceptions: The case of the subject "probability"*. Computers & Education, 58(3): 931-941.
- [9] He, W., Goodkind, D., & Kowal, P., 2016. *US Census Bureau, International Population Reports*. An aging world: 2015.
- [10] Kim, M. S., Kim, H. J., Choi, J. E., Kim, S. J., & Chang, S. O., 2017. *Special issue: nursing home nurses conceptualize how to care for residents with cardiac vulnerability*. Nursing in critical care. 22(6), 329-338.
- [11] Kim, J.Y., & Choi, E.Y., 2008. *Learning element recognition and academic achievement of nursing student receiving PBL with simulation education*. Journal of Korean Academy of Adult Nursing, 20(5): 731-742.
- [12] Lapkin, S., Fernandez, R., Levett-Jones, T., & Bellchambers, H., 2010. *The effectiveness of using human patient simulation manikins in the teaching of clinical reasoning skills to undergraduate nursing students: a systematic review*. JBI Database of Systematic Reviews and Implementation Reports, 8(16): 661-694.
- [13] Mortazavi, S. S., Shati, M., Keshtkar, A., Malakouti, S. K., Bazargan, M., & Assari, S., 2016. *Defining polypharmacy in the elderly: a systematic review protocol*. BMJ open, 6(3): e010989.

- [14] Reed, H. C., Drijvers, P., & Kirschner, P. A., 2010. *Effects of attitudes and behaviours on learning mathematics with computer tools*. Computers & Education, 55(1): 1-15.
- [15] Shanley, C., Whitmore, E., Conforti, D., Masso, J., Jayasinghe, S., & Griffiths, R., 2011. *Decisions about transferring nursing home residents to hospital: highlighting the roles of advance care planning and support from local hospital and community health services*. Journal of clinical nursing, 20(19- 20): 2897-2906.
- [16] Spilsbury, K., Hewitt, C., Stirk, L., & Bowman, C., 2011. *The relationship between nurse staffing and quality of care in nursing homes: a systematic review*. International journal of nursing studies, 48(6): 732-750.
- [17] Spinello, E. F., & Fischbach, R., 2008. *Using a web-based simulation as a problem-based learning experience: perceived and actual performance of undergraduate public health students*. Public Health Reports, 123(2_suppl): 78-84.
- [18] Yldz-Feyziolu, E., Akpınar, E., & Tatar, N., 2013. *Monitoring students' goal setting and metacognitive knowledge in technology-enhanced learning with metacognitive prompts*. Computers in Human Behavior, 29(3): 616-625.