The effectiveness of concept mapping on development of critical thinking in nursing education: A systematic review and meta-analysis

Meng Yue a, Meng Zhang b, Chunmei Zhang a, Changde Jin c,⁎

a Nursing College, Tianjin University of Traditional Chinese Medicine, No. 319 Anshanshi Road, Nankai District, Tianjin 300193, China
b Nursing Faculty of Tianjin Medical College, No. 14 Liulin Road, Hexi District, Tianjin 300222, China

Objectives: As an essential skill in daily clinical nursing practice, critical thinking ability has been an important objective in nursing education. Concept mapping enables nursing students connect new information to existing knowledge and integrates interdisciplinary knowledge. However, there is a lack of evidence related to critical thinking ability and concept mapping in nursing education. The purpose of this systematic review and meta-analysis was to assess the effect of concept mapping in developing critical thinking in nursing education.

Design: This systematic review was reported in line with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).

Data sources: A search was conducted in PubMed, Web of science, Embase, Cochrane Central Register of Controlled Trials (CENTRAL), Cumulative Index to Nursing and Allied Health (CINAHL) and China National Knowledge Infrastructure (CNKI). Randomized controlled trials (RCT) comparing concept mapping and traditional teaching method were retrieved.

Review methods: Data were collected by two reviewers according to the data extraction tables. The methodological quality of included studies was assessed by other two reviewers. The results of meta-analysis were presented using mean difference (MD).

Result: Thirteen trials were summarized in the systematic review and eleven trials were included in the meta-analysis. The pooled effect size showed that, comparing with traditional methods, concept mapping could improve subjects’ critical thinking ability measured by California Critical Thinking Disposition Inventory (CCTDI), California Critical Thinking Skill Test (CCTST) and Critical Thinking Scale (CTS). The subgroup analyses showed that concept mapping improved the score of all subscales.

Conclusion: The result of this review indicated that concept mapping could affect the critical thinking affective dispositions and critical thinking cognitive skills. Further high quality research using uniform evaluation is required.

Keywords: Critical thinking, Concept mapping, Nursing, Education, Meta-analysis

1. Introduction

With rapid development of clinical practice environment and expanded opportunity of making decisions, nurses were required to think independently and make rational judgments which are in accordance with patients' problems or needs. Critical thinking is connected with possible consideration, argument examination and articulated proposition (Condor, 2014). It included critical thinking affective disposition and critical thinking cognitive skills (Facione, 1990). Critical thinking enables nurses to serve as a knowledgeable executor who selects, combines, judges and applies information in order to solve patients' problems effectively (Price, 2015). Critical thinking is an essential skill in daily clinical nursing practice (Papathanasiou et al., 2014). Developing critical thinking has been an important cultivation objective in nursing education (American Association of Colleges of Nursing, 1999). It could enhance nurse students’ clinical practice skills by improving the ability of problem analysis and decision making.

Until now, three systematic reviews demonstrated that the evidence of problem-based learning (PBL) on nursing students' critical-thinking ability remains inconsistent (Yuan et al., 2008; Kong et al., 2014; Oja, 2011). Besides PBL, studies (Wilgis and McConnell, 2008; Taylor and Littleton-Kearney, 2011; Vacek, 2009) supported that concept mapping was another effective strategy to promote critical-thinking development.

Many findings suggested that concept mapping could be employed as an effective tool in improving critical thinking (Wahl and Thompson, 2013; Sinatra-Wilhelm, 2012; Barrett, 2014). In Wahl's...
study (Wahl and Thompson, 2013), concept mapping was used instead of traditional method in novice nurses. The result indicated that novice nurses’ critical thinking has been improved by using concept maps. Sinatra (Sinatra-Wilhelm, 2012) compared concept mapping with nursing care plans in improving critical thinking. The result suggested that concept mapping could be effective in developing critical thinking skills. Barrett’s study (Barrett, 2014) also supported that concept mapping increases students’ critical thinking skill. However, apparent inconsistency still remains. A randomized controlled trial (RCT) conducted by Wheeler (Wheeler and Collins, 2003) showed insignificant difference between experimental and control groups. Brune (Brune, 2014) explored the impact of concept mapping on critical thinking ability. The result showed no significant increase in the intervention group for critical thinking skills. Another study (Chen et al., 2011) also showed no statistically significant difference between traditional lecture group and concept mapping group, but after controlling age and pretest score, the adjusted mean scores of concept mapping group were higher than traditional lecture group.

For nursing education, the effect of concept mapping on critical thinking must be certain. The objective of this study was to systematically review and statistically aggregate studies evaluating the effect of concept mapping method on critical thinking and to establish greater clarity of the evidence base for the application of concept mapping in nursing education. By using the critical thinking measuring tools to assess the effectiveness of critical thinking, this review and meta-analysis answered the following questions: What is the quality of studies in which concept mapping was used to improve critical thinking in nursing education, and what is the effect of concept mapping on development of critical thinking in nursing education?

2. Background

American Philosophical Association put forward that critical thinking was a complex process with purposeful judgment. In the profession of nursing, critical thinking had been defined by several researchers (Alfaro, 1999; Kataoka-Yahiro and Saylor, 1994; Oermann, 1997). However, the definition presented by Yahiro (Kataoka-Yahiro and Saylor, 1994) that “the critical thinking process is reflective and reasonable thinking about nursing problems without a single solution and is focused on deciding what to believe and do” was widely accepted. Critical thinking in nursing has been equated with the nursing process which constitutes a problem solving model including nursing assessment, diagnosis, planning, implementation and evaluation.

To our best knowledge, many tools were designed to measure critical thinking in nursing, such as California Critical Thinking Disposition Inventory (CCTDI) (Facione and Facione, 1992), Critical Thinking Scale (CTS) (Cheng et al., 1996), and California Critical Thinking Skill Test (CCTST) (Facione and Facione, 1998). The CCTDI, a scale that was designed to assess the affective dispositions domain of critical thinking, studies have reported good reliability about it (Facione and Facione, 1994; Atay and Karabacak, 2012; Yu et al., 2013). The scale contains seven domains including open-mindedness, analyticity, inquisitiveness, systematicity, truth-seeking, self-confidence and maturity. CCTST assesses critical thinking by measuring participants’ ability of analysis, inference, evaluation, deduction and inductive reasoning (Facione and Facione, 1998). It emphasizes subjects’ cognitive skills. This tool contains 34 items in multiple-choice format, and the internal consistency reliability ranged from 0.69 to 0.74 (Facione et al., 2009). CTS, developed by Cheng (Cheng et al., 1996), is a 60-item scale with 5 subscales.

Fig. 1. Flow chart for selection of included studies.
inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments. It also measures critical thinking cognitive skills. The scale demonstrated adequate internal consistency as well as split half reliability (Cheng et al., 1996).

Concept mapping organizes information, themes or their relationships in a visual fashion. It takes into account the integrity and logicality of the thinking process. Concept mapping was based on meaningful learning and assimilation theory (Novak, 1998) and was introduced to nursing field since last century. It could promote nurses’ analytical ability in complex nursing process, and facilitate critical thinking by clear representation (Clayton, 2006; Chabeli, 2010). Through the mapping process, nursing students interpret, analyze and evaluate their logical flow of thought about the themes, so that they can perceive deficiencies that occurred when they execute these processes in the usual way (Harpaz et al., 2004). As an effective learning strategy on increasing the relation of theory and clinical practice, concept maps make nursing students connect new information to existing knowledge and integrate interdisciplinary knowledge meaningfully, so that it facilitates the development of self-appraisal of individual thinking; in clinical nursing practice, concept maps also make nurses collect patients’ clinical data,

Table 1

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Design</th>
<th>Subject</th>
<th>Sample size</th>
<th>Class</th>
<th>Intervention (duration)</th>
<th>Control</th>
<th>Measurement of outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atay and Katarbak (2012)</td>
<td>Turkey</td>
<td>RCT</td>
<td>Freshman and sophomore intern nursing students</td>
<td>E:40 C:40</td>
<td>Medical-surgical nursing</td>
<td>3 sessions: 1. Introduce CM; 2. Create CM; 3. Feedback 2. Create CM; 3. Discussion (15 w)</td>
<td>Traditional lectures</td>
<td>CCTDI, CMCPE</td>
</tr>
<tr>
<td>Chen et al. (2011)</td>
<td>Taiwan</td>
<td>RCT</td>
<td>Students participated in BSN</td>
<td>E: 47 C: 48</td>
<td>Medical-surgical nursing</td>
<td>3 sessions: 1. Introduce CM; 2. Create CM; 3. Discussion (15 w)</td>
<td>Traditional lectures</td>
<td>CTS</td>
</tr>
<tr>
<td>Huang et al. (2012)</td>
<td>Taiwan</td>
<td>RCT</td>
<td>Nurses working in a hospital</td>
<td>E: 67 C: 67</td>
<td>Eight case studies</td>
<td>2 sessions: 1. Introduce CM; 2. Create CM (16 w)</td>
<td>CS</td>
<td>CCTST, CCTDI</td>
</tr>
<tr>
<td>Lee et al. (2013)</td>
<td>Taiwan</td>
<td>RCT</td>
<td>Nursing students participated in RNB program</td>
<td>E:47 C:48</td>
<td>Medical-surgical nursing</td>
<td>3 sessions: 1. Introduce CM; 2. Create CM; 3. Discussion (15 w)</td>
<td>Traditional lectures</td>
<td>CTS</td>
</tr>
<tr>
<td>Kaddoura et al. (2016)</td>
<td>USA</td>
<td>RCT</td>
<td>Baccalaureate nursing students</td>
<td>E:41 C:42</td>
<td>Four courses and related clinical rotation</td>
<td>3 sessions: 1. Data collection 2. Discussion 3. Feedback</td>
<td>Traditional nursing care plan</td>
<td>HESICT</td>
</tr>
<tr>
<td>Moattari et al. (2014)</td>
<td>Iran</td>
<td>RCT</td>
<td>Nursing students</td>
<td>E:16 C:16</td>
<td>Medical-surgical pediatric clinical rotation</td>
<td>3 sessions: 1. Data collection 2. Discussion 3. Feedback</td>
<td>Traditional lectures</td>
<td>Specially designed</td>
</tr>
<tr>
<td>Li (2016)</td>
<td>China</td>
<td>RCT</td>
<td>Nursing students</td>
<td>E:49 C:50</td>
<td>Medical nursing</td>
<td>3 sessions: 1. Data collection 2. Discussion 3. CM statement</td>
<td>Traditional lecture</td>
<td>CCTDI</td>
</tr>
<tr>
<td>Li and Ruihua (2010)</td>
<td>China</td>
<td>RCT</td>
<td>Nursing students</td>
<td>E:30 C:30</td>
<td>5 cases</td>
<td>4 sessions: 1. Data collection 2. Discussion 3. CM statement</td>
<td>Traditional nursing care plan</td>
<td>CCTDI</td>
</tr>
</tbody>
</table>

CM = concept map; CCTDI = California Critical Thinking Disposition Inventory; HESIC = Health Education Systems Incorporated Critical Thinking; BSN program = RN-to-Bachelor of Science in Nursing program; CTS = Critical Thinking Scale; RNB program = registered nurse baccalaureate (RNB) program; CS = case studies; w = week; HCTSR = Holistic Critical Thinking Scoring Rubric; CCTST = California Critical Thinking Skill Test; CMCPE = Critical of Concept Map Care Plan Evaluation.
recognize nursing problems, analyze the relationships between the problems and make rational decisions, as a consequence, it improves nursing process.

The aim in what follows is to provide a systematic review and meta-analysis of the evidence on the effect of concept mapping as a learning strategy in the development of critical thinking in nursing education.

3. Methods

3.1. Search Strategy

A systematic search of the literature was conducted in electronic databases. The databases included PubMed, Web of science, Embase, Cochrane Central Register of Controlled Trials (CENTRAL), Cumulative Index to Nursing and Allied Health (CINAHL) and China National Knowledge Infrastructure (CNKI). The search was restricted from 1998 to August 2016 since concept mapping originated in 1998. Trials were restricted to English-language and Chinese-language. After researching relevant systematic reviews in Cochrane Library and Joanna Briggs Institute Library (JBI), and summarizing the titles, abstracts and keywords of involved studies, the search terms were identified. The search terms and mesh headings included the following: pupil nurse*, nursing student*, nurse*, nursing personnel*, registered nurse*, nursing education*, critical thinking, think critically, critical reasoning, educational model*, and concept map*. In addition to an electronic database search, a manual search of previous reviews on concept mapping for critical thinking in nursing education as well as references of identified trials was undertaken.

3.2. Study Inclusion

Studies were eligible for inclusion in this systematic review if they conformed to the predetermined inclusion and exclusion criteria. The following inclusion criteria for trials were devised: (1) RCT or non-RCT including comparative study; (2) subjects were nursing students or clinical nurses who join in continuing education; (3) used concept mapping as intervention; (4) assess critical thinking as an outcome; and (5) reported the sample size of the subjects, the mean difference and 95% CI of critical thinking scores. The exclusion criteria were: (1) articles without complete data and (2) duplicate articles.

3.3. Data Extraction

Data were collected within data extraction tables, which allow data synthesis and analysis with the first authors, publication years, countries, study designs, subjects, sample size, teaching method in intervention and control groups, intervention duration; outcome and outcome measures. When data were not reported in the text but were illustrated with figures, the figures were expanded and data were extracted according to the measurement.

3.4. Study Quality Appraisal

The methodological quality of included studies was assessed by using the most commonly used scoring system (Cochrane Handbook for Systematic Reviews of Intervention) (Higgins and Green, 2011), which comprises 7 items addressing whether the study generates a random sequence, whether conceal the allocation, whether participants and personnel are blind, whether outcome assessment is blind, whether outcome data is incomplete, and whether selective reporting and other bias exist. The assessment was performed by one researcher and was independently verified by another assessor. Disagreement was resolved by discussion with a third researcher.

3.5. Statistical Analysis

After the extraction of data from included trials, scores of critical thinking measurement using the same scale were combined and a meta-analysis was performed by using Review Manager 5.3. The meta-analysis was carried out to explore differences between intervention groups and control groups. The effect size was reported as the difference in mean ± SE. Statistical heterogeneity was measured by using chi-squared test and I² value. The fixed effect model was used to pool data if there was no heterogeneity. Otherwise the random effect model was used. The difference was considered statistically significant if the I² value was <0.05. A sensitivity analysis was conducted to test whether the exclusion of studies changed the results. Subgroup analyses were conducted when necessary.

4. Result

4.1. The Search Results

The flow chart of the study selection process was showed in Fig. 1. Through the electronic database search, 591 citations were identified. 2 studies were identified through references screening according to related studies. 158 studies were excluded after screening the titles and abstracts. The full text of 22 studies was evaluated and 9 studies were excluded for different reasons: 5 studies were self-controlled studies, 2 studies were reported with Spanish language, and 2 studies did not evaluate critical thinking by measuring tools. 13 studies were eligible for qualitative analysis and 11 studies were included in meta-analysis.

4.2. Description of Included Studies

A summary of the included studies is showed in Table 1. The total sample size was 1204 (605 in the intervention group and 599 in the
control group). Two included studies were performed in Turkey (Atay and Karabacak, 2012) and Iran (Moattari et al., 2014) respectively, three (Chen et al., 2011; Huang et al., 2012; Lee et al., 2013) in Taiwan and three (Sinatra-Wilhelm, 2012; Wheeler and Collins, 2003; Kaddoura et al., 2016) in USA, five (Jiang et al., 2013; Zhu et al., 2011; Zou et al., 2013; Li, 2016; Li and Ruihua, 2010) in Chinese Mainland. The subjects of two studies (Huang et al., 2012; Jiang et al., 2013) were nurses who have already worked and join in continuing education. The remaining studies were nursing students. Five of the included studies were performed in medical-surgical nursing course, and two studies conducted in the case study lecture. The sessions of intervention ranged from 2 to 4.

Seven scales were used in these RCTs as following: CCTDI (Atay and Karabacak, 2012; Huang et al., 2012; Jiang et al., 2013; Zhu et al., 2011; Zou et al., 2013; Li, 2016; Li and Ruihua, 2010), Critical of Concept Map Care Plan Evaluation (CMCPE) (Atay and Karabacak, 2012), CTS (Chen et al., 2011; Lee et al., 2013), Approaches to Learning and Studying Inventory (ALSI) (Chen et al., 2011; Lee et al., 2013), CCTST (Huang et al., 2012; Sinatra-Wilhelm, 2012; Wheeler and Collins, 2003), Health Education Systems Incorporated Critical Thinking (HESI CT) (Kaddoura et al., 2016) and specially designed scales (Moattari et al., 2014). ALSI was used to evaluate how the students studied within the course unit so that this instrument is not eligible for critical thinking measurements, and the studies measuring with ALSI were not included in this meta-analysis. Therefore, for meta-analysis, studies using CCTDI, CCTST and CTS were synthesized.

4.3. The Quality of Included Studies

Each included studies using the criteria mentioned above were assessed as high risk, low risk and unclear risk. All included studies were grade B. Among fourteen included studies, six reported the randomization methods in detail (42.9%). Similarly, six of the studies described the blind of outcome assessors (42.9%). All studies reported the drop outs and reasons, which could prevent attrition bias. In addition, all studies described the results to avoid reporting bias. All studies reported that there were no statistically differences between the intervention and control group at baseline. The baseline data included age, educational level and years of work experience. The indifference between two groups for each included study revealed that every study conducted random allocation adequately and the evidence of each study was reliable. However, none of the included RCTs described allocation concealment, which may produce selection bias. Moreover, none of the studies performed blinding of the participants and personnel. Figs. 2 and 3 present the results of risk of bias assessment.

4.4. The Result of Meta-analysis

4.4.1. Critical Thinking Score Measured by CCTDI

A total of seven studies (877 subjects) measured critical thinking using CCTDI scale. Among the included studies, Turkish version of CCTDI was used by only one study (Atay and Karabacak, 2012), the remaining studies all used Chinese version. The result of meta-analysis
showed a significant heterogeneity ($I^2 = 69\%$) and indicated that concept mapping had a significant effect on critical thinking affective dispositions (MD = 16.50, 95\% CI [11.60, 21.40], $P < 0.001$) (Fig. 4). Considering that CCTDI scale contains seven domains, therefore subgroup analyses were conducted. The result showed a significant effect on the domains of open-mindedness (MD = 2.46, 95\% CI [1.28, 3.64], $P < 0.001$), truth-seeking (MD = 4.22, 95\% CI [2.25, 6.20], $P < 0.001$), analyticity (MD = 3.48, 95\% CI [2.66, 4.31], $P < 0.001$), systematically (MD = 3.12, 95\% CI [2.53, 3.55], $P < 0.001$), self-confidence (MD = 2.33, 95\% CI [1.98, 2.68], $P < 0.001$) and maturity (MD = 2.40, 95\% CI [2.12, 3.60], $P < 0.001$) (Fig. 5). The sensitivity analyses showed that if any

### Table 1: Subgroup Analyses on the Impact of Concept Mapping on Critical Thinking Affective Dispositions

<table>
<thead>
<tr>
<th>Study</th>
<th>Concept Mapping</th>
<th>Traditional Education</th>
<th>Total Mean Difference (MD)</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yue et al. 2012</td>
<td>48.7</td>
<td>5.2</td>
<td>40</td>
<td>44.2</td>
<td>5.8</td>
</tr>
<tr>
<td>Huang et al. 2013</td>
<td>39.7</td>
<td>3.0</td>
<td>67</td>
<td>37.62</td>
<td>3.61</td>
</tr>
<tr>
<td>Jiang et al. 2013</td>
<td>44.3</td>
<td>2.0</td>
<td>50</td>
<td>41.79</td>
<td>3.80</td>
</tr>
<tr>
<td>Li et al. 2013</td>
<td>43.1</td>
<td>3.5</td>
<td>30</td>
<td>42.07</td>
<td>3.83</td>
</tr>
<tr>
<td>Liu et al. 2013</td>
<td>40.0</td>
<td>8.9</td>
<td>48</td>
<td>38.81</td>
<td>4.56</td>
</tr>
<tr>
<td>Zhou et al. 2013</td>
<td>36.3</td>
<td>3.3</td>
<td>60</td>
<td>34.25</td>
<td>3.93</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>388</td>
<td>39.5</td>
<td>150</td>
<td>35.2</td>
<td>3.22</td>
</tr>
</tbody>
</table>

### Figure 5: Forest plot of subscale scores measured by CCTDI

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one included study was excluded, the result was unchanged. Hence, the total scale and all seven domains could be affected.

4.4.2. Critical Thinking Score Measured by CCTST

Three studies, accounting for 254 subjects, provided data for pooling to show the effect of concept mapping on critical thinking. Heterogeneity analysis indicated that there was significant heterogeneity between the included studies ($I^2 = 67\%$) (Fig. 6). Therefore, meta-analysis was based on random-effects model. The result indicated that overall score was significantly higher in the intervention group than in the control group ($MD = 1.78, 95\% CI[0.17, 3.39], P = 0.03$) (Fig. 7).

4.4.3. Critical Thinking Score Measured by CTS

Meta-analysis was conducted for critical thinking measured by CTS scale and two studies were included. In Lee's study (Lee et al., 2013), critical thinking was measured at two different time points, hence the meta-analysis combined the two results of one included study. The meta-analysis was conducted by fixed-effects model, for no heterogeneity presented in the eligible studies ($I^2 = 0\%$) (Fig. 7). Analysis results demonstrated that subjects in the intervention group scored higher than those in control group ($MD = 1.41, 95\% CI[0.11, 2.72], P = 0.03$) (Fig. 7).

5. Discussion

5.1. Overview of Findings

This systematic review and meta-analysis provided evidence supporting the effectiveness of concept mapping in nursing education. To our knowledge, this is the first meta-analysis of the effect of concept mapping on critical thinking to nursing students and clinical nurse who participate in continuing education.

The methodological problem concerns the lack of description of random allocation and concealment allocation. Considering the implementation of educational interventions, it was impossible to perform double-blinding of learners and educators, because learners or educators that allocated in different groups might discuss their lecture after class. However, collecting data by researchers who did not involve in teaching is feasible. In this review, limited number of RCTs stated briefly that data were collected by other researchers.

Among different scales that used to evaluate critical thinking in this systematic analysis, CCTDI, CCTST and CTS were mostly used. The subgroup analyses suggested that concept map users had significantly higher critical thinking affective dispositions of open-mindedness, truth-seeking, analyticity, systematicity, self-confidence, inquisitiveness and maturity compared with traditional methods. Concept mapping benefited the open-mindedness, because it helped users to connect the information, accept different ideas and recognize the problem of themselves. Concept mapping affected truth-seeking through the procedure of identifying information resource, acquiring knowledge and truth. A higher score in analyticity indicated that individual is liable to use reason and evidence to solve the problems. The reason may be that concept mapping requires individuals to rearrange the existing concepts inductively and deductively, by organizing and correlating of the data and information, analyticity ability could be enhanced (Kostovich et al., 2007). Concept mapping benefited systematicity by integrating thinking process. It also improved self-confidence by helping users to assure their reasoning ability. Inquisitiveness was benefited by obtaining information, observation and deep consideration. Maturity reflects learner's disposition to be prudent in decision making. Concept mapping facilitates that learners make decisions independently and they tend to be mature (Gerdeman et al., 2013). The pooled effect size for critical thinking assessed by both CCTST and CTS showed that concept mapping was superior to control group in the training of critical thinking cognitive skills. According to the sensitivity analyses, the result is reasonably stable.

By using nodes and links, concept maps present information and their relationships clearly. It can be easily implemented by educators and learners. Besides, concept mapping can be used as an assessment tool and allow the educators to focus on the learning outcomes in an active manner. On the contrary, in traditional lectures, students couldn't
involves in the curriculum and explore on their own initiative, their critical
thinking ability and autonomous learning competencies could not
be benefited.

5.2. Strengths and Limitations

The strengths of this review are as follows: the systematic review
and meta-analysis only included RCTs which provide more reliable evi-
dence for pooled analysis; the research was conducted in several main
databases and related articles were screened as many as possible; the
quality of included studies was moderate and the overall sample size
was large enough, so the result could reflect the true effect of concept
mapping. However, several limitations shouldn’t be ignored. Firstly, dis-
sertations were not included in this review, hence related data in disser-
tations might be omitted; Secondly, for critical thinking is considered to
be a multidimensional concept, self-reported scales may not compre-
hensively assess critical thinking ability (Carter et al., 2015). Thirdly, the
included RCTs were performed in different countries and race, so se-
lection bias may influence the outcome.

5.3. Implications for Practice and Future Research

In clinical nursing, nursing process including assessment, diagnosis,
planning, implementation and evaluation can’t be achieved without
the guide of critical thinking skill. Cultivating critical thinking ability
was influenced by personality trend and individual values. The assess-
ment of critical thinking should not only emphasize on the affective dis-
positions and cognitive skills, personality and social environment
should also be taken into consideration. Improving critical thinking abil-
ity is a prolonged process, it permeates into the periods of classroom
teaching, internship and clinical work. Therefore, no matter in learning
or working stage, critical thinking ability should be valued. Moreover, to
evaluate the critical thinking ability, a comprehensive assessment sys-
tem should be created. Further research performing blinding of data col-
lectors and evaluating more other influence is needed.

6. Conclusions

This systematic review and meta-analysis supports using concept
tools to improve critical thinking ability in nursing education. By using
CCTDI, CCTST and CTS as measuring tools for assessing critical
thinking, the result of meta-analysis suggested that concept maps could
affect the critical thinking affective dispositions, including open-
ness, truth-seeking, analyticity, systematicity, self-confidence, in-
quisitiveness, maturity, and critical thinking cognitive skills. In view of
differences of critical thinking measuring tools, there is a need to use
uniform measurement and conduct high-quality studies in the future,
so as to provide more evidence to support the application of concept
mapping in nursing education.

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