

A preliminary investigation into critical thinking of in-service and pre-service middle school chemistry teachers in Shaanxi province of China

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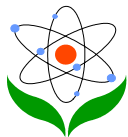
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Abstract

This research investigated the development of critical thinking of middle school chemistry teachers in Shaanxi province of China. In-service and pre-service



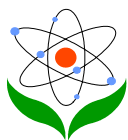
teachers' critical thinking are examined in order to provide evidence for establishing teachers' standard. The sample in this study consisted of 69 in-service and 61 pre-service chemistry teachers. The California Critical Thinking Disposition Inventory (CCTDI) and California Critical Thinking Skills Test (CCTST) are used to assess the teachers' critical thinking. The results indicate that the teachers' dispositions toward critical thinking are at an average level while their scores of critical thinking skills are very low. This research also shows there are statistically significant differences between in-service and pre-service teachers in their critical thinking skills, but no significant difference in their critical thinking dispositions. Additionally, both CCTST and CCTDI mean scores reflect that the pre-service chemistry teachers performed better than the in-service teachers toward critical thinking.

Keywords: Critical thinking, in-service teacher, Pre-service teacher, CCTST, CCTDI

Introduction

The notion of critical thinking has received a great deal of attention in recent years (Ennis, 1987; Tony, Christine, Rebecca, John & Jennifer, 2001). There has been much debate on the question 'what is critical thinking?' There is no universally agreed upon definition of critical thinking (Brookfield, 1987; Cassel & Congleton, 1993; Daly 2001; Thurmond, 2001; Yeh, 2002; 8-Tiwari, Avery & Lai, 2003). The definition of critical thinking varies because of its abstract characteristics. Watson and Glaser (1980) defined critical thinking as a combination of attitude, knowledge and skill. Attitude is an ability to recognize the existence of problems and an acceptance of the general need for evidence in support of what is asserted to be true. Knowledge is a combination of accurate inferences, abstractions and generalized knowledge that connotes the accuracy of various conclusions that are logically determined.

Facione (2007) mentioned that critical thinking skills CTS and CTD critical thinking disposition are two separate things in people. The California Critical Thinking Disposition Inventory (CCTDI) was set to test the students' critical thinking disposition. It includes seven subscales such as: The Truth-seeking scale (the T-scale), the Open-mindedness scale (the O-scale), the Analyticity scale (the

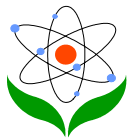


A-scale), the Systematicity scale (the S-scale), the CT Self-Confidence (the C-scale), the Inquisitiveness scale (the I-scale) and the Maturity scale (the M-scale). Skill is the ability to apply and use attitude and knowledge (Shin, Lee, Ha & Kim, 2006). A critical thinking skill is the ability to think critically. The California Critical Thinking Skills Test (CCTST) was developed by Facione & Facione(1994) to test the people' CTS. It contains five subscales including analysis, evaluation, inference, deductive reasoning and inductive reasoning.

It is widely held that developing critical thinking is one of the goals of science education (Sharon, 2002). Che (2002) examined the importance of critical thinking and an account of the project of teaching critical thinking was given. Paul et al. (2003) reported on the design and evaluation of a project aimed at fostering the critical thinking abilities and dispositions of students. The research combining critical thinking with subject teaching was very common, including nursing, writing, reading, philosophy, accounting, statistics, information and mathematics, also involving art, literature, economy, environment sanitation, electronic, investigating, media and library retrieving (Richard & Linda, 2004). Especially, there has so much research on the nursing education of critical thinking (Asako & Marcia, 2004; Tibari, Avery & Lai, 2003; Shin, Lee, Ha & Kim, 2006; Colucciello 1997). Researchers also pointed critical thinking is very important to chemistry education (Leonard, 1996; Maria, 2003; Theresa, 2004; Zhou & Shen, 2010; Zhou & Guo, 2010).

Many papers have reported how to cultivate people' critical thinking. Through reading course, science course and history course, the students' critical thinking ability can be improved (Ron & Randy, 1995). Richard (2005) pointed that students' critical thinking ability could be improved if the teacher adopted proper teaching method, model and selected appropriate content. Other researches indicated it is helpful to cultivate the critical thinking by emphasizing the teaching model of solving-problem and critical thinking (Stacy D. et al., 2003). Zhou and Guo (2010) pointed inquiry-based chemical experiment can promote the pre-service teachers' critical thinking skills. Also the critical thinking can be developed by ask-based learning in chemistry experiment teaching (Zhou & Shen, 2010).

Nowadays many researchers are increasingly concerned about the teachers' quality. Such as many papers report the imaginative and activity thinking of the teachers



(Ronald, 2008; Panagiotis, Eleni & Perti, 2009). Also others pay attention to the teachers' critical thinking (Grosser & Lombard, 2008; Lorenzo, 2009; Bruce Torff, 2006). Teachers' beliefs about critical thinking have been the focus of a growing body of literature in teacher education (Torff, 2005; Torff & Warburton, 2005; Zohar & Dori, 2003), researches indicate that beliefs about critical thinking influence how teachers interact with learners and organize classroom tasks (Fang, 1996; Putman & Borko, 2000). However, in China, few researches concern about the teachers' critical thinking. Thus, the main goal of this study was to investigate the development of critical thinking of middle school chemistry teachers in China, and so as to provide evidence for establishing teachers' standard. The aim of the present study is : to investigate the critical thinking skills (CTS) and critical thinking dispositions (CTD) of pre-service and in-service chemistry teachers from Shaanxi province of China; to compare the critical thinking of in-service and pre-service teachers in Shaanxi province of China.

Method

Research design

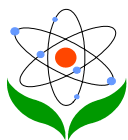
A cross-sectional, descriptive and comparative study was used.

Sample

The convenience sample consisted of two groups that involved in-service and pre-service chemistry teachers from Shaanxi province in China. The first group of participants comprised of 95 chemistry teachers, with a mean age of 30.4 years, who were being trained in Shaanxi Normal University for advanced learning in winter 2007. They work in middle school and are full of working experience. The second group of participants consisted of 61 full-time junior students from Shaanxi Normal University, with a mean age of 22.7 years. These students major in chemistry education and majority of them will be teachers after graduation.

Instrument

The California Critical Thinking Disposition Inventory (CCTDI), revised into Chinese by Luo and Yang in 2001, was used to measure students' critical thinking disposition. Through both test and test-retest, the CCTDI test designers found it



comparable with the English CCTDI in its validity and reliability, whose Cronbach coefficient is 0.86 and split-half coefficient 0.79. The correlation coefficient among seven subscales indicates CCTDI poses a good internal consistency and reliability. One subscale is independent with the others. The revised CCTDI was analyzed in terms of factor load, we found majority of factor loads reach to 0.4. This showed the revised CCTDI has good construct validity. Simultaneously, it showed a good congruent validity after making NEO-PI-R questionnaire and CCTDI investigation statistics.

The Chinese version California Critical Thinking Skills Test' (CCTST) Pearson $r = 0.63$, $p < 0.01$; $r/2 = (0.75-0.8)$, $p < 0.05$, which shows a good reliability and good construct validity. Luo and Yang also examined content validity, test-retest reliability, internal consistency reliability and construct validity. There are also 34 questions (1 point for 1 question) in the CCTST. According to answer's right or wrong, who obtains high points indicates he owns high critical thinking skills.

Procedure

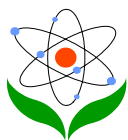
Anonymity was ensured, and informed consent was obtained from all participants. In November 2007, the researchers distributed the questionnaires (CCTDI and CCTST) to the In-service teachers in classroom after class. Teachers participating in the study were provided with a verbal explanation of study. Then the same questionnaires were distributed to the Pre-service teachers in the same month. In order to ensure a high return rate, this was done in the classroom too. Both groups present in the study were given 60 minutes to complete two questionnaires. The collected data were analyzed with SPSS software (ver.12.0)

Results

For the in-service teachers, 69 valid questionnaires were returned, representing a response rate of 72.6%. The response rate for the pre-service cohort was 100%, with 48 valid questionnaires returned.

In-service and pre-service teacher' critical thinking skills

Table 1 show that the CCTST mean scores of the pre-service teachers are higher than scores of the in-service teachers: the pre-service teachers' is 12.46 with an SD



of 2.34, vs. the in-service 11.01 with an SD of 2.80. Compared with the data of the CCTST manual offered by Luo and Yang's report on the revision of the Chinese-version CCTST (2002) ($M=15.98$, $SD=4.457$), the critical thinking skills of the teachers attending the test are at low level.

Figure 1 is the profiles of the three skills' scores of in-service and pre-service teachers on the CCTST. Obviously, the three subscales' mean score reflect that the pre-service teacher performed better than the in-service teacher: A-scale's score of in-service teacher is 4.59, vs. pre-service 5.00, E-scale's of in-service 3.65, vs. pre-service 4.31 and Inf-scale's of in-service 2.77, vs. pre-service 3.15. According to statistical t-test, there is significant difference between in-service teacher and pre-service teacher ($p = 0.002$), which shows that critical thinking skills of pre-service teachers are reliably higher than that of in-service teachers.

Table 1. Descriptive and inferential statistics of all the participation's CCTST score.

Subscale	In-service(N=69)		Pre-service(N=61)		t-test	
	Mean	SD	Mean	SD	t	p
Analysis	4.59	1.54	5.00	1.55	-2.465	0.015
Evaluation	3.65	1.47	4.31	1.59	-1.497	0.0137
Inference	3.15	1.11	3.15	1.11	-1.772	0.079
CCTST	-3.174	2.80	12.46	2.34	-3.174	0.002**

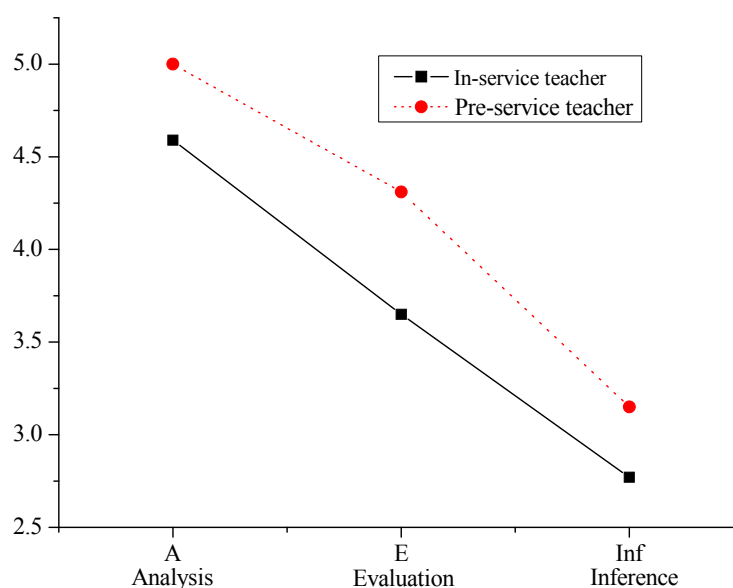
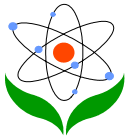


Figure1. The profiles of the three skills' scores of in-service and pre-service teachers on the CCTST



In-service and pre-service teachers' Critical thinking dispositions

The subscales and overall scores, means and standard deviations of the dispositions toward critical thinking of the research populations (in-service and pre-service teachers) are given in table 2, followed by their corresponding CTD profiles in figure 2.

The data indicate two groups have an overall positive disposition towards CT, with a mean score of 294.08 with a SD of 27.82(In-service teacher) and a mean score of 296.69 with a SD of 22.26 (Pre-service). These show the Chinese teachers' CT disposition at an average level.

See table 2 and figure 2, four of the seven subscale mean scores (Analyticity, Systematicity, CT-confidence, Inquisitiveness) for the in-service teachers were founded to be above 40 and three below 40 (Truth-seeking, open-mindedness, Maturity). In contrast, for the pre-service teachers, five of the seven subscales mean scores (Maturity, Analyticity, Systematicity, CT-confidence, Inquisitiveness) were found to be above 40 and two below 40 (Truth-seeking, open-mindedness).

As can be seen in table 2, there are no statistically significant differences between the in-service teacher and the pre-service teacher on seven out of the seven subscales of the CCTDI. Statistical t-test as follows: Truth-seeking ($p = 0.237$), Open-mindedness ($p = 0.721$), Analyticity ($p = 0.800$), Systematicity ($p = 0.910$), CT Self-Confidence ($p = 0.109$), Inquisitiveness ($p = 0.660$) and Maturity ($p = 0.066$). Similarly, the difference between the total scores on the CCTDI of the in-service and pre-service teachers (294.08 VS. 296.69) is not statistically significant ($p = 0.636$), the pre-service teachers have higher critical disposition than the in-service teachers'.

Table 2. Descriptive and inferential statistics of all the participation's CCTDI score.

Subscale	In-service(N=69)		Pre-service(N=61)		t-tests	
	Mean	SD	Mean	SD	t-value	p-value
Truth	37.62	7.28	39.15	7.31	-1.189	0.237
Openmind	38.91	6.58	37.15	5.78	-0.357	0.721
Analyt	46.79	6.88	47.08	5.74	-0.254	0.800
System	43.36	6.35	43.24	5.17	0.114	0.910
Confid	42.80	6.35	43.18	5.81	1.616	0.109
Inquis	45.72	7.86	46.26	5.73	-0.441	0.660
Mature	38.16	7.17	40.23	5.28	-1.854	0.066
CCTDI	294.08	29.74	296.29	22.26	0.474	0.636

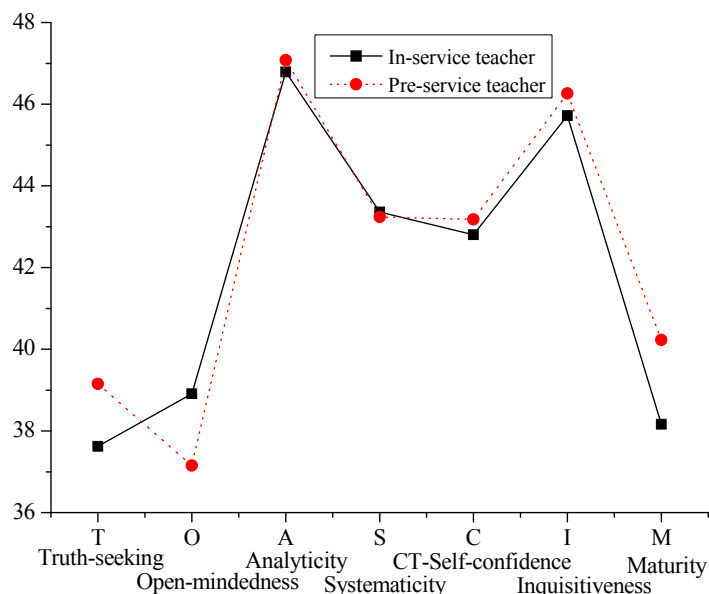
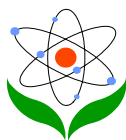
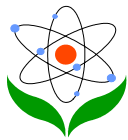


Figure 2. In-service and pre-service teachers' subscales-based profiles of disposition toward critical thinking

Discussion

Constructivist Views of Science Teaching and Learning

The result is rather close to our presuppose. The possible explanations for the finding could be related to limited teaching strategies and the learning milieu (Stockhausen and Kawashima, 2003). And the participants' prior educational and cultural backgrounds are very important (Asako & Marcia, 2004). Also the existing traditional values can affect people's critical thinking (Asako & Marcia, 2004). The curriculums taught in Chinese normal university are instructed by the subject-center thought. Middle school teachers in China take advantages on the ability of analyticity and systematicity. However, Chinese teachers get into the habit of strongly depending on textbooks and reference books. They think the textbook is the authority during the teaching, by which majority of them are not good at querying. So the scores of truth-seeking and open-minded subscale are low. High scores of self-confidence and inquisitiveness indicate that teachers become full of confidence to their work, they also showed a positive inclination towards intellectual curiosity and a desire for learning.



The most interesting finding is that the mean scores of the pre-service teachers are higher than the scores of in-service teachers both on CCTDI and CCTST. It seems to that working experience is not beneficial to CT. It can be found in other fields like nursing (Asako & Marcia, 2004). Maybe the in-service have a lot of things to do just as working and family affairs, there is no time to think critically and young people have a strong learning desire than the elder (Zhou & Wang, 2007).

See table 3, it is reassuring that the majority (61%) of the teachers in this current study achieved CCTDI scores of 280-350 because "critical thinking dispositions are essential for the development of higher-order critical thinking and learning". (Colucciello, 1999). In a word, majority teachers' dispositions toward critical thinking are at a high-average level.

Furthermore, as shown in table 1, we find that analysis score is high while evaluation and inference scores are low. Significant differences only can be found on Analysis subscale ($p = 0.015$), compared with no significant difference on Evaluation ($p = 0.137$) and Inference ($p = 0.079$). Both in-service and pre-service teachers have the highest mean scores for Analyticity, at 46.79 and 47.08 respectively, indicating that they were inclined to anticipate consequences and demand the application of reason (Facione, 1997; Colucciello, 1997). The possible explanations could be chemistry is a subject based on experiment; it is very common to use the ability of analysis. In addition, the method of inducting and analyzing are the most essential method in chemistry subject, thus probably resulting in the teachers' high score of analysis. The in-service teachers studied are positively disposed to Inquisitiveness, Systematicity, CT-confidence, with the mean score separately are 45.72, 43.36 and 42.80, but ambivalent toward Open-mindedness (38.91), Maturity (38.16), Truth-seeking (37.62). While the pre-service teachers positively disposed to Inquisitiveness (46.26), Systematicity (43.24), CT self-confidence (43.18), Maturity (40.23), and ambivalent toward Open-mindedness and Truth-seeking. It is rather unconceivable the maturity of the pre-service teacher is higher than that of in-service teacher. Is the elder not mature? It is not consistent with other papers (Zoller, Fastow, Lubezky & Tsaparlis, 1998). Maybe the in-service teachers are too cautious to present their real characteristics.

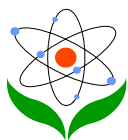


Table 3. Percentage distribution of CCTDI degree

	<210	210-280	280-350	>350
N	0	46	79	5
Percentage(N/the total N)	0%	35%	61%	4%

Conclusion

First, the participators in this study have average level in the CCTDI test but lower level in the CCTST, which strongly urges us to recognize that the actuality of critical thinking development of the in-service and pre-service teachers' in Shaanxi province in the China is not optimal.

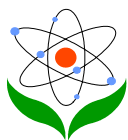
Second, we can see that there are no differences between in-service and pre-service teachers in critical thinking dispositions but there are significant differences in critical thinking skills.

Third, pre-service teacher performed better than the in-service teacher toward critical thinking both on CCTST and CCTDI challenge that high schools should to reform their teaching setting or even curriculum setting.

As the study was a convenience sampling and a preliminary study, the conclusion has its limitation. The further study is needed be continuous.

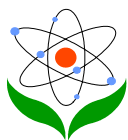
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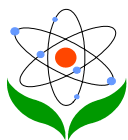


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