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# Promoting Critical Thinking Skills Through Problem-Based Learning

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## ABSTRACT

***The objectives of this study were to compare the critical thinking skills before and after the implementation of the problem-based learning (PBL) approach among Chinese baccalaureate nursing students and to describe students' comments on PBL. A quasi-experimental pre-test/post-test design was conducted. Through purposive sampling, twenty-three second-year baccalaureate nursing students were invited to participate in this study. PBL was used as the intervention for a one-semester course in nursing. The California Critical Thinking Skills Test Form A (CCTST-A Chinese Taiwan Version) was used to measure the critical thinking skills and was given to students at both pre-test (at the beginning of the course) and post-test (at the end of the course). A paired t-test indicated that PBL students' critical thinking skills significantly increased over one semester (P< .05). In addition, most of the students suggested that PBL encouraged them to share their opinions with others, analyze situations in different ways and think of more possibilities for solving problems. However, a few students felt very stressed and overloaded during the PBL process. In conclusion, PBL promoted nursing students' critical thinking skills.***

**Key words:** Problem-based learning, Critical thinking, Chinese, Nursing students

## INTRODUCTION

In a contemporary healthcare environment characterized by rapidly-changing development and relentlessly-increasing knowledge, the possession of critical thinking is essential for nurses in order to make a sound judgment when solving clinical problems (Alfaro-LeFevre, 1995).

Professional nurses need to develop critical thinking skills that will provide them with expertise in flexible, individualized and situation-specific problem solving (Higgs and Jones, 2000). Critical thinking is an essential component of practice, communication, problem-solving ability, theoretical and conceptual understanding of nursing concerns and research endeavors that advance and broaden the knowledge base of nursing (Shin, 1998). Nursing education strives to develop critical thinking abilities in students through emphasis on process, inquiry and reasoning (Bowles, 2000).

Problem-based learning (PBL) is a student-centered approach to learning which enables students to participate in small group work during the learning process in order to foster deeper learning. In the PBL approach, students encounter the problem-solving situations in small groups. Students' critical thinking skills are fostered through their group discussions (Rideout and Carpio, 2001). The literature suggested that students' perceptions that the curriculum encouraged critical thinking significantly increased after PBL curriculum was conducted (Birgegard and Lindquist, 1998). PBL offers the opportunity for students to enhance their critical thinking and self-directed learning skills, and engages students in solving problems (Williams, 1999). There is a theoretical basis for using PBL to promote students' critical thinking skills (Biley and Smith, 1999), but little empirical evidence exists to verify such a theoretical hypothesis in Mainland China. The empirical studies are needed to compare critical thinking skills before and after the implementation of the PBL approach among Chinese baccalaureate nursing students. The objectives of this study were to compare the critical thinking skills before and after the implementation of the PBL approach among Chinese baccalaureate nursing students and to describe students' comments on PBL.



## MATERIALS AND METHOD

### *Study design and sample*

A quasi-experimental pre-test/post-test design was conducted from September 2006 to January 2007 at Fudan University, Shanghai, P.R. China. Purposive sampling was used to identify 23 second-year baccalaureate nursing students who were enrolled in the course entitled "Introduction to Nursing".

*Instruments*

Students' critical thinking skills were measured using the California Critical Thinking Skills Test Form A (CCTST-A ) Chinese Taiwan Version which was developed by Peter A. Facione and authoritatively translated by Young Ming Neim. It is a standardized, 34-item multiple-choice test with five subscales which include analysis (9 items), evaluation (14 items), inference (11 items), deductive reasoning (16 items) and inductive reasoning (14 items). Each correct response is assigned one point, therefore, scores can range from 0 to 34, with higher scores reflecting stronger critical thinking skills (Facione and Facione, 1993). The CCTST-A has well-documented validity and reliability. Construct validity of the CCTST-A was grounded in a Delphi study and consensus statement from the American Philosophical Association. Concurrent validity of the CCTST-A was supported by the pilot validation study. The scores of CCTST-A (Facione and Facione, 1994) were correlated with Scholastic Aptitude Test Verbal Critical Reading Exam (.55, $P$ <.000), Scholastic Aptitude Test Math Problem Solving Exam (.44, $P$ <.000 ), and Nelson-Denny Reading Score (.40, $P$ <.000). Based on the aggregate research report compiled by Facione (1997), internal consistency of the CCTST-A ranged from 0.68 to 0.70 with a Kuder Richardson (KR) score of 20. In this study, the reliability of Chinese Taiwan Version CCTST-A was .80 for the total scale, and .60, .70, .69, .78 and .61 for subscales of analysis, evaluation, inference, deduction and induction, respectively. In addition, an open-ended question was included for collecting the information about the students' response to the advantages and disadvantages of PBL.



*Data collection*

The CCTST-A Chinese Taiwan Version was completed before and after implementing the PBL approach. The same supervisor administered both the pre-and post-tests to students. At the end of the course, students were asked to independently write down the advantages and disadvantages of PBL.

*Intervention*

Twenty-three students were voluntarily divided into two PBL tutorial groups. Each PBL tutorial group consisted of either 11 or 12 students and a tutor.

1. At the beginning of the course, students were given the learning guidebooks which contained a PBL learning outline and PBL learning packages. Each learning package consisted of a core concept map, learning goals, a scenario based on a real nursing practice situation and trigger questions.

2. Students did small group work with five learning packages over 36 learning hours (2 hours per week for 18 weeks). The students were expected to review the previously-learned concepts and working definitions document as appropriate to the scenarios.

3. The tutors acted as facilitators who stimulated students towards self-directed learning, kept the learning process going, deeply probed the students' knowledge and modulated the challenge of the scenario situation.

Each learning package was completed within 6 or 8 learning hours through the process of PBL (Table 1).



**Table 1:** The process of PBL.

| PBL process | Learning activities | Learning hours |
|---|---|---|
| 1. Group clarification | • Students clarified what happened in the scenario, defined the problems which required explanation, and wrote down the unclear terms or concepts on the white board.<br>• Tutor encouraged students to think and discuss openly, and helped students understand the scenario. | 2 |
| 2. Brainstorming | • Students applied previous knowledge, as well as their own ideas, to produce possible explanations. The problem scenario became clearer, allowing them to evaluate what knowledge and skills they needed to solve the problem. The learning issues were identified. They checked unclear terms or concepts against the core concept map. When all core concepts in the scenario were identified, the concepts were grouped together and the research topics were defined. Individual group members volunteered or were assigned by the group to research each of the concurrent topics.<br>• The tutor helped the group to maintain group dynamics and helped move the group through the tasks, facilitated student thinking about what else they needed to know. Meanwhile, the tutor assisted the group ensuring that each key concept in scenario was included in the individual research topics. | |

| PBL process | Learning activities | Learning hours |
|---|---|---|
| 3. Self-directed learning | • Students worked on the identified research topic. They searched the advanced information using textbooks, journal articles and internet resources such as CINAHL database, Medline, Chinese Journal Full-text Database, www.google.com, and so on. Sometimes they also consulted content experts. Students developed informative handouts for their peers and prepared critical thinking questions for group discussion.<br>• The tutor stimulated students towards self-directed learning, facilitated students to thinking broadly and deeply, gave the comments on each paper to assist students to probe the knowledge deeply. | Student's own learning time |
| 4. Group discussion | • Students reconvened to discuss the findings and further critically analyzed information found. They shared what they had learned and discussed the critical thinking questions, generated a number of possible hypotheses to explain the situation. The knowledge acquired was discussed and debated critically. The group identified further gaps in knowledge and further learning needs.<br>• The tutor encouraged students to think about the trigger questions involved in the learning package, and to discuss the situation broadly and critically. The tutor also encouraged students to ask each other to explain topics in their own words or by the use of drawings and diagrams, and asked students to think of a few possible solutions to the problems. Tutors assisted the students to manage group conflict, and modulated the challenge of the problem. | 2 or 3 |

| PBL process | Learning activities | Learning hours |
|---|---|---|
| 5. Care planning | • Students shared the newly-acquired information with the peers and applied nursing theory to the particular situation. Using the nursing process, each group developed one relevant care plan for two problems in the scenario. Knowledge was applied to the situation/problem in a practical way. The two tutorial groups shared and critiqued their care plans with each other.<br>• The tutor facilitated student thinking about the questions (e.g., "What is going on here?, "What did we do during the situation/problem that was effective?"). The tutor helped students understand why some situations were too difficult to be dealt with completely and why there were so many factors to be considered. The tutor encouraged students to discuss their opinions and debate the issues. Finally, the tutor provided comments on each care plan. | 2or 3 |
| 6. Evaluation and reflection | • Students engaged in self evaluation and peer evaluation and reflection on communication, self-directed learning, problem solving, critical thinking, knowledge acquirement and participation in the tutorial process.<br>• The tutor encouraged students to check their understanding and knowledge acquired, and helped the students evaluate whether the group achieved appropriate learning objectives or not. The tutor assisted students to reflect on their performance in the tutorial group, listened to the students' responses, and helped them solve the difficulties which they faced during the PBL tutorial process. | |



***Data analysis***

Both descriptive and inference statistics were performed for data analysis, using the Statistical Package for Social Science (SPSS 11.5). The mean, standard deviation and ranges were generated for the data description of critical thinking skills. After normal distribution testing, paired sample t-tests were performed to compare mean scores of baccalaureate nursing students' critical thinking skills before and after a one-semester PBL course at the significant level of .05. The effect size was estimated by calculating Cohen's *d*. The formula was: *Cohen's d=mean difference between*

*the pair/standard deviation of the difference.* The magnitudes of effect size were interpreted, using Cohens'(1988) descriptors (cited in Kotrlik and Williams, 2003):

| The value of Cohen's *d* | Interpretation |
|---|---|
| .20 | Small effect size |
| .21 - .49 | Small to medium effect size |
| .50 | Medium effect size |
| .51 - .79 | Medium to large effect size |
| .80 and over | Large effect size |

The data from the open-ended question in PBL evaluation questionnaire were summarized according to common themes.




## RESULTS

### *Demographic characteristics of students*

A total of 23 students (21.74% male and 78.26% female) participated in the study. The age ranged from 18 to 22 with a mean of 19.83 (SD =1.11). Six students had experience in small group learning within the last 4 years. No student had experience with self-directed learning, critical thinking, problem solving and PBL.

### *Students' critical thinking skills*

The CCTST-A Chinese Taiwan Version was completed within 45 minutes before and after implementing PBL approach through self-report technique. At the beginning of the semester, the overall scores of CCTST ranged from 14 to 26 with a mean of 19.39 (SD= 2.90). On the subscales, the mean scores were: analysis 4.78 (SD = .95), evaluation 7.39 (SD =1.50), inference 7.22 (SD=1.45), deduction 10.70 (SD=2.01) and induction 6.65 (SD =1.49). The highest mean score occurred on the deduction subscale (66.88% of the possible score) while the lowest one was on the induction subscale (47.50% of the possible score).

At the end of the semester, the overall score on the CCTST for the PBL group ranged from 17 to 28 with a mean of 21.83 (SD=2.74). On the subscales, the mean scores were: analysis 5.48 (SD=1.12), evaluation 8.48 (SD=2.15), inference 7.87 (SD=1.36), deduction 12.13 (SD=2.10) and induction 8.00 (SD=1.73). The highest mean score occurred on the deduction subscale (75.81% of the possible score) while the lowest one was on the induction subscale (57.14% of the possible score) (Table 2).

**Table 2:** Description of scores of critical thinking skills at the pre-test and post-test.

| Critical thinking skills (Maximum possible score) | At the pre-test (n=23) | | | At the post-test (n=23) | | |
|---|---|---|---|---|---|---|
| | Mean | SD | Min-Max | Mean | SD | Min-Max |
| Analysis (9) | 4.78 | .95 | 3-7 | 5.48 | 1.12 | 4-8 |
| Evaluation (14) | 7.39 | 1.50 | 4-10 | 8.48 | 2.15 | 5-13 |
| Inference (11) | 7.22 | 1.45 | 5-10 | 7.87 | 1.36 | 6-10 |
| Deduction (16) | 10.70 | 2.01 | 7-15 | 12.13 | 2.10 | 8-16 |
| Induction (14) | 6.65 | 1.49 | 3-9 | 8.00 | 1.73 | 5-11 |
| **Total score (34)** | 19.39 | 2.90 | 14-26 | 21.83 | 2.74 | 17-28 |



After testing the normal distribution, the paired sample t-test was performed to compare mean scores of critical thinking skills on pre-test and post-test in both PBL and lecture groups. In PBL group, students' critical thinking skills significantly increased with an overall mean score of 2.43 ($P$=.001) over one semester. Subscales scores also increased significantly: analysis (.69, $P$ =.002), evaluation (1.09, $P$ =.046), deduction (1.44, $P$ =.006) and induction (1.35, $P$ =.006). This change represents a medium to large effect size. Scores on inference subscale increased slightly (.65, $P$ =. 087) but not significantly (Table 3).

**Table 3:** Difference between pre-test scores and post-test scores of critical thinking skills.

| Critical thinking skills | Paired Difference (subtracting pre-test score from post-test score) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mean diff. | SD | t | *df* | P | Cohen's *d* | Effect size |
| Analysis | .69 | 1.33 | 2.510 | 22 | .002 | .52 | Medium to Large |
| Evaluation | 1.09 | 2.47 | 2.114 | 22 | .046 | .44 | Small to Medium |
| Inference | .65 | 1.75 | 1.789 | 22 | .087 | .37 | Small to Medium |
| Deduction | 1.44 | 2.27 | 3.027 | 22 | .006 | .63 | Medium to Large |
| Induction | 1.35 | 2.15 | 3.014 | 22 | .006 | .63 | Medium to Large |
| **Total score** | 2.43 | 3.17 | 3.679 | 22 | .001 | .77 | Medium to Large |

*Students' comments on PBL*

The PBL group students were also asked for written comments on the advantages and disadvantages of PBL. In order to analyze the open-ended question, responses were divided into three categories: (1) Benefits focusing on the process of PBL learning, (2) Benefits focusing on social and emotional aspects, and (3) Negative aspects of PBL learning. Most of the students (91.30%) considered that PBL facilitated sharing opinions with others, analyzing situations in different ways and thinking of more possibilities for solving problems. Nineteen students (82.61%) indicated that PBL promoted thinking in different ways. However, nine students complained that they knew less from the textbook. Five students considered PBL was time-consuming, felt hard to catch the key points and much stressed, experienced a great workload associated with the PBL process and had insufficient time to complete task while a couple of students indicated that they wasted a lot of time explaining the material to other group members (Table 4).



**Table 4:** Categorical description of students' open-ended responses to PBL (N=23).

| **Categorical description of students' responses** | **Comments** | **Number of responses (n)** | **%** |
|---|---|---|---|
| 1. Benefits focusing on the process of PBL learning | | | |
| • Being motivated to learning | Being motivated to work on the assignments | 13 | 56.52 |
| | Maximizing learning opportunities for searching for information | 12 | 52.17 |
| | Being motivated to do my own learning | 7 | 30.43 |
| • Enhancing problem solving | Thinking of more possibilities for solving problems | 21 | 91.30 |
| | Trying to find the best way to solve problems | 18 | 78.26 |
| | Looking at concepts or ideas from many different angles | 15 | 65.22 |
| | Using a structured and organized way of analyzing and assessing a problem thoroughly | 4 | 17.39 |

| Categorical description of students' responses | Comments | Number of responses (n) | % |
|---|---|---|---|
| • Improving critical thinking | Analyzing situations in different ways | 21 | 91.30 |
| | Thinking in different ways | 19 | 82.61 |
| | Stimulated thinking critically | 17 | 73.91 |
| | Extending thinking area | 10 | 43.48 |
| | Getting new perspectives | 9 | 39.13 |
| | Thinking systematically | 3 | 13.04 |
| • Developing effective communication | Sharing the opinions with others | 21 | 91.30 |
| | Fostering oral and written communication skills | 11 | 47.83 |
| | Being encouraged to express own opinion in the group | 10 | 43.48 |
| | Communicating with others effectively | 6 | 26.09 |
| • Developing effective group collaboration | Being more involved with my classmates | 17 | 73.91 |
| | Collaborating with others effectively | 12 | 52.17 |
| | Working as a team effectively | 12 | 52.17 |
| | Having effective interaction with peers | 11 | 47.83 |
| | Contributing to teaching each other | 11 | 47.83 |
| | Getting the helpful feedback | 10 | 43.48 |
| | Fostering the ability of dealing with confronts | 5 | 21.74 |
| • Enhancing self-directed learning | Being much more responsible for own learning | 10 | 43.48 |
| | Focusing on my learning needs | 6 | 26.09 |
| 2. Benefits focusing on social and emotional aspects | Being in more relaxed atmosphere for problem solving | 18 | 78.26 |
| | Feeling warm during working as a team | 15 | 65.22 |
| | Having greater responsibility for myself and the group | 10 | 43.48 |
| | Knowing each other well | 9 | 39.13 |
| | Enjoying debating issues and new ideas | 8 | 34.87 |
| | Having respect for others' opinions | 8 | 34.87 |

| Categorical description of students' responses | Comments | Number of responses (n) | % |
|---|---|---|---|
| 3. Negative aspects of PBL learning | Knowing less from text book | 9 | 39.13 |
| | Time-consuming | 5 | 21.74 |
| | Hard to catch the key points and not understanding deeply | 5 | 21.74 |
| | Feeling too stressed | 5 | 21.74 |
| | Experiencing a greater work-load | 5 | 21.74 |
| | Having insufficient time to complete tasks | 5 | 21.74 |
| | Wasting time explaining the material to others | 2 | 8.70 |



## DISCUSSION

### *Students' critical thinking skills*

In this study, students' overall scores of CCTST on pre-test ranged from 14 to 26 with a mean score of 19.39 (SD=2.90), and on post-test ranged from 17 to 28 with a mean score of 21.83 (SD=2.74). Compared with the previous study, the overall mean scores on both pre-test and post-test were higher. Facione (1997) reported that the total mean score of CCTST among 775 junior nursing students was 16.28 (SD=3.63). The difference was attributed to characteristics of the subjects in this study. The subjects of this study consisted of 23 second-year undergraduate nursing students who studied at the School of Nursing, Fudan University. The enrolled nursing students had high scores on the enrollment examinations which focused on testing the logical analysis, inference, reasoning and reflection. Critical thinking can be considered as the process of purposeful thinking and reflective and logical reasoning, and the CCTST is specifically designed to measure core critical thinking skills including analysis, evaluation, inference, deductive reasoning and inductive reasoning (Facione and Facione, 1993). In this case, the subjects of this study had high overall mean scores of CCTST.

Additionally, on the subscales, students scored lowest on the induction subscale (Mean=6.65, 47.50% of the possible score) and highest on the deduction subscale (Mean=12.13, 75.81 % of the possible score). It could be that the standards for establishing induction might be more demanding than those for deduction. Deduction is the process of reasoning from the general to the specific. In deduction, people only need to consider the logical form of the argument and may assume that premises are true.

The conclusion necessarily follows from the stated premises. However, induction is the process of deriving general principles from particular facts or instances. The premises probably, but do not necessarily, imply the conclusion. Compared with the deduction, induction is more coherent, comprehensive process since people must possess more expert knowledge and add more information to consider the probability of conclusions and assess the strength of inductive arguments (Yezzi, 1992).

From pre-test to post-test, students' overall scores and scores on the analysis, evaluation, deduction and induction subscales significantly increased. The findings support the notion that using PBL can promote students' critical thinking skills since all scenarios used in this course were derived from the real nursing practice situations. Minor modifications were made to ensure students were able to achieve the objectives of the course. The scenarios addressed common and contemporary issues of professional practice and exposed students to the ambiguity that may exist in real life situations. The scenarios were complex enough that cooperation of all members of the group was necessary to work towards solution/resolution. Scenarios were arranged in order of situation complexity with the degree of difficulty gradually increasing. Students were provided the minimum guidance so that they practiced problem solving on their own. The trigger questions were developed for stimulating broad thinking based on course objectives. Students identified the issues in the scenarios, analyzed the issues critically, assessed the need for further information, utilized the appropriate learning resources, and determined the intended and actual inferential relationships among the concepts. Following self-directed study students shared newly acquired information, generated a number of possible hypotheses to explain the situation, debated the issues related to the situation, derived the general principles from particular instances, considered the alternative solutions, and assessed the probability and strength of conclusions. They understood that a situation could be tackled in different ways and some situations were too difficult to be dealt with completely. In this way, students enhanced their analytical, critical thinking and problem-solving skills.

PBL is an instructional approach that challenges students to seek solutions to real-world situations/problems in groups. PBL provides students with opportunities to direct their own learning while developing critical thinking and evaluation skills through analysis of real-life situations/ problems (Smith, 1995). The small group PBL tutorials encouraged students to develop thinking skills. Students demonstrated this critical thinking in their group discussions. They analyzed and synthesized data, developed

hypotheses and applied deductive reasoning to a problem situation, drew conclusions, synthesized strategies and solutions and finally evaluated their own thinking processes (Ryan and Quinn, 1995).

Furthermore, the findings of this study are consistent with those of previous studies. Day and Williams (2002) conducted a quasi-experimental study among 27 first-year nursing students (91% female, 9% male). The CCTST was used to measure students' critical thinking at the beginning and the end of the first year in a PBL undergraduate nursing program. The students' mean overall scores of critical thinking increased significantly in overall mean scores of 1.89 (P =.014) on CCTST, with a mean of 1.59 (P =.002) on the evaluation subscale and a mean of 1.37 (P =.024) on the induction subscale. Scores on the analysis inference, and deduction subscales did not significantly increase. The authors concluded that statistically- significant increases in the mean overall scores and the evaluation and induction subscale scores did occur over one year in a PBL curriculum. In addition, the results of a randomized controlled trial in Hong Kong (Tiwari et al., 2006) were evident that over one-semester PBL course learning, students' critical thinking dispositions increased in overall CCTDI mean scores from 270.4 (SD=22.27) to 276.32 (SD= 25.8) among 38 first-year undergraduate nursing students. PBL students indicated that their contribution to group discussion facilitated them to think more critically during PBL tutorials.



***Students' comments on PBL***

In this study, most of the participants suggested that PBL facilitated sharing their opinions with others, analyzing situations in different ways and thinking of more possibilities for solving problems. However, a few participants felt very stressed and overloaded during the PBL process. The findings might possibly be attributed to characteristics of PBL which include self-directed learning and constant small-group work with tutors acting as facilitators. Cooperation from all members of the student group is necessary in order to effectively work through a good problem. The group's task is to evaluate and define the different aspects of the situation/problem. In this collaborative learning environment, students learn from interacting with each other. They need to explain the material to other students and also ask and answer questions during discussion. They work together to construct collaborative explanations (Rideout and Carpio, 2001).

Previous studies also report similar findings. White et al. (1999) asked 24 registered-nurse students who had participated in a 1-year PBL course to identify outcomes of PBL through a questionnaire. The out-

comes listed included critical thinking, learning how to learn, creativity in thinking, community focus, teamwork, research skills and personal growth. The outcome selected most often was critical thinking. In the focus group interviews, students identified that PBL encouraged them to take large amounts of information and synthesize the information for presentation back to their group. PBL also required them to critically analyze the relevant research and apply the findings to the PBL case. Celia and Gordon (2001) assessed 26 novice nurses from a PBL program. The results showed that graduates rated the best features of PBL as group participation, self-directed learning, interacting with various individuals and recognizing how to apply critical thinking skills. PBL increased collaborative group dynamics, problem-solving techniques and critical thinking skills. Morales-Mann and Kaitell (2001) reported that clear benefits for the students from the use of the PBL format included increased autonomous learning, critical thinking, problem-solving and communication skills. Cook and Moyle (2002) examined students' evaluation of the use of PBL over a 4–week period among 130 second-year students who experienced the period of PBL. Students indicated that the PBL approach promoted critical thinking and problem solving and active participation in the learning process. Although several negative aspects of PBL were identified in the literature, including a fear of knowledge gaps, possible reinforcement of the wrong information and too much time and work required (Caplow et al., 1997), there has been no substantiation through research.



## CONCLUSION

Clearly, in this study, students' critical thinking skills significantly increased over a one-semester PBL course. PBL facilitated students sharing their opinions with others, analyzing situations in different ways and thinking of more possibilities for solving problems. The findings provide empirical evidence to verify promoting critical thinking skills through PBL among Chinese baccalaureate nursing students. Further studies need to compare the effects on critical thinking development between PBL and other teaching methods.

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