

## Research Article

## Impact of a concept map teaching approach on nursing students' critical thinking skills

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## Abstract

Nurses confront complex problems and decisions that require critical thinking in order to identify patient needs and implement best practices. An active strategy for teaching students the skills to think critically is the concept map. This study explores the development of critical thinking among nursing students in a required pathophysiology and pharmacology course during the first year of a Bachelor of Science in Nursing in response to concept mapping as an interventional strategy, using the Health Education Systems, Incorporated critical thinking test. A two-group experimental study with a pretest and posttest design was used. Participants were randomly divided into a control group ( $n = 42$ ) taught by traditional didactic lecturing alone, and an intervention group ( $n = 41$ ), taught by traditional didactic lecturing with concept mapping. Students in the concept mapping group performed much better on the Health Education Systems, Incorporated than students in the control group. It is recommended that deans, program directors, and nursing faculties evaluate their curricula to integrate concept map teaching strategies in courses in order to develop critical thinking abilities in their students.

## Key words

concept map, critical thinking, HESI critical thinking test, nursing students, teaching and learning.

## INTRODUCTION

Nurses confront complex problems and decisions that require critical thinking (CT) in order to identify patient needs and implement best practices. CT is one of the most highly valued educational outcomes of nursing education, and both national and international educational organizations, such as the Institute of Medicine (2010) and the American Association of Colleges of Nursing (2014), recognize its importance as an outcome criterion in postsecondary education and mandate that new nurse graduates think critically to solve problems in a variety of clinical settings.

Critical thinking is a complex cognitive process broadly defined as the use of purposeful, insightful judgment that involves the development and effective utilization of multiple dimensions of cognition to interpret and analyze a situation and arrive at and act on an appropriate conclusion or solution (Facione, 2013). Thus, CT involves higher-order reasoning and evaluation (Facione, 2013). Expanded nursing roles have increased the opportunity for making high stakes decisions and nurses must possess CT as a central learnable skill and outcome of undergraduate and graduate nursing programs (Vacek, 2009). The five elements of critical thinking include: analysis, interpretation, inference, self-regulation, and explanation of a specific situation, based on evidence, methods, concepts, criteria, and

contexts, with an ability for self-correction and regulation (Facione, 2013).

An active strategy for teaching students the skills to think critically is the concept map – a cognitive tool that encourages learners to process information deeply in order to understand study material (Lee *et al.*, 2013). Developed by Novak and Gowin (1984), based on Ausubel's theory of learning, "A concept map is a schematic device for representing a set of concept meanings in a framework of propositions" (p. 15). In a concept map, each word or phrase is connected to another and linked back to the original idea, word, or phrase. Concept mapping is considered a valuable active teaching method because it prompts learners to make connections and establish relationships between new concepts and prior schema (McMillan, 2010; Pottier *et al.*, 2010; Sadler *et al.*, 2015). Learners use graphic representations to depict their understanding of the meaning of a set of concepts, to organize and represent knowledge, to summarize and analyze their ideas, and to visualize their thinking (Lee *et al.*, 2013). Concept maps have been used effectively in nursing education since 1984 (Daley & Torre, 2010; Harris & Zha, 2014).

Studies of the effect of concept mapping on CT among students in Bachelor of Science in Nursing (BSN) programs, although scarce, have shown generally positive and significant effects. These studies have focused on students in courses related to medical-surgical nursing (Chen *et al.*, 2011), cardiovascular nursing (Sarhangi *et al.*, 2011), and midwifery (Nirmala & Shakuntala, 2011). Three studies have shown more mixed effects of concept mapping on CT as assessed by clinical care

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Received 10 September 2015; revision 24 December 2015; accepted 6 January 2016.

plans (Wheeler & Collins, 2003; Pickens, 2007; Atay & Karabacak, 2012). Tools used to measure CT across these studies have varied widely. Chen *et al.* (2011) conducted a study of BSN students in the second semester, measuring CT by the Critical Thinking Scale (CTS), developed by Cheng *et al.* (1996). Atay and Karabacak (2012) compared the California Critical Thinking Disposition Inventory (CCTDI) scores of experimental and control groups that included freshman and sophomore students in a licensed practical nurse (LPN)-to-BSN program. Nirmala and Shakuntala (2011) studied fourth year BSN students, finding a significant difference in CT scores measured by the Thinking Skill Assessment Tool, a standard tool from Cambridge University containing 32 multiple-choice questions involving CT skills. Sarhangi *et al.* (2011) and Wheeler and Collins (2003) both employed the California Critical Thinking Skills Test (CCTST) to measure CT skills in BSN students (Facione, 2013). Among fifth semester BSN students, concept mapping led to a significant increase in CT scores in all domains except analysis and deductive reasoning compared with the control group not exposed to concept mapping (Sarhangi *et al.*, 2011).

No previous studies on concept mapping have been found utilizing the Health Education Systems, Incorporated (HESI) CT test as an outcome measure. The HESI exam has been used more than 47,000 times and has both reliability and validity measures that make it useful and practical (Morrison *et al.*, 2008). The HESI CT exam prompts responses to situations encountered in healthcare settings in four domains: problem solving, biases and ethical dilemmas, argument analysis, and analysis of data (HESI, n.d.). Previous studies have not assessed the development of CT in the basic science courses that are foundational for nursing science. The current study fills these gaps in the evidence base by exploring the development of CT among nursing students in a required pathophysiology and pharmacology course during the first year of a BSN program in response to concept mapping as an interventional strategy, using the HESI CT.

## METHODS

### Design and sample

A two-group experimental study with a pretest and posttest design was used in this study. A convenience sample of students ( $n = 83$ ) enrolled in a pathophysiology and pharmacology class in the second semester of a baccalaureate nursing program in an American university were included. Participants were randomly divided into control ( $n = 42$ ) and intervention groups ( $n = 41$ ). The intervention group was taught by traditional didactic lecturing and used concept mapping, while the control group was taught by traditional didactic lecturing alone. Participants had not previously been exposed to concept mapping in their curriculum.

### Ethical considerations

This study conformed to the Helsinki Declaration of Human Rights (Levine, 2009). Prior to collecting data, institutional review board approval from the MCPHS University was

obtained. All participants voluntarily took part and signed an informed consent prior to administration of the pretest. Participants were reassured that the data were confidential. Codes were provided to participants for the demographic survey and the CT pretest and posttest to ensure data confidentiality. Only the researcher had access to the names of the participants related to their respective codes. Neither the researcher nor the research assistant who collected the data was involved in teaching the pathophysiology and pharmacology course.

Participants were provided with detailed verbal and written explanations of the study and were advised that they could withdraw from the study at any time. They were reassured that their participation in the study would not affect their success in the course or in the nursing program. Instructions for completing the CT test were also given to the participants by the research assistant.

## Measures

Intervention included an introductory lecture on concept mapping and its applicability in nursing education. The nursing students in the experimental group were educated by a teaching assistant about concept mapping and its appropriate use in the context of pathophysiology and pharmacology during a one hour session as part of the first class. The introductory session included a brief case study scenario of an adult patient with diabetes. Students were trained and practiced how to create a concept map to correlate the pathophysiology of diabetes to the pharmacologic treatment of the patient in the case. Concept maps included data such as objective and subjective assessment information, possible diagnostic tests and results, laboratory values, and important medications used in the treatment of the patient. The teaching assistant, who facilitated the training by providing guidance and feedback regarding the appropriate concept map process, answered questions about the process of developing a concept map. Participants compared similarities and differences between their concept maps to assist in development of their individual concept map during their pathophysiology and pharmacology class.

After the training, each student developed one paper-based concept map per week for a total of 14 concept maps assigned. Concept maps were not graded; however, the course faculty provided the students with constructive feedback on every concept map. The feedback focused on the appropriateness of the concept map in linking the pathophysiology to the pharmacology of each disease presented in class. The topics of the concept maps included patients with asthma, hypertension, gastric ulcer, stroke, renal failure, acne vulgaris, hyperthyroidism, osteoporosis, urinary tract infection, sexually transmitted infection, breast cancer, acquired immune deficiency syndrome, obesity, and metabolic syndrome. Concept map topics were assigned by the course faculty based on topics discussed in each class. Neither the teaching assistant nor the course faculty was an investigator in this research.

The outcome measure used in this study was the HESI CT exam, which is a valid and reliable standardized computerized exam developed to assess nursing students' CT skills and used nationwide by nursing schools. This multiple-choice test is composed of 30 questions in the form of health-oriented scenarios.

Each question has a choice of four possible answers. The correct answer demonstrates the highest level of CT applied to the scenario, while the three incorrect answers reflect plausible but non-optimal responses to the scenario (Morrison *et al.*, 2008). Each student receives an overall CT score, in addition to scores on five subscales: analysis, argument, prioritization, problem solving, and resolution. Possible scores on the HESI CT test range from 0–1000 (Morrison *et al.*, 2008). The higher a student's score, the better his/her ability to think critically within the discipline of nursing. The HESI was administered to all participants in both groups at the beginning and end of the course.

Covariates included gender, ethnicity, English as a second language (ESL), the average number of hours the students worked each week, and the average number of hours the students spent studying each day.

### Analytic strategy

Statistical analysis was performed using SAS 9.4 (SAS Institute, Cary, NC, USA), including descriptive statistics, independent *t*-tests, and chi-square tests. Student characteristics were described, chi-square tests of differences between groups were conducted for categorical variables, and *t*-tests were performed for continuous variables. Two-group independent *t*-tests compared the HESI CT scores at the beginning and end of the course, as well as any change in HESI scores between the two measures. Finally, a linear regression model was used to model the change in HESI scores between the start and end of the course. Concept mapping intervention was included as a group variable and adjusted for covariates. Both a full model and a model reduced using the stepwise method were estimated.

## RESULTS

Table 1 presents the students' demographic characteristics by group. No statistically significant differences were found. This

**Table 1.** Students' characteristics by the two different teaching methods

Characteristic	Concept mapping (n=41)n (%)	No concept mapping (n=42)n (%)	<i>P</i> value
<b>Gender</b>			0.10
Male	8 (19.51)	3 (7.14)	
Female	33 (80.49)	39 (92.86)	
<b>Ethnicity</b>			0.59
White	27 (65.85)	25 (59.52)	
Black	3 (7.32)	6 (14.29)	
Hispanic, Asian, Other	11 (26.83)	11 (26.19)	
<b>Language</b>			0.75
English	37 (90.24)	37 (88.10)	
ESL	4 (9.76)	5 (11.90)	
	<b>Mean (SD)</b>	<b>Mean (SD)</b>	
<b>Hours worked</b>	10.27 (9.64)	12.34 (11.03)	0.36
<b>Hours studied</b>	3.96 (2.76)	3.68 (2.47)	0.44

ESL, English as a second language; SD, standard deviation.

means that the randomization between the two groups worked well and the student characteristics were comparable.

As presented in Table 2, pretest scores of CT skills in the intervention and control groups did not differ, which indicated that the students' performances were similar when they started the course. However, posttest CT scores were significantly higher in the intervention group. Students in the intervention group performed much better on the HESI than students in the control (*P* value = 0.0003). On average, students taught with concept mapping increased their HESI scores by 84.15 points upon exit from the course, compared with 25.24 points among students not exposed to concept mapping (*P* value < 0.0001).

Table 3 presents the results from the full multiple regression model. Intervention (concept mapping) was a significant predictive variable (*P* value < 0.0001) after adjusting for all possible confounders, none of which were significant. Based on the reduced model, which is consistent with the bivariate analysis presented in Table 2, participants' HESI scores in the intervention group increased on the posttest by about 60 points over that of the control group.

## DISCUSSION

Concept mapping was found to be a useful teaching strategy and an effective method to promote BSN students' CT skills.

**Table 2.** HESI score comparison between the two different teaching methods

	Concept mapping Mean (SD)	No concept mapping Mean (SD)	<i>P</i> value
<b>HESI score at entry exam</b>	795.9 (43.18)	811.7 (49.13)	0.12
<b>HESI score at exit exam</b>	880.0 (48.73)	836.9 (54.97)	0.0003
<b>Mean change in HESI score</b>	84.15 (50.79)	25.24 (54.33)	<0.0001

HESI, Health Education Systems, Incorporated; SD, standard deviation.

**Table 3.** Multiple regression model for change in HESI score between the two different teaching methods.

Parameter	Estimate	Standard Error	<i>t</i> Value	Pr >   <i>t</i>
<b>Intercept</b>	72.77	40.64	1.79	0.0775
<b>Teaching Method: Concept Map (vs No Concept Map)</b>	60.62	11.88	5.10	<0.0001
<b>Female (vs Male)</b>	6.59	17.36	0.38	0.7055
<b>Ethnicity</b>				
White	-31.16	15.49	-2.01	0.0510
Black	-33.87	21.34	-1.59	0.1168
Other	0	.	.	.
<b>English Language (vs Other)</b>	-34.33	23.11	-1.49	0.1418
<b>Hours Worked</b>	-0.71	0.60	-1.20	0.2359
<b>Hours Studied</b>	-4.81	3.85	-1.25	0.2160

HESI, Health Education Systems, Incorporated.

The findings of our study are consistent with Wilgis and McConnell (2008) who analyzed the effects of concept mapping on CT, as measured by the Schuster's Concept Map Care Plan Evaluation Tool (Schuster, 2011). Wilgis and McConnell found that the mean scores of these novice nurses at the beginning and end of the orientation program were significantly different, consistent with our study findings among pre-licensed students. Our findings also conform to two dissertations that have shown similar results: Studley (2005), using the Critical Thinking Indicators tool, and Pickens (2007), using the HESI CT test. These authors proposed that concept mapping facilitates representation of related information units as related to a main theme. This promotes understanding and assists the learner to add new information to their knowledge base – which is a cognitive construction – and, thus, promotes meaningful learning and CT. Concept mapping promotes an active role in learning.

Correspondingly, the findings of this study are also consistent with Chen *et al.* (2011), Maneval *et al.* (2011), Wahl and Thompson (2013), Moattari *et al.* (2014), and Orique and McCarthy (2015), who explored the effects of concept mapping in developing CT ability and the approach to learning and studying. These authors concluded that concept mapping is an effective tool for improving students' ability to think critically.

However, our study findings are inconsistent with Wheeler and Collins (2003) who used the CCTST in a quasi-experimental pretest/posttest study of undergraduate baccalaureate nursing students (Facione, 2013). Wheeler and Collins found no significant differences between the pretest and posttest scores of the students for CT disposition and its subscales. Students prepared concept map care plans in the first 7.5 weeks of the study and conventional care plans in the final 7.5 weeks. Wheeler and Collins proposed that there may be a dose effect for concept mapping, that is, more practice across more different kinds of scenarios may be required to equip learners in this complex skill. This hypothesis requires additional research.

Our findings were also inconsistent with Bixler *et al.* (2015) who found no significant increase in CT as measured by the CCTST and CCTDI from pretest to posttest when students were educated using a concept mapping approach. Bixler *et al.* concluded that although the difference in CT scores was not significant, the study could serve as an important start toward the development of a curriculum devoted to improving CT.

## Implications

This study builds on previous work to suggest that concept mapping is an effective tool for improving students' ability to think critically (Chen *et al.*, 2011; Maneval *et al.*, 2011; Wahl & Thompson, 2013; Moattari *et al.*, 2014; Orique & McCarthy, 2015). Using concept mapping in the education of nursing students appears to predict the development of CT skills, which is one of the most important duties of nursing education. Nurse educators are expected to apply educational methods for improving the CT skills of their students. Developing a high level of thinking skills as one of the important missions of nursing education requires appropriate pedagogical approaches. It is recommended

that deans, program directors, and nursing faculties evaluate their curricula to integrate concept map teaching strategies in pathophysiology and pharmacology courses and potentially in other clinical and specialty courses to develop CT abilities in their students.

## Limitations

A limitation of this study was the small sample size; only 83 nursing students participated. Another limitation was the use of only one nursing program. These limitations preclude the findings of this study from being generalized to all nursing students educated by all nursing programs in the United States.

A potential threat to validity associated with adding the CT measure to the course could be a maturation effect, which occurs when changes in a CT score over time result from naturally occurring internal processes. However, the duration of the course, 17 weeks, may not be a sufficient time for students' maturation to take place (Graziano & Raulin, 2013).

## CONCLUSIONS

Posttest mean scores demonstrated significant differences in CT skills between the intervention and control groups. The mean scores of the intervention group students regarding concept maps increased from the pretest to the posttest, with statistically significant differences between the mean scores.

According to the results of the present study, concept mapping is considered an effective educational method to promote CT skills, as concept mapping reflects an image of the learners' thinking process. Appropriate CT skill assessment tools may differ between nursing programs, and more consistency in tools to measure CT outcome would support conclusions. Further research is required to promote concept mapping as a teaching and learning strategy to develop nursing the CT skills of students.

## CONTRIBUTIONS

Study Design: MK  
Data Collection and Analysis: MK, QY  
Manuscript Writing: MK, OV

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