Thinking Skills and Creativity 24 (2017) 86–94

Contents lists available at ScienceDirect

Thinking Skills and Creativity

journal homepage: http://www.elsevier.com/locate/tsc

The influence of teaching methods on creative problem finding

Xiaojuan Jia[a,b], Weiping Hu[a,b,*], Fengchun Cai[a,b], Haihong Wang[a,b], Jing Li[a,b], Mark A. Runco[c,**], Yinghe Chen[d]

[a] *MOE Key Laboratory of Modern Teaching Technology, Shaanxi Normal University, Xi'an, China*
[b] *National Innovation Center for Assessment of Basic Education Quality, China*
[c] *American Institute for Behavioral Research & Technology, La Jolla, CA, USA*
[d] *Beijing Normal University, Beijing, China*

ARTICLE INFO

Article history:
Received 24 May 2015
Received in revised form 5 January 2017
Accepted 2 February 2017
Available online 13 February 2017

Keywords:
Teaching methods
Inquiry-based teaching
Lecture-based teaching
Creative problem finding
Opened instruction type
Closed instruction type

ABSTRACT

Problem finding is an important component of creativity, but research on it does not offer much guidance to teaching. The present research takes a step in that direction with two investigations. The first was a between-subjects evaluation of a short-term classroom teaching process, using creative Chinese problem finding (CCPF) to assess the impact. The second was a long–term, mixed-design of creative scientific problem finding (CSPF) as it developed in response to teaching that emphasized problem finding. Results showed that there were improvements, but different teaching methods had varied impact on students' creative problem finding (CPF) performance. A mixed teaching method that included both lecture- and inquiry-based teaching was superior to the lecture-based or inquiry-based methods when used separately. The mixed teaching showed the strongest improvements in students' flexibility and originality on the problem finding tasks. Finally, there was a significant interaction between teaching methods and instructional type (opened, closed) in flexibility and originality of CPF. Practical implications and limitations are discussed.

The strength of the Chinese educational system is probably that it provides students with factual knowledge. The weakness is no doubt that it does little to teach students to think. Yuan (1999), who was previously the Deputy Director of the Normal Education Department of Ministry of Education, said that the educational evaluation system of China was disabling students from having questions and was attempting to insure that students master everything. Education is very different in Western cultures, including America (Kim, 2005; Kumar, Daniel, Doig, & Agamanolis, 1998; Ng, 2003; Walczyk, Griffith-Ross, Tobacyk, & Walczyk, 2006). There is more emphasis on asking questions, independent thought, and creative problem solving.

Problem finding is an important component of creativity (Chand & Runco, 1993; Hu, Shi, Han, Wang, & Adey, 2010; Wakefield, 1985) and has received a great deal of attention in psychology and education. Definitions of *problem finding* vary. It is sometimes viewed as a kind of cognitive strategy and tied to effective learning (Graesse, 1992; Torres, 1998), but is also viewed as reflection of cognitive development (Kelley & Sigel, 1986). In the present study, problem finding was defined as a thinking activity that utilizes existing contexts and experience to produce and express new questions. It is cognitive, meta-cognitive, and even affective.

* Corresponding author at: Center for Teacher Professional Ability Development, Shaanxi Normal University, Xi'an, 710062, China.
** Corresponding author at: American Institute for Behavioral Research and Technology, La Jolla, CA.
E-mail addresses: weipinghu@163.com (W. Hu), mark.runco@gmail.com (M.A. Runco).

http://dx.doi.org/10.1016/j.tsc.2017.02.006

In order to enhance the development of students' problem finding skills, attention must be directed not only to the quantity of problems posed, but also problem diversity (Yoshioka et al., 2005), problem quality (Kalady, Elikkottil, & Das, 2010), and the creative process (Hu, Adey, Shen, & Lin, 2004; Hu et al., 2010; Paletz & Peng, 2009). School experiences can influence problem finding as well, such as teaching methods, teachers' knowledge, teachers' attitudes towards questions, the classroom atmosphere, the evaluation system used and so on (Han, Hu, & Zou, 2005).

Teaching methods may play the most important role in promoting students' creativity (Hu, 2010). In traditional lecture-based teaching (LBT) there is usually a curriculum of disciplinization where each subject had relatively fixed structure and sequence, and a standard text book are used (Jayawickramarajah, 1996; Phil, 2000). The aim of LBT is to expose all students to identical knowledge (Finch, 1999). Teachers using such curricula are there to provide learning objectives and assignments, lectures (Albanese & Mitchell, 1993; Cariaga-Lo, Richards, Hollingsworth, & Camp, 1996; Enarson & Cariaga-Lo, 2001). Lecturing remains a crucial component in virtually all models of teaching methods, including problem-based teaching (Daine, Beverly & Barbara, 1989; Kusum et al., 1998). LBT is advantageous for students who have low levels of self-awareness (Cariaga-Lo et al., 1996), because frequent examinations provide regular feedback, which can compensate for low self-awareness.

Yet there are concerns about LBT. Knowledge may be blindly memorized, and thus transfer and generalization is difficult. When students encounter new problems they are unable to adapt what they have learned, they are not flexible and will tend to rely on inappropriate strategies or rote knowledge. Students often complain that some teachers dislike questions regarding the topic being taught (Abdul-Ghaffar, Ken, & Usha, 1999; Diaz & Cartnal, 1999; Guilbert, 1998; McCrorie, 2001; Remmen et al., 1998; Ronchetto, Budkles, TBarath, & Perry, 1992). Also problematic is the fact that LBT may not take the varied learners' perspectives into account. The LBT conveys information and content while lacking sufficient development of critical thinking skills and problem solving (Stetzik, Deeter, Parker, & Yukech, 2015).

Not surprisingly, Inquiry-based teaching (IBT) has become more and more popular. IBT focuses on students' critical thinking, hands-on ability, and problem solving ability (Kitot, Ahmad, & Seman, 2010). NRC describes inquiry as 'a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; . . .; and communicating results' (Alake-Tuenter et al., 2012; NRC, 1996, p.23). Inquiry teaching is defined as a pedagogical method combining higher order questioning with student-centered discussion and discovery of central concepts through laboratory activities (Damnjanovic, 1999; NRC, 1996). Some aspects of inquiry are individual efforts, but many are not, and teachers need to experience the value and benefits of cooperative work (NRC, 1996, p.61), and design many activities for group learning, not simply as an exercise but as collaboration essential to inquiry (NRC, 1996, p.50). Working in groups enables students to appreciate the availability of alternative solutions as proposed by their classmates. In IBT students are encouraged to not only learn the details of the knowledge, but also learn to apply them in the solution of relevant problems. Thus, students can be accessed on the basis of their understanding and ability to apply knowledge, rather simply their skill at reciting facts. There is an additional benefit: their transfer into other subjects. For example, this approach of teaching information retrieval was successfully implemented in an undergraduate module where students were assessed in a written examination and a written assignment (Jones, 2009).

Previous researches, which investigated the effectiveness of IBT method on critical thinking of primary school students (Kazempour, 2013), secondary school students (Kitot et al., 2010) or undergraduates (Gao & Quitadamo, 2015; Greenwald & Quitadamo 2014; Magnussen, Ishida, & Itano, 2000; Thaiposri & Wannapiroon, 2015) in different disciplines such as history, biology, science and so on, had showed that IBT was effective in enhancing students' critical thinking, which is an extremely important aspect of creativity (Gao & Quitadamo, 2015; Greenwald & Quitadamo 2014; Kazempour, 2013; Kitot et al., 2010; Magnussen et al., 2000; Thaiposri & Wannapiroon, 2015). IBT has also proven to be more effective in promoting the teaching of information technology than traditional teaching methods (Lu, Liu, & Chen, 2012). A comparative study of problem- and lecture-based learning in junior secondary school science showed that seemingly problem-based learning was favored for knowledge retention, compared to a more conventional teaching method (Wong & Day, 2009). Knowledge is another important component of creativity (David, 1998; Hayes, 1989).

As to the effect of combined of two teaching methods, evidence from some teaching researches showed that combination of LBT and IBT can strengthen the teaching effect—improve the students' academic achievement on Chemistry lessons (Shen, 2009) and Idelogical-Political lessons (Zhou, 2012). According to Babansky's Optimization of the Teaching Process (Babansky, 1973a, 1973b; as cited in Wang, 2012), in the process of teaching teachers should adopt diversified teaching methods: each teaching method has its advantages and disadvantages, teachers should choose appropriate teaching methods according to the concrete situation and pay attention to the integrated use of a variety of methods, in order to achieve the optimization of teaching process.

A current review of literature did not offer much guidance to whether teaching methods have impact on students' creative problem finding (CPF).With this in mind the present investigation compared LBT and IBT in terms of creative problem finding. A combined version, or hybrid, of LBT and IBT was also examined, given that both LBT and IBT may contribute, in different ways, to CPF. The purpose of this study was to explore, over short- and long-term classroom experiences, the impact of LBT, IBT, and mixed teaching on students' CPF performance. The hypotheses were as follows: Different teaching methods differ significantly in terms of the impact on CPF performance. Mixed teaching would be significantly more effective than LBT and IBT, not only in improving the three indices of students' CPF performance, but also in improving students' CPF performance of different instruction type.

This investigation was original in that it was the first time to investigate the relationship between a combination of two teaching methods and students' CPF performance. Quite possibly the blended advantages of the two teaching methods would improve students' CPF.

1. Experiment 1

Experiment 1 was designed to test over a short-term classroom teaching process whether teaching methods had a significant impact in improving students' creative Chinese problem finding (CCPF) performance.

1.1. Method

1.1.1. Design and participants

A between-subjects design was used in this experiment. Before the experiment, 150 students from the sixth-grade of a Chinese school were chosen to receive the Creative Scientific Problem Finding Test of Primary Students (CSPF; Hu et al., 2010) to make sure that the three groups of students had no significant differences in CSPF. After controlling for CSPF scores, 90 students were assigned to three groups (30 students each), with equal representation of boys and girls. Then, each group was randomly assigned to one of the three types of teaching methods.

1.1.2. Materials

The Creative Scientific Problem Finding Test of Primary Students (Hu et al., 2010), which showed reliability and validity, was used as a pre-test. Two open-ended questions were included in the test, with one open question "According to the phenomena observed in everyday life, list the questions you can think of as many as possible," and the other closed question that instructed students to list questions related to a picture of an astronaut standing on the moon.

For the post-test, a self-designed questionnaire named Creative Chinese Problem Finding (CCPF) Test was utilized, in which require students to list questions according to the teaching material named *Blue Leaves*. The Cronbach's alpha was 0.78, the inter-rater reliability was 0.69 and the correlations between CCPF total score and each of the three dimensions' score were higher than the correlations between each two of the three dimensions.

The CSPF/CCPF responses were rated for fluency, flexibility, and originality. The number of questions generated was the fluency score. The number of categories across which a subject's questions were distributed was the flexibility score. The Originality score was based on the frequency of occurrence of a question (i.e., its percentage in the total sample). The student gained a score of 2 if the response frequency percentage was smaller than 5%; 1 point if the response frequency was between 5 and 10%; and 0 if above 10% (Chen, Hu, & Plucker, 2016; Hu et al., 2010). The total CSPF score was simply the sum of scores of the three dimensions.

1.1.3. Teaching materials

As to choosing the teaching materials, the following factors were considered: firstly, material is interesting; secondly, be familiar with, which is also concrete and comprehensible; thirdly, with rich information, which is beneficial for students thinking or asking questions from multiple angles; lastly, suitable difficulty. Finally, the *Blue Leaves* was chosen from 18 materials with the help of primary school teachers who teach Chinese, which tells a story about painting and borrowing colored pencils.

1.1.4. Procedure

Three identical groups of students were selected using scores on the *Creative Scientific Problem Finding Test of Primary Students*. All three groups then received a 40-min class with the teaching content *Blue Leaves*, with each group receiving a different teaching method. It is worth mentioning that both the teaching content and teacher were same in each of the three groups.

In the LBT condition, the teacher instructed the students to read through the learning materials, solve the basic problem of the understanding of materials, and to recognize new words. Then, the teacher explained paragraph-by-paragraph and guided students to the answers of their questions.

In the IBT condition, the teacher devoted the first 5 min to the creation of problem situations, inspiring students to think about the material content. The teacher then arranged the students to read the text in the form of a sub-group cooperation, recognizing new words in this process and afterwards discussed the content of the material. After discussion, every sub-group had chances to express their views and the teacher would give a conclusion.

In the mixed teaching condition, the teacher began with an effort to guide the students to the creation of problem situations. Students subsequently read through the text with a teacher's assistance and discussed in the form of sub-group, assigning a group leader to make a conclusion of their views and exchange views with other groups.

In the last 10 min of the classes, the students were asked to raise questions about the content of the learning material. Their performance was recorded. Scoring rules was same as the pre-test.

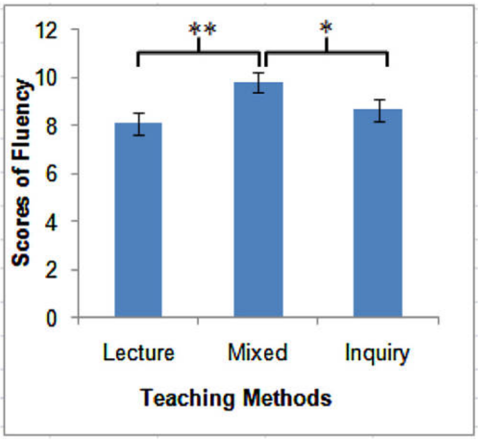

Fig. 1. Comparison of different teaching methods on fluency. Error bars represent standard errors of the mean. **p < 0.01; *p < 0.05.

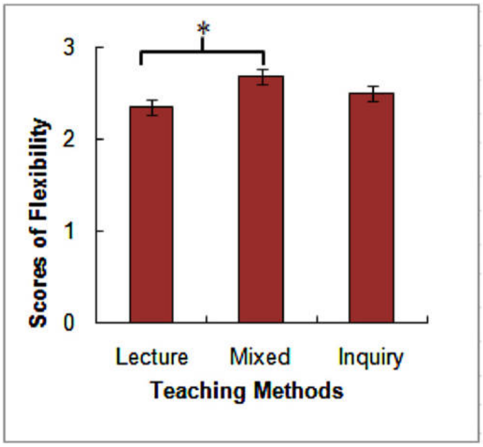

Fig. 2. Comparison of different teaching methods on flexibility. Error bars represent standard errors of the mean. **p < 0.01; *p < 0.05.

1.2. Results

MANOVA showed a significant effect of teaching methods on CCPF ($F[6, 110] = 2.22$, $p < 0.05$, *Partial* $\eta^2 = 0.108$). Univariate tests indicated that there was a significant difference of post-test scores of fluency ($F[2, 87] = 4.33$, $p < 0.05$, *Partial* $\eta^2 = 0.132$), flexibility ($F[2, 87] = 3.68$, $p < 0.05$, *Partial* $\eta^2 = 0.114$) originality ($F[2, 87] = 6.08$, $p < 0.01$, *Partial* $\eta^2 = 0.176$) of CCPF. It indicated that teaching methods had a significant difference in improving students' CCPF performance by improving the three dimensions of CCPF.

Multiple comparisons adjusted by Bonferroni showed that in mixed teaching situation scores of fluency and originality was significantly higher than that of LBT (*ps* < 0.01) and IBT ($p < 0.05$, $p < 0.01$, respectively). And in mixed teaching situation scores of flexibility was significantly higher than that of LBT ($p < 0.05$), while there was no significant difference between mixed teaching and IBT in flexibility (see Fig. 1–3).

2. Experiment 2

Experiment 2 was designed to explore over a long-term classroom-teaching process, in order to establish whether teaching methods had a significant influence on improving students' CSPF performance.

2.1. Method

2.1.1. Design and participants

This study utilized a 2 (type of question: opened or closed) x 3 (teaching methods: mixed, LBT, IBT) experimental design. Teaching method and type of question (open vs. closed) were between- and within-subjects variables, respectively.

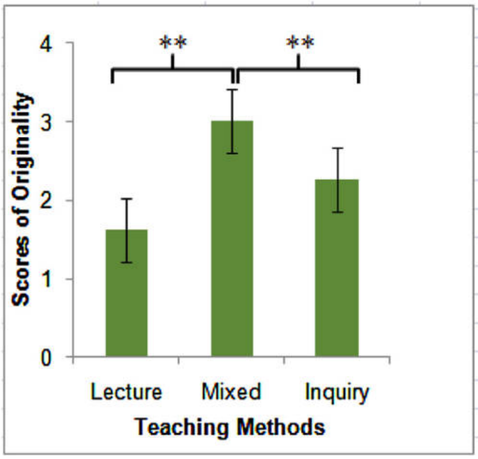

Fig. 3. Comparison of different teaching methods on originality. Error bars represent standard errors of the mean. $^{**}p < 0.01$; $^{*}p < 0.05$.

Three of the eight classes of 6th-grade children from a Chinese primary school participated. The classes were each randomly assigned to one of three different teaching methods to be conducted. To ensure that the three classes had no significant difference in CSPF, we administered a pre-test and then matched three homogeneous groups with 40 students to each of the three groups (20 boys and 20 girls), for a total of 120 students.

2.1.2. Materials

The *Creative Scientific Problem Finding Test of Primary Students* (Hu et al., 2010) was used as the pre-test, the same as used in Experiment 1. In the post-test, a self-designed parallel questionnaire was utilized, of which Cronbach's alpha was 0.80 and inter-rater reliability was 0.91. Items in this parallel test were similar to the pre-test, also including two open-ended questions, with one open question which is same as the pre-test "According to the phenomena observed in everyday life, list the questions you can think of as many as possible," and the other closed question that instructed students to list questions related to a picture of a rainy sky with thunderstorm and lightning. Scoring rules was same as that of the pre-test in experiment 1. Table 1 showed the mean scores and correlations among the pretest and posttest scores.

2.1.3. Procedure

First, the three groups of students were selected via pre-test to make sure that the three groups of students had no significant difference at initial CSPF performance. Then each group had a lesson with 40 min once a week, totally 10 lessons. The teaching content was knowledge about science and was same across all three groups. Teaching methods of the three groups were mixed teaching, LBT and IBT respectively.

After the intervention of the 10 classes, the self-designed parallel questionnaire was utilized as the post-test to rate the students' final CSPF.

2.4. Results

A repeated measures MANOVA was used to test the main and interaction effects of Teaching Methods (3), Time (pre-test, post-test) (2) and Type of Instruction (2) on CSPF scores, in which Teaching Methods was one between-subject variable and Time and Type of Instruction were two within-subject variables. Results showed a significant main effect of teaching methods ($F[6, 230] = 10.76$, $p < 0.001$, *Partial* $\eta^2 = 0.219$), significant main effect of type of instruction ($F[3, 115] = 86.06$, $p < 0.001$, *Partial* $\eta^2 = 0.692$), of time ($F[3, 115] = 32.93$, $p < 0.001$, *Partial* $\eta^2 = 0.462$), as well as a significant interaction effect among time, teaching methods, and type of instruction, ($F[6, 230] = 4.6$, $p < 0.001$, *Partial* $\eta^2 = 0.107$).

Univariate tests suggested that there was a significant main effect of teaching methods on fluency ($F [2, 117] = 8.72$, $p < 0.001$, *Partial* $\eta^2 = 0.13$), flexibility ($F[2, 117] = 5.14$, $p < 0.01$, *Partial* $\eta^2 = 0.08$), and originality ($F[2, 117] = 7.95$, $p < 0.01$, *Partial* $\eta^2 = 0.12$). Further analysis showed that in a mixed teaching situation scores of flexibility and originality were significantly higher than that IBT ($p < 0.001$, $p < 0.01$, respectively), originality scores in mixed teaching was also significantly higher than that of LBT ($p < 0.01$). Fluency scores in mixed teaching and LBT were significantly higher than that of IBT ($p < 0.001$, $p < 0.01$, respectively), while there was no significant difference within mixed teaching and LBT.

Also there was a significant main effect of type of instruction on fluency ($F[2, 117] = 176.58$, $p < 0.001$, *Partial* $\eta^2 = 0.601$), flexibility ($F[2, 117] = 175.69$, $p < 0.001$, *Partial* $\eta^2 = 0.600$) and originality ($F[2, 117] = 257.47$, $p < 0.001$, *Partial* $\eta^2 = 0.688$).

There was a significant main effect of time on fluency ($F[2, 117] = 16.63$, $p < 0.001$, *Partial* $\eta^2 = 0.12$), flexibility ($F[2, 117] = 47.13$, $p < 0.001$, *Partial* $\eta^2 = 0.28$), and originality ($F[2, 117] = 9.53$, $p < 0.01$, *Partial* $\eta^2 = 0.08$).

Table 1
Mean scores on Creative Scientific Problem Finding Test of Experiment 2 and correlations among the pretest and posttest scores.

Teaching Methods	Type of Instruction	Time	n	Fluency				Flexibility				Originality			
				M	*SD*	*r*	*p*	*M*	*SD*	*r*	*p*	*M*	*SD*	*r*	*p*
Mixed	Open	Pre-test	40	14.90	5.00	0.308	0.053	9.62	3.09	0.225	0.162	8.55	3.57	0.258	0.108
		Post-test		22.22	5.89			15.67	4.43			11.60	3.40		
	Closed	Pre-test		13.92	3.39	0.357	0.024	8.73	2.83	0.283	0.077	6.50	2.10	0.167	0.303
		Post-test		13.12	5.11			9.80	3.55			5.88	3.25		
Lecture-based	Open	Pre-test	40	15.27	3.38	0.376	0.017	10.35	2.39	0.190	0.240	7.43	2.30	0.229	0.156
		Post-test		20.55	6.31			13.50	3.89			8.22	2.55		
	Closed	Pre-test		13.58	3.35	0.336	0.034	8.83	2.56	0.260	0.105	5.55	2.17	−0.085	0.604
		Post-test		12.23	4.42			9.20	3.06			5.20	2.43		
Inquiry-based	Open	Pre-test	40	13.18	6.32	0.156	0.338	9.05	4.08	0.088	0.588	7.30	3.66	0.308	0.053
		Post-test		17.78	5.56			13.70	3.67			9.73	3.15		
	Closed	Pre-test		12.22	5.41	0.174	0.283	8.32	3.11	0.002	0.990	5.02	2.41	−0.018	0.914
		Post-test		8.78	5.58			6.62	3.64			4.92	2.96		

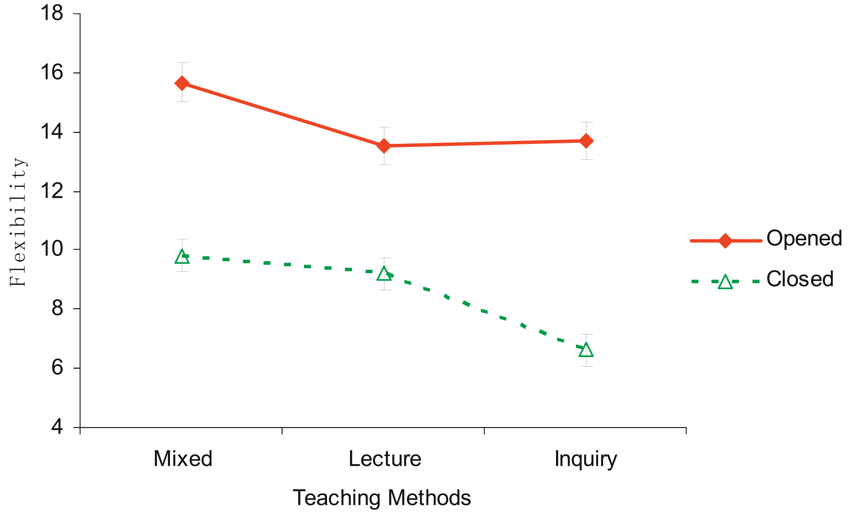

Fig. 4. Scores of flexibility of different instruction type under different teaching methods. Error bars represent standard errors of the mean.

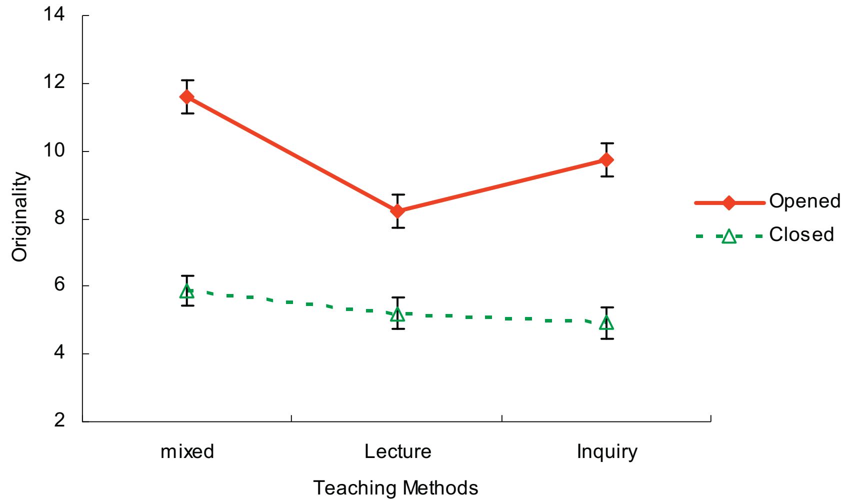

Fig. 5. Scores of originality of different instruction type under different teaching methods. Error bars represent standard errors of the mean.

Additionally, significant interaction effects among time, teaching methods, and type of instruction were found both on flexibility ($F[2, 117] = 5.03$, $p < 0.01$, *Partial* $\eta^2 = 0.08$) and originality ($F[2, 117] = 3.75$, $p < 0.05$, *Partial* $\eta^2 = 0.06$) scores. Further analysis showed that in the open instruction condition of post-test, scores of flexibility and originality in mixed teaching situation were significantly higher than that of LBT ($p < 0.05$, $p < 0.001$, respectively) and IBT ($p < 0.05$, $p < 0.01$, respectively). In the closed instruction condition of post-test, scores of flexibility in mixed and LBT situation were significantly higher than that of IBT ($ps < 0.001$), while there was no significant difference within mixed teaching and LBT (see Fig. 4 and 5).

3. Discussion

The results showed that mixed teaching methods promoted the development of students' CPF more than the two separate teaching methods, especially in terms of flexibility and originality. Why did mixed teaching methods show more efficient in improving students' CPF? No doubt both LBT and IBT contribute, albeit in different ways, to creativity and CPF.

LBT is highly efficient at imparting structured knowledge. It has been repeatedly demonstrated that knowledge contributes to creativity (David, 1998; Hayes, 1989). Thus, it is a given that even though LBT is conventional and structured, it is probably also crucial to creativity. LBT is, however, not interactive. This is a concern because interaction provides students with opportunities to creative meaning for themselves. Previous research demonstrated that a Science and Technology course supported with active learning methods significantly increased students' creative thinking levels (Selda, 2011). This is one reason that IBT plays an important role in improving students' creativity; it is an interactive teaching method. Other research has demonstrated that inquiry-based science instruction assists students in discovering knowledge for themselves instead of simply being asked to recall information. Inquiry learning probably also promotes creativity by increasing motivation, wonderment, and curiosity (Christopher, 2010).

Previous studies have shown that IBT was stronger than many conventional teaching methods in improving students' creativity, and other skills as well, but no previous research has mixed the different types of teaching methods and tested the effect of the mixture on CPF. One previous study showed that inquiry was the key to enhancing creativity, while still meeting the demands of standardized testing (Christopher, 2010). Others have pointed to a complementary relationship between LBT and IBT, which supports our results that showed an optimized combination of the two teaching methods, each with their own advantages, can strengthen the teaching effect, and that neither should be omitted (Shen, 2009; Zhou, 2012).

Certainly, different teaching goals need different teaching methods. For example, when teaching declarative science knowledge or normative operation skills, LBT can take advantage of its high efficiency in transferring relatively settled knowledge (Finch, 1999; Stetzik, Deeter, Parker, & Yukech, 2015). It is widely believed that IBT is of low in efficiency when transferring such kinds of knowledge. But when the knowledge is closely connected with real situation, where students' critical thinking, hands-on ability, and their dominant role are pivotal, IBT stimulates students' interest in learning (Gao & Quitadamo, 2015; Greenwald & Quitadamo 2014; Kazempour, 2013; Kitot et al., 2010; Magnussen et al., 2000; Thaiposri & Wannapiroon, 2015). What's more, the knowledge constructed through inquiry activity can keep away the dull and inert, and is easier to apply and transform to other situations (Jones, 2009).

There is no one best teaching method. The present research indicates that relying on LBT or IBT does not by itself guarantee enhanced CPF. IBT may be questioned because it is time-consuming and not highly efficient nor highly structured. This makes implementation in the classroom difficult. Perhaps in the future teachers can master the teaching ideas and goals of IBT to make it more efficient. It should be possible to create an optimal fusion of LBT and IBT for the classroom. Future research is certainly warranted.

Acknowledgements

This research was supported by National Social Science Foundation Key Project (14ZDB160), National Natural Science Foundation of China (31271110, 31470977), Science and technology foundation project (2013IM030200), and the Program of Key Science and Technology Innovation Team in Shaanxi Province (2014KTC-18).

References

Abdul-Ghaffar, T. A., Lukowiak, K., & Nayar, U. (1999). Challenges of teaching physiology in a PBL School. *American Journal of Physiology*, *277*(22), S140–S147.

Alake-Tuenter, E., Biemans, H. J. A., Tobi, H., Wals, A. E. J., Oosterheert, I., & Mulder, M. (2012). Inquiry-based science education competencies of primary school teachers: a literature study and critical review of the american national science education standards. *International Journal of Science Education*, *34*(17), 2609–2640.

Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*, *68*(8), 52–81.

Babansky, I. K. (1973a). Optimization of the teaching process. *Soviet Education*, 3–18. http://dx.doi.org/10.2753/res1060-939315123

Babansky, I. K. (1973b). *Optimization of the teaching process in the Soviet Union*. Soviet Education, N/A.

Cariaga-Lo, L. D., Richards, B. F., Hollingsworth, M. A., & Camp, D. L. (1996). Non-cognitive characteristics of medical students: entry to problem-based and lecture-based curricula. *Medical Education*, *30*(3), 179–186.

Chand, I., & Runco, M. A. (1993). Problem finding skills as components in the creative process. *Personality and Individual Differences*, *14*(1), 155–162.

Chen, B., Hu, W., & Plucker, J. A. (2016). The effect of mood on problem finding in scientific creativity. *The Journal of Creative Behavior*, *50*(4), 308–320. http://dx.doi.org/10.1002/jocb.79

Christopher, L. (2010). Fostering creativity or teaching to the test? Implications of state testing on the delivery of science instruction. *The Clearing House*, *83*(2), 54–57.

Daine, E. H., Beverly, B. T., & Barbara, D. A. (1989). Responding to perceived needs of the twenty-first century: A case study in curriculum design. *Medical Teacher*, *11*, 157–167.

Damnjanovic, A. (1999). Attitudes toward inquiry-based teaching: Differences between preservice and in-service teachers. *School Science & Mathematics*, *99*(2), 71–76.

David, D. (1998). Knowledge, creativity and innovation. *Journal of Knowledge Management*, *2*(1), 5–13.

Diaz, D. P., & Cartnal, R. B. (1999). Students' learning styles in two classes: online distance learning and equivalent on-campus. *College Teaching*, *47*(4), 130–135.

Enarson, C., & Cariaga-Lo, L. (2001). Influence of curriculum type on student performance in the United States medical licensing examination step 1 and step 2 exams: Problem-based vs. lecture-based curriculum. *Medical Education*, *35*(11), 1050–1055. http://dx.doi.org/10.1046/j. 1365-2923.2001.01058.x

Finch, P. M. (1999). The effect of problem-based learning on the academic performance of students studying podiatric medicine in Ontario. *Medical Education*, *33*(6), 411–417. http://dx.doi.org/10.1046/j.1365-2923.1999.00347.x

Gao, M., & Quitadamo, I. J. (2015). Using inquiry teaching to promote student critical thinking and content knowledge in a nonmajors biology course. *Education Journal*, *4*(4), 182–188. http://dx.doi.org/10.11648/j.edu.20150404.17

Graesse, A. C. (1992). Questioning mechanisms during complex learning. *Reports- Research*, 60.

Greenwald, R. R., & Quitadamo, I. J. (2014). A mind of their own: using inquiry-based teaching to build critical thinking skills and intellectual engagement in an undergraduate neuroanatomy course. *Journal of Undergraduate Neuroscience Education*, *12*(2), A100–A106.

Guilbert, J. J. (1998). Comparison opinion of students and teachers concerning medical education programmes in Switzerland. *Medical Education*, *32*(1), 65–69. http://dx.doi.org/10.1046/j.1365-2923.1998.00645.x

Han, Q., Hu, W., & Zou, Y. (2005). Creative question-asking ability and its cultivation in primary and middle school students. *Journal of Shanxi Teachers University (Social Science Edition)*, *32*(5), 131–134.

Hayes, J. R. (1989). Cognitive processes in creativity. In J. A. Glover, R. R. Ronning, & C. R. Reynolds (Eds.), *Handbook of creativity* (pp. 135–145). New York: Plenum.

Hu, W., Adey, P., Shen, J., & Lin, C. (2004). The comparisons of the development of creativity between English and Chinese adolescents. *Acta Psychological Sinica*, *36*(6), 718–731.
Hu, W., Shi, Q., Han, Q., Wang, X., & Adey, P. (2010). Creative scientific problem finding and its developmental trend. *Creativity Research Journal*, *22*(1), 46–52. http://dx.doi.org/10.1080/10400410903579551
Hu, W. (2010). Factors that affect the development of creativity of primary and secondary school students in classroom teaching. *Theory and Practice of Education*, *30*(8), 46–49.
Jayawickramarajah, P. T. (1996). Problems for problem-based learning: A comparative study of documents. *Medical Education*, *30*(4), 272–282. http://dx.doi.org/10.1111/j.1365-2923.1996.tb00829.x
Jones, G. J. F. (2009). An inquiry-based learning approach to teaching information retrieval. *Information Retrieval*, *12*(2), 148–161. http://dx.doi.org/10.1007/s10791-009-9088-x
Kalady, S., Elikkottil, A., & Das, R. (2010). Natural language question generation using syntax and keywords. In K. E. Boyer, & P. Piwek (Eds.), *Proceedings of QG2010: the third workshop on question generation* (pp. 1–10).
Kazempour, E. (2013). The effects of inquiry-based teaching on critical thinking of students. *Journal of Social Issues & Humanities*, *1*(3), 23–27.
Kelley, T. D., & Sigel, I. E. (1986). A cognitive developmental approach to question asking: A learning cycle-distancing model. *Reports-Research*, 61.
Kim, K. H. (2005). Learning from each other: Creativity in east asian and american education. *Creativity Research Journal*, *17*, 337–347. http://dx.doi.org/10.1207/s15326934crj1704_5
Kitot, A. K. A., Ahmad, A. R., & Seman, A. A. (2010). The effectiveness of inquiry teaching in enhancing students' critical thinking. *Procedia – Social and Behavioral Sciences*, *7*(C), 264–273. http://dx.doi.org/10.1016/j.sbspro.2010.10.037
Kumar, K., Daniel, J., Doig, K., & Agamanolis, D. (1998). Teaching of pathology in United States medical schools, 1996/1997 survey. *Human Pathology*, *29*(7), 750–755.
Lu, X. S., Liu, Q. H., & Chen, J. (2012). Inquiry learning' implementation and evaluation in the teaching of information technology. *Physics Procedia*, *24*, 1851–1856.
Magnussen, L., Ishida, D., & Itano, J. (2000). The impact of the use of inquiry-based learning as a teaching methodology on the development of critical thinking. *Journal of Nursing Education*, *39*(8), 360–364.
McCrorie, P. (2001). Tales from tooting: reflection on the first year of the MBBS graduate entry programme at St. George's Hospital Medical School. *Medical Education*, *35*(12), 1144–1149.
National Research Council. (1996). *National science education standards*. Washington, D.C: National Academy Press.
Ng, A. K. (2003). A cultural model of creative and conforming behavior. *Creativity Research Journal*, *15*, 223.
Paletz, S. B. F., & Peng, K. (2009). Problem finding and contradiction: examining the relationship between naive dialectical thinking, ethnicity, and creativity. *Creativity Research Journal*, *21*(2–3), 139–151. http://dx.doi.org/10.1080/10400410902858683
Remmen, R., Denekens, J., Scherpbier, A. J. J. A., van der Vleuten, C. P. M., Hermann, I., Van Puymbroeck, H., et al. (1998). Evaluation of skills training during clerkships using student focus groups. *Medical Teacher*, *20*(5), 428–431.
Ronchetto, J. R., Budkles, T. A., Barath, R. M., & Perry, J. (1992). Multimedia delivery systems: A bridge between teaching methods and learning styles. *Journal of Marketing Education*, *14*(1), 12–21. http://dx.doi.org/10.1177/027347539201400103
Shen, Y. (2009). *The research on the effective conformity of inquiry teaching and traditional teaching in chemistry lesson. Unpublished Master dissertation*. Hohhot, Inner Mongolia, China: Inner Mongolia Normal University.
Stetzik, L., Deeter, A., Parker, J., & Yukech, C. (2015). Puzzle-based versus traditional lecture: Comparing the effects of pedagogy on academic performance in an undergraduate human anatomy and physiology ii lab. *BMC Medical Education*, *15*(1), 1–11.
Thaiposri, P., & Wannapiroon, P. (2015). Enhancing students' critical thinking skills through teaching and learning by inquiry-based learning activities using social network and cloud computing. *Procedia – Social and Behavioral Sciences*, *174*, 2137–2144.
Torres, B. B. (1998). Learning by posing questions. *Biochemical Education*, *26*(4), 294–296.
Wakefield, J. F. (1985). Towards creativity: Problem finding in a divergent-thinking exercise. *Child Study Journal*, *15*(4), 265–270.
Walczyk, J. J., Griffith-Ross, D. A., Tobacyk, J. J., & Walczyk, D. F. (2006). The impact of culture and individualism-collectivism on the creative potential and achievement of American and Chinese adults. *Creativity Research Journal*, *18*(3), 355–366. http://dx.doi.org/10.1207/s15326934crj1803_10
Wang, C. (2012). Review of Babansky's optimization of the teaching process. *Shandong Social Sciences*, *10*, 188–192. http://dx.doi.org/10.14112/j.cnki.37-1053/c.2012.10.040
Wong, K. K. H., & Day, J. R. (2009). A comparative study of problem-based and lecture-based learning in junior secondary school science. *Research in Science Education*, *39*(5), 625–642. http://dx.doi.org/10.1007/s11165-008-9096-7
Yoshioka, T., Suganuma, T., Tang, A. C., Matsushita, S., Manno, S., & Kozu, T. (2005). Facilitation of problem finding among first year medical school students undergoing problem-based learning. *Teaching and Learning in Medicine*, *17*(2), 136–141. http://dx.doi.org/10.1207/s15328015tlm1702_7
Yuan, Z. (1999). Introspection of scientific education. *The Management of Primary and Secondary School*, *12*, 2–4.
Zhou, Y. (2012). *The research on the conformity of inquiry teaching and traditional teaching in ideological and political lesson. Unpublished Master dissertation*. Dalian, Liaoning Province, China: Liaoning Normal University.