Integrating direct and inquiry-based instruction in the teaching of critical thinking

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Integrating Direct and Inquiry-Based Instruction in the Teaching of Critical Thinking: An Intervention Study

The goal of modern education is to nurture students "to use their minds well, in school and beyond" (Kuhn 2007, p. 110), hence, instruction designed to cultivate a critical mind is crucial for today's students. Educators have been stumbling along the search of an effective instructional approach to teaching critical thinking in higher education. Divergent findings have been noted in studies utilizing different instructional strategies making guidelines for teaching critical thinking inconclusive. Besides, empirical studies of the existing literature have mostly examined the effectiveness of a single instructional approach, though it would allow researchers greater control over the experimental situations, it would have been a less realistic simulation of real-life teaching situations. In the current study, we proposed an intervention that combined the direct and the inquiry-based instructional approaches in different sequence and proportion, and examined their effects on the critical thinking performance of secondary school students.

Literature Review on Critical Thinking and Its Instructional Approaches

Defining Critical Thinking

Critical thinking is dynamic, reflective and evidence-based. Halpern (2003) described critical thinking as "the use of those cognitive skills or strategies that increase the probability of a desirable outcome… [and] is purposeful, reasoned, and goal directed." (p. 6). Likewise, Paul and Elder (2004) defined critical thinking as the "mode of thinking … in which the thinker improves the quality of his or her thinking by skillfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them" (p. 1). These definitions reflect a convergent view of critical thinking as a synthesis of cognitive skills and dispositions. While cognitive skills reflect a person's ability in executing a mastered skill, dispositions capture a person's conscious choice of a skill that best suits solving a particular task at hands (Stanovich and West 1997). The relation between cognitive skills and dispositions are considered by many as mutually reinforcing (see, for example, Facione and Facione 1997; Norris 2003). Cognitive skills underlying logical reasoning and argumentation are central to critical thinking; examples include drawing inferences, weighing evidence, identifying imbedded assumptions, assessing casual claims, detecting biases and fallacies (see, for example, Beyer 2001; Dick 1991; Facione 1990; Halpern 2003). These are generic skills of thinking which allow an individual to use objective rules of reasoning to evaluate subjective opinions, and these skills are applicable to different domains of thinking such as making decision, making judgments, scientific reasoning, and solving problem. Critical thinking dispositions are "tendencies toward patterns of intellectual activity that condition and guide cognitive behavior specifically" (Perkins et al. 1993, p. 6). The disposition to think critically accounts for a person's inclination to engage in effortful thinking, as well as a proper approach towards thinking tasks. A range of attitudes, habits, and values

are identified as desirable to thinking critically: openness, truth-seeking, inquisitive, and a systematic approach to thinking etc. (The Delphi Report, cited in Facione 1990) Though more research has been focusing on the skill component compared to the disposition component of critical thinking, there has been empirical evidence suggesting that the relation between the two is mutually reinforcing. Clifford and colleagues (2004) found that after controlling for an individual's cognitive ability, whether the person was open to new ideas and experience was associated with better critical thinking performance. Likewise, other researchers have identified the trait to seek and enjoy intellectual activities, and the trait to be diligent and careful in task approach, as measured by Need for Cognition Scale (NCS; Cacioppo and Petty, 1982), and Conscientiousness and Openness to Experience (NEO-PI-R; Costa and McCrae, 1992), to be conceptually and empirically related to good thinking (Halpern 2007; Macpherson and Stanovich 2007).

To exemplify the components of cognitive skills and disposition in practical teaching terms, effective training for critical thinking should cultivate thinking skills in a context that brings forth a learner's dispositions to engage in scientific reasoning, argument analysis, informal reasoning, and verbal reasoning skills. Educators have debated whether critical thinking is domain generic or subject-specific. For instance, McPeck (1981) has argued that thinking cannot be done in a vacuum and is therefore inevitably subject to a particular domain, whereas others such as Paul (1995) and Ennis (1987) believed that cognitive skills that allow us to think logically are not bounded by any contexts. The debate has mostly been settled on acknowledging both views with a consensus among scholars that although subject knowledge always plays a role, there are some generic cognitive skills that can be effectively taught to students for better reasoning across disciplines (Angeli and Valanides 2009; Voss et al. 1991). Educators now regard the teaching of generic cognitive skills separately from a subject domain the General Approach, and regard embedding thinking skills in a subject domain the Infusion Approach. The present study adopts the general approach framework to examine the effectiveness of a critical thinking intervention program that trains for generic cognitive skills. In-line with the literature, the intervention program aimed to provide training of cognitive skills underlying informal reasoning and argumentation, as well as proper dispositions toward critical thinking.

Conception of Direct Versus Inquiry-Based Instructional Approaches

There has been an on-going debate among educators on how best to teach generic critical thinking skills. The efficacy of two categories of instructional approaches is often being compared: direct instruction and inquiry-based instruction. The center of discussion has long been revolving around an either-or comparison, with an assumption that inquiry-based instruction refers to minimally-guided learning activities, and that direct

instruction refers to guided learning (see Kuhn 2007). Yet whether an activity is guided or not does not make a clear indicator of pedagogy as guidance is often needed and provided in many inquiry-based activities. A more effective way to distinguish the two approaches is to examine their grounding assumptions of how learning takes place. The direct instructional approach adopts a top-down approach, that learning takes place given knowledge being explicitly passed down from the teacher. To foster critical thinking skills with this method is to demonstrate and teach independent cognitive skills and procedures to students for them to practice accordingly (Cordingley 2005; Jones et al. 1985; McGuinness 1999). On the other hand, the inquiry-based instructional approach adopts a bottom-up process that aims to have students construct their own understanding of a piece of knowledge. A critical mind is developed through having students engaged in interactive investigations of intellectual activities so that they can discover and understand important cognitive rules for themselves (Brown 1997; Ruggiero 1988; Sigel 1984)." The inquiry-based instructional approach is an umbrella concept for learning modes, including, but not limited to, inquiry learning (Rutherford 1964), discovery learning (Bruner 1961), and problem-based learning (Barrows and Tamblyn 1980). The approach rests on the constructivist premise that learning takes place due to the continuous process of the learner's construction and reconstruction of his or her own representations of phenomena of interest (Tynjala 1998; Vygotsky 1978) through activities that are directed toward question formulation, interactive discussion, and reflection. Typically it emphasizes open investigations of authentic problem scenarios in a student-centered and collaborative learning classroom context. On the contrary, the direct instruction is a method characterized by three components: teacher demonstration, systematic practice, and independent assessment. The approach focuses on teaching the step-by-step procedure for carrying out a cognitive skill; this includes explicit instruction emphasizing why, when, where, and how to use a specific cognitive skill. Students usually learn through supervised and repeated exercises in a teacher-centered and highly structured classroom context. It is argued that by making explicit demonstration of how a skill can be effectively applied is essential for skill mastery, it allows students to make the application of skills a routine from the very beginning (Beyer 2008).

The two instructional approaches and their underlying assumptions about how learning takes place have continued to be vigorously discussed in recent years. For instance, Kirschner et al. (2006) urged educators to consider the limitations of the human working memory and its effects on how students learn. They argued that direct and explicit instruction is more compatible with the way our memory system works to retain information such as facts, theories, and complex cognitive procedures. In other words, much conscious effort is needed to remember what is being taught in school, and therefore it is more appropriate for school knowledge to be taught

explicitly and with lots of guidance. Hmelo-Silver et al. (2007) have argued that an inquiry-based instructional approach takes scaffolding as an essential learning component to "guide students in the learning process, pushing them to think deeply, and model the kinds of questions that students need to be asking themselves, thus forming a cognitive apprenticeship" (Hmelo-Silver et al., p. 110). Such in-depth guidance in fact helps to reduce cognitive load and foster the learning of complex knowledge. Researchers have found empirical support for each of these two instructional methods. The next section describes some of those findings as well as the recent literature's questioning on viewing the two approaches as opposite ends.

Empirical-Based Evidence of the Two Instructional Approaches in Teaching Critical Thinking

The acquisition of critical thinking skills through direct instruction is evident in a few studies. Scholars found that participants employed informal reasoning rules in solving everyday problems more frequently, in a more sophisticated manner, and made less belief-biased responses in argument evaluations after receiving explicit informal reasoning skills training (Kosonen and Winne 1995). Similarly, Neilens et al. (2009) demonstrated that after training for informal reasoning, those undergraduate participants who utilized more reasoning skill made less belief-biased responses in argument evaluations than those who received no skill training but were simply told to be alert to belief bias. These studies have positively demonstrated that informal reasoning skills can be explicitly taught, learned, and applied.

The literature consists also of evidence supporting an inquiry-based instructional approach. Ernst and Monroe (2004) found that students who joined an intervention program which used an inquiry-based teaching strategy were more skilled in critical thinking than their peers in traditional lecture-based classes. Semerci (2006) revealed similar findings in an empirical investigation comparing the effect of an inquiry-based learning approach and the traditional method of direct teaching on the generic critical thinking skills of students. In the experimental condition of this study, students were asked to work in groups to describe, discuss, define, and solve problems resembling real-life scenarios. Participants' critical thinking performances were measured before and after the 4-week program. The results suggested that the participants in the experimental condition achieved significantly higher scores on a critical thinking test than those in the traditional direct teaching mode.

Whilst it appears neither the direct nor the inquiry-based instructional approach displays an overriding advantage over the other, many have argued that it is hard to place and provide an insight into why inquiry-based instruction and direct instruction should be regarded as absolute opposites (Alfieri et al. 2011). Providentially, what we have found in the recent literature shows the tendency to explore the potential of various mixed teaching methods as opposed to a closed debate on whether one method is superior to another. For

instance, to reduce the ambiguous nature of inquiry-based learning tasks, Klahr (2009) postulated the application of a certain amount of direct instruction as the structural basis for less-guided learning tasks. This view is shared by Kuhn (2007), who argued that structure is needed even for constructivist methods, and that the major challenge of any mixed teaching method is to get the right "balance and sequence" (p. 112) according to different subject's instructional goals and needs. Likewise, Angeli and Valanides (2009) have stated that examining "specific sequence of the instructional tactics' (p.332) is a future direction for research on critical thinking teaching. The present study is a response to this call for an examination of various possible proportion and order in the context of critical thinking training.

The Present Study

Empirical evidence is much needed to substantiate the literature's discussion on the potential of mixed instructional approach for teaching critical thinking. We designed the current study to search for the most effective mode that integrates the direct and the inquiry-based instructional approaches in teaching critical thinking. The study was designed to compare three modes of instruction, with each mode combining the direct instruction and the inquiry-based instruction in different sequences and to different extents. We provided training of critical thinking to Chinese secondary students in an 18-hour intervention program. The program included three modules on learning generic cognitive skills underlying informal reasoning and argumentation, and one module on nurturing proper thinking dispositions. This design was in-line with the general approach framework which proposed teaching critical thinking separately from a particular subject domain.

The two major research questions were as follows: (a) could an 18-hour critical thinking training program enhance Chinese secondary students' critical thinking performance? and (b) which training mode—teaching approach combination—is the most effective in enhancing students' performance in response to two different critical thinking assessments? We were also interested in observing the relationships between students' critical thinking dispositions and performance.

Methodology

Experimental Design

A pretest–posttest design was used to compare the effectiveness of three training modes of critical thinking instruction against a control group. With regard to the three experimental groups, the length, scope of training teaching, and teaching materials were comparable, but the groups differed in terms of the balance and sequence of the direct and the inquiry-based instructional approaches (See Table 1). Altogether, the intervention program consisted of six lessons (18 hours).

Group A (Direct instruction predominant mode): In Lessons 1 to 4, the participants received explicit and direct teaching of critical thinking skills. The materials used were arranged in ascending order of difficulty; the aim was to introduce the basic taxonomies of critical thinking skills. The instructors demonstrated each skill with examples, and the participants were asked to practice the application of skills in in-class exercises. In Lessons 5 and 6, the participants engaged in inquiry-based group discussion exercises to think about hypothetical scenarios that resembled real-world issues.

Group B (Balanced mode): In the first half (1.5 hours) of each lesson, the participants received direct teaching of critical thinking skills; in the second half (1.5 hours) of each lesson, they worked on an inquiry-based discussion exercise which focused on the application of skills learned in the first part of the lesson. The emphasis throughout this group was on the immediate transfer of skills.

Group C (Inquiry-based instruction predominant mode): This group served as the reverse of Group A. An inquiry-based instructional approach was adopted in Lessons 1 to 4: The participants were asked to discuss, report, and critique each other's thoughts on nine different scenario-based controversial issues. During the inquiry process, the participants were left to explore the rules of effective reasoning on their own; the instructors served as facilitators to encourage thought-exchange and challenge participants to re-evaluate their reasoning. In the last two lessons, the instructors explicitly reviewed the specific thinking skills that were used or should have been used to analyze each of the issues presented in previous lessons.

In all of the three experimental groups, each inquiry-based discussion exercise lasted about 45 minutes. Groups A, B, and C respectively explored four, six, and nine controversial issues during the course. The participants in the control group completed the pre- and post-program assessments without receiving any training.

Materials for the Intervention Program

The course materials were developed using a critical thinking teaching package (Halpern 1998) as the basis. There were four modules: (a) argument analysis, (b) evaluating causal claims, (c) understanding mental models, and (d) decision-making skills. Modules a, b & d concern training of generic cognitive skills underlying informal reasoning and argumentation, whereas module c aims at nurturing thinking dispositions favorable to the development of critical thinking.

The teaching materials for the parts of the course aimed at a direct instructional approach included PowerPoint slides with clear learning objectives, step-by-step explanations, and examples of discrete critical thinking skills. In addition, there were corresponding worksheets with exercises for practicing the applications

of skills (Ku et al. 2009).

The teaching materials for those parts of the course aimed at an inquiry-based instructional approach included hypothetical scenarios (e.g., determining the criteria important to the selection of a keep fit program; evaluating the reasoning in a speech given by a spokesperson of a political party). Each scenario was followed by open-ended questions and/or interactive activities (i.e., debate, role play) (Ku et al. 2011). A brief outline of the course materials and an example of an issue for inquiry are presented in Appendix A and B, respectively.

Recruitment and Training of Instructors

To reduce the idiosyncratic effects associated with a particular efficient or ineffective teacher in the context of a certain teaching approach, we involved a large number of teachers in our program. A total of 41 instructors were recruited and interviewed in education-related seminars. All of the teachers were degree holders and in-service teachers from local secondary schools with a postgraduate certificate in education or equivalent. The recruited teachers were teaching in secondary schools of middle to upper tiers.

We randomly assigned each teacher to teach in one of the three experimental conditions. All teachers received a three-hour general training on critical thinking. They then attended two three-hour workshops in small groups on training of the intervention materials and the assigned instructional approach. Altogether the instructors received nine hours of training. The trainer was a university professor experienced in teaching critical thinking. After the training, the instructors were given one month to familiarize themselves with the course materials and to discuss any areas of uncertainty with the trainer. During the intervention period, the trainer observed one session from half of all the classes to ensure quality of teaching.

Measures

Critical thinking performance. Tasks were selected from the Chinese version of the Halpern Critical Thinking Assessment using Everyday Situations (HCTAES; Halpern 2007). The HCTAES contains 25 scenarios, each with open and forced-choice parts, and there are five scenarios in each of the five dimensions: verbal reasoning skills, argument analysis skills, skills in hypothesis testing, using likelihood and uncertainty, and decision making and problem solving. In the current study, the best two scenarios in terms of discrimination power from each of the dimensions were adopted. Confirmatory analyses of the five dimensions were conducted in which the uniqueness of the open- and closed-ended items from the same scenario was allowed to be correlated in order to reflect the similarity in the content in these two items (Marsh and Hau 1996). The fit of the model was reasonably good: $\chi^2(150) = 180.44, 182.83$; RMSEA (Root Mean Square Error of Approximation) = .0177, .0204; NNFI (Non-Normed Fit Index) = .920, .928; CFI (Comparative Fit Index) = .937, .943 for the

pre- and post-training performance, respectively. A second-order factor model treating the five components as first-order did not deteriorate too much, thus supporting the suitability of using a simplified one total score in the analyses: $\chi^2(155) = 192.06, 186.52$; RMSEA = .0194, .0197; NNFI = .904, .932; CFI = .922, .947 for the pre- and post-training performance, respectively.

To provide further information for triangulation, an independent multiple-choice critical thinking instrument, the Watson-Glaser Critical Thinking Appraisal (WGCTA; Watson and Glaser 1980) was used (parallel Forms A and B for the pre- and post-test, respectively) to assess the participants' critical thinking competence; the pre- and post-training internal consistency Cronbach's αs were .77 and .68, respectively.

Critical thinking disposition. The thinking disposition of each participant was measured before and after the intervention. Measures on need for cognition, openness to experience, and conscientiousness were selected based on their relations to critical thinking in previous studies (e.g., Clifford et al. 2004; Spector et al. 2000; West et al. 2008). All of the dispositional measures employed the format of a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

The Chinese version of the revised Need for Cognition Scale-Short Form (NCS-SF; Cacioppo et al. 1984; Hui 2003) measures the tendency of participants to engage in activities that require cognitive effort and the enjoyment of such activities. It consists of 18 statements, such as ‘‘I enjoy abstract thinking.” Cronbach's αs were .86 and .88 in pre- and post-training respectively.

The Idea Facet of the Openness to Experience subscale of the NEO Five Factor Inventory (NEO-FFI; Costa and McCrae 1992) measures nondogmatic attitudes and values. It consists of eight items, such as ‘‘I believe controversial topics will only confuse students.” The Cronbach's αs were .80 and .84 in pre- and post-training respectively.

The Conscientiousness subscale of the NEO Five Factor Inventory (NEO-FFI; Costa and McCrae 1992) measures a cautious and methodical approach to tasks. It consists of 12 items, such as ‘‘I work toward my goal systematically.” Cronbach's αs were .80 and .83 in pre- and post-training respectively. The correlations of the pre- and post-training scale scores for NCS, openness to experience, and conscientiousness, as estimates of test-retest reliability, were .76, .76, and .73, respectively.

Participants

A total of 651 Grade 12 students participated in this research. The participants were openly recruited from newspaper advertisements and from posters sent to schools. We did not target to recruit participants of a particular background. The majority of the applications received were from students studying in middle- to

upper-tier local mainstream secondary schools. The training program took place in either a centralized venue located in a secondary school or classrooms of some of the (i.e. 16 out of 41) recruited instructors' schools. 320 participants attended the training in the centralized venue, whereas 246 participants attended the training in one of the classrooms provided by the instructors. In any case, the training took place in on-campus authentic classroom settings. Those in the control group did not receive any training. All recruited participants were randomly assigned to one of the three experimental groups or the control group. The 41 instructors were randomly assigned to teach using one of the instructional modes (i.e., Group A, B or C) either in their own school or in the centralized venue. The number of students attending this experimental teaching in different schools varied due to reasons such as convenience of location and schedule of classes, so the final sample sizes across the three experimental groups were not identical. The final sample size in each group was: 242 in Group A, 155 in Group B, 169 in Group C, and 85 in the control group. The participants in each group were further divided into smaller classes (20 classes in total) with an average class size of 28.3 students. Due to random assignment, the majority of the instructors were teaching participants who were not their own students. The participants in the three experimental groups were told that they would be given a certificate of attendance after the completion of the course. For the control group, US$25 book coupon was given.

Procedures

Over a 2-week period, the participants in the experimental groups attended six 3-hour sessions, with pre- and post-program assessments (see Table 1). During the pre- and post-assessments, the participants completed the Chinese 10-item version of HCTAES, the WGCTA, and dispositional scales of critical thinking. On average, the participants required 2.5 hours to complete all of the assessments.

Statistical Analyses

Hierarchical regression analyses were conducted with each of the individual post-training critical thinking skill, thinking disposition, and transfer of knowledge measures being used separately as the dependent (outcome) variable and the respective pre-training measures being controlled as the predictors. This enabled us to compare the improvement (value-added) in the open-ended critical thinking questions. The three experimental groups were coded as three dummy variables (coded as 1) with the control group as the reference (coded as 0 in all three dummy variables).

We were also interested to know whether any of these training modes was more effective for students with (a) a higher (or lower) initial critical thinking competence and (b) a certain kind of initial disposition (e.g., whether a certain method was more effective for students with a stronger need for cognition). This was achieved

by the inclusion of the related interaction terms if they reached the necessary significance level ($p < .01$). Following the advice of Aiken and West (1991), the predictor variables were standardized, the interactions were formed by multiplying the standardized variables, and the unstandardized solutions were treated as if they had been standardized.

Results

The descriptive statistics of the pre- and post-training critical thinking performance and thinking dispositions are listed in Table 2. Overall, for the HCTAES and WGCTA, , the participants with better initial critical thinking performance performed better in the corresponding post-training critical thinking assessment. The b^*ranged from .33 to .51 for WGCTA and HCTAES (see Table 3, row 1, the first four columns). Similarly, post-training thinking dispositions were strongly related to pre-training dispositions (b^* ranged from .60 to .72; see Table 3, row 1, the last three columns).

Effects of Training on Critical Thinking Performance

Compared to the control group, there was a general trend of improvement in students' critical thinking competence after training, particularly as measured by HCTAES open-ended items ($b^* = .18$, .11, and .23 for direct instruction predominant, balanced, and inquiry-based instruction predominant methods, respectively) and total scores ($b^* = .13$ for both the direct instruction predominant and inquiry-based predominant methods). Only the balanced mode was effective in enhancing students' WGCTA performance after training ($b^* = .12$).

Results also showed that students with a stronger initial need for cognition also had better critical thinking skills as measured by WGCTA ($b^* = .18$). We examined the potential interactions among various main effects. The first three lines of interactional effects (1 × 2, 1 × 3, 1 × 4; Table 3) show the significant interactions between pre-training critical thinking ability and the training mode. The results showed a positive interaction between initial critical thinking competence and the direct instruction predominant, balanced, and inquiry-based predominant methods ($b^* = .22$, .23, and .19, respectively) in the HCTAES closed-ended task performance (see Table 3, under "Interactional Effects", 3rd column).

To sum up, the three training modes were generally useful in enhancing students' critical thinking competence. The interactions effects were small, but they showed (a) the advantages of all three methods for students with a high initial critical thinking ability on the HCTAES closed-ended items; (b) the advantages of the direct instruction method for low ability students in the WGCTA; and (c) the extra gain from the balanced method for high conscientiousness and low openness students on the HCTAES closed-ended items.

Effects of Training on Critical Thinking Dispositions

Students' post-training dispositions were related to their pre-training dispositions (b^* = .60, .72, and .66 for need for cognition, conscientiousness, and openness, respectively). Despite the short duration of the training, the three training modes generally enhanced the participants' thinking dispositions in having greater need for cognition and openness to experience (need for cognition: b^* = .09 and .08 for the direct instruction predominant and balanced modes respectively; openness: b^* = .11 and .08 for the balanced mode and inquiry-based predominant modes respectively.) There seemed to be some mutually reinforcing effects among the dispositions. For example, the students with a stronger pre-training conscientiousness and openness (b^* = .07, .20) had a stronger post-training need for cognition, while those with a stronger pre-training need for cognition had greater post-training openness (b^* = .13). As for the potential interactions with the training modes, significant negative interaction effects were found, namely that with the balanced method, the students with low initial openness increased their openness more than those with high initial openness (b^* = -.10). With regard to the inquiry-based predominant method, the students with a low initial need for cognition improved their need for cognition (b^* = -.09) and openness (b^* = -.10) more than those with a high initial need for cognition.

Students' pre-training dispositions were found unrelated to their post-training critical thinking assessments, except for those with a stronger pre-training need for cognition (b^* = .18) exhibited better performance of WGCTA .

Discussion

We investigated, in authentic classroom settings, the effectiveness of three mixed training modes of critical thinking featuring the two instructional approaches to various degrees and sequences. In general, students who received training clearly showed greater improvement on at least one of the critical thinking assessments compared to those who received no training. The results demonstrated that the training effect of the three mixed training modes of critical thinking were all transferable to other academic domains. In line with the results of a meta-analysis of 117 studies (Abrami et al. 2008) which found that the effect size of critical thinking instruction contributed uniquely to the total variance in an individual's critical thinking development, our finding points to the importance of systematic training of student's reasoning.

Initial Evidence for Mixed Instructional Approach to Teaching Critical Thinking

The current study has highlighted the benefits of adopting more than one instructional approach to teach critical thinking. The inquiry-based and the direct instruction should not be made exclusive in the classrooms. Future research should direct towards how best to bridge the two approaches in order to maximize their benefits on students' learning. Our argument of a mixed instructional approach is in-line with Mayer's

(2004) that constructivist learning is not restricted to pure inquiry methods, but "may be best supported by methods of instruction that enable deep understanding of targeted concepts, principles, and strategies–even when such methods involve guidance and structure" (p. 14). It is also supported by the findings of Angeli and Valanides' (2009) intervention, which pointed to the ineffectiveness of having students explore and discuss problems without providing any guidance. We urge teachers to be made aware that for many students, the repeated discussion of issues without clear guidance and explicit statements of the critical thinking skills involved might not be effective. Discussions or debates appear to be "good activities" in attracting and inviting students' participation. Yet these activities could end with insufficient consolidation of learning, leaving students at a loss as to what the main arguments and learning points are. Teachers should not underestimate the advantages of the direct instruction approach in enhancing the quality of students' thoughts.

It is worth to note that the students who received a half and half combination of direct and inquiry-based instruction (i.e., balanced mode) showed an improvement in both critical thinking assessments and the transfer of learning tasks. A distinctive feature of this mode was that the students experienced both teaching approaches in each lesson, with factual and procedural knowledge taught as the base for more in-depth exploration, and this enabled information acquired to be better maintained through immediate application. . The design of the balanced mode allowed the teacher to define what was to be learned in a particular lesson and provided ample opportunities for the students to make use of the cognitive skill learned in longer discussions so as to uphold their interest and consolidate their learning. Whereas, for the students in the groups using the other two training modes, the learning of a particular skill and the application of this skill did not happen in a simultaneous manner: there was up to a 2-week gap in between. The effectiveness of the balanced mode sheds light on the importance of how different instructional strategies should be sequenced and arranged to fit the nature of what is to be taught. Indeed, our results echo the proposition of having direct teaching act as the foundation for more inquiry-based activities that come in later in the learning process (Klahr 2009), as such an arrangement allows students to build up retrieval cues corresponding to the structural aspects of a cognitive skill and, in so doing, better able to apply the skill to tasks of a similar structure (Halpern 2003).

Assessment and Critical Thinking Performance

A few other observations from our findings are worth highlighting. The open-ended part of the HCTAES allowed the improvement in the students' critical thinking competence to show through, but the closed-ended part did not. Although those with a high initial critical thinking ability benefited more than those with a low initial critical thinking ability in all of the three training modes when they were assessed by the HCTAES

closed-ended tasks, intervention did not effectively raise the performance of low critical thinkers. This points to the interlocking relationship between assessment and instructional needs. Halpern (2007) referred to multiple-choice tasks as testing the individual's ability to recognize the correct conclusion from a given list options, whereas open-ended tasks test the person's ability to generate and express his or her own reasoning. To perform well in open-ended tasks, students have to pay an additional effort to choose and execute the right skills for the right problems, and to put their reasoning into precise wordings. In other words, apart from mastery of cognitive skills, performance on open-ended tasks reflects also an individual's critical thinking dispositions and verbal reasoning ability, which the multiple-choice tasks do not adequately capture. In addition, the teaching materials utilized in the current study for inquiry-based activities consisted of issues that were ill-structured and open to diverse views. These characteristics facilitated conjecture and the use of argumentation skills: As the students were required to overtly articulate their state of understanding and the justifications for their beliefs, they engaged in active knowledge construction (Koschmann et al. 1994). Such progress in student's reasoning might not be adequately captured by multiple-choice questions; hence, teachers must take note that tasks that ask for self-constructed answers are needed in order to objectively assess students' progress, strengths, and needs (Norris 2003).

Given the three instructional modes produced slightly different impact on students' performance on the two critical thinking assessments, it is worth to consider the implication that any single assessment of critical thinking is perhaps unable to examine all relevant aspects of a person's thinking ability (Ku 2008). When evaluating a student's ability to think, it is therefore important to use more than one form of test, such as utilizing both multiple-choice exercises and assignments that allow self-constructed responses, so as to capture comprehensively the student's strengths and weaknesses.

Nurturance of Critical Thinking Dispositions

The thinking habits of the students were positively influenced by the training despite its short length. We were pleased to observe that all of the students who received training showed more enjoyment in learning and a quest for intellectual activities at the end of the program. The students who attended the balanced and inquiry-based predominant training groups also showed more flexibility toward new ideas. In a learning context where the open exchange of ideas was a constant, the students learned to become more tolerant of different opinions and obliged to consider alternatives and diversity.

Students with a stronger initial quest for thinking-related activities performed significantly better in WGCTA, but not the HCTAES, than those with a weaker initial disposition, regardless of which training mode

they were in. This is perhaps due to the nature of the WGCTA as focusing more on the cognitive component of critical thinking compared to the HCTAES (Ku 2008), and therefore better captured by a thinking disposition that measure cognitive effort and the enjoyment of such activities.

Limitations and Future Directions

The foremost limitation of the current study is the small effect sizes of the intervention. However, we must emphasize that the nature of teaching for critical thinking is in many ways unlike subject teaching in the usual classroom. A common way of assessing growth in subject knowledge is to test students with items very similar to those being taught (e.g., solving addition problems), and thus substantial progress is not difficult to see. In contrast, in the domain of critical thinking, what is being assessed is the relatively stable trait of competence, which might not be easily improved or observed, particularly in such a short intervention program. We therefore have not evaluated whether the students can retain this ability for an extended period of time. Further in-depth assessment of the long-term and delayed transferable effects is definitely required to establish any firm relations between various instructional approaches and critical thinking.

Given the short length of the training program, and that only one module of the program tapped on dispositions, we do not see a consistent evidence of students with stronger initial dispositions toward critical thinking showing a greater improvement in performance compared to those with a weaker initial inclination. However, the need for critical thinking training to include nurturance of dispositions together with the teaching of cognitive skills is clear. Future research exploring the relationships between the skill component and disposition component of critical thinking and how best to facilitate both in real-life classrooms is much needed.

Conclusion

In sum, it is important to note that the direct and the inquiry-based instructional approaches should not be seen from an either-or perspective; they should be discussed with the aim of maximizing student learning. Any critical thinking program should provide to students an interactive learning environment that enhances the students' awareness of their own ideas, beliefs, and thinking processes and hence prompts them to engage in reflection and seek alternative solutions.

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Table 1

Experimental Design and Treatment of Groups

<table>
<tr><th>Procedure</th><th>Group A
(Direct instruction predominant,
n = 242)</th><th>Group B
(Balanced mode,
n = 155)</th><th>Group C
(Inquiry-based instruction predominant,
n = 169)</th><th>Control Group
(No training,
n = 85)</th></tr>
<tr><td>Pre-training assessment [a]</td><td colspan="4">For critical thinking performance:
Chinese version of HCTAES, WGCTA-Form A

For critical thinking dispositions:
NCS, Openness, and Conscientiousness subscale</td></tr>
<tr><td>Training [b]
Lesson 1[a]
Lesson 2
Lesson 3
Lesson 4</td><td>Direct instruction</td><td rowspan="3">Direct instruction for the first half of each session, with the second half of each session adopted an inquiry-based instructional approach</td><td>Inquiry-based instruction</td><td rowspan="3">No training</td></tr>
<tr><td>Lesson 5
Lesson 6</td><td>Inquiry-based instruction</td><td>Direct instruction</td></tr>
<tr><td>Post-training assessment</td><td colspan="4">For critical thinking performance:
Chinese version of HCTAES, WGCTA-Form A

For critical thinking dispositions:
NCS, Openness, and Conscientiousness subscale</td></tr>
</table>

Note. Group A is the direct instruction predominant group. Group B is the balanced training group. Group C is the inquiry-based instruction predominant group. HCTAES = Halpern Critical Thinking Assessment Using Everyday Situations; WGCTA = Watson-Glaser Critical Thinking Appraisal; NCS = Need for Cognition Scale-Short Form; Openness = NEO Five Factor Inventory, Openness to Experience subscale; Conscientiousness = NEO Five Factor Inventory, Conscientiousness subscale.

[a] Unlimited time was given for participants to finish the tests and instruments in pre-training and post-training session. [b] Each training session lasted for 2 hours.

Table 2

Pre- and Post-training Critical Thinking Skills Performance and Thinking Dispositions

	Group A (Direct instruction predominant)			Group B (Balanced mode)			Group C (Inquiry-based instruction predominant)			Control Group (No training)		
Measure	*M*	*SD*	Range[a]	*M*	*SD*	Range[a]	*M*	*SD*	Range[a]	*M*	*SD*	Range[a]
Pre-training												
WGCTA-Form A	53.48	8.46	0-69	56.54	7.07	32-73	55.41	7.58	26-72	55.01	6.92	32-69
HCTAES-Open-ended	19.70	4.83	9-32	20.09	4.56	9-30	20.29	4.88	8-33	19.95	4.80	10-32
HCTAES-Close-ended	35.01	4.20	22-45	35.81	3.93	25-47	35.63	4.80	18-45	34.20	4.44	21-44
HCTAES-Total	54.71	7.51	37-73	55.91	6.65	39-71	55.92	8.00	31-75	54.15	6.61	38-69
NCS	60.33	8.33	37-87	61.79	9.32	36-88	61.45	10.49	30-83	59.55	9.66	31-80
Conscientiousness	40.89	6.16	25-55	40.97	6.22	25-57	41.41	6.77	20-56	41.41	5.82	28-56
Openness	28.62	4.53	17-39	29.04	5.03	16-40	28.92	5.09	13-39	27.50	5.86	10-39
Post-training												
WGCTA-Form B	54.16	6.76	36-72	58.10	6.06	38-74	57.50	7.34	35-70	54.82	6.93	37-73
HCTAES-Open-ended	23.61	4.89	12-33	23.35	4.45	13-33	24.42	4.43	10-34	22.37	4.78	8-32
HCTAES-Close-ended	36.81	4.50	20-46	37.45	4.33	22-46	36.99	4.30	21-47	35.58	4.78	24-46
HCTAES-Total	60.42	7.65	37-76	60.79	7.02	39-75	61.41	7.09	40-79	57.94	7.93	39-75
NCS	28.51	5.16	14-40	29.39	4.62	17-40	28.91	4.75	14-40	26.95	5.70	10-40
Conscientiousness	61.78	8.72	36-84	62.76	9.30	37-90	62.30	8.98	36-85	59.33	10.07	27-83
Openness	41.84	6.09	28-57	41.31	5.99	27-60	41.14	6.44	17-58	41.46	5.72	27-53

Note. $n_{\text{group A}} = 242$, $n_{\text{group B}} = 155$, $n_{\text{group C}} = 169$, $n_{\text{control}} = 85$. HCTAES = Halpern Critical Thinking Assessment Using Everyday Situations; WGCTA = Watson-Glaser Critical Thinking Appraisal; NCS = Need for Cognition Scale-Short Form; Openness = NEO Five Factor Inventory, Openness to Experience, Idea facet; Conscientiousness =

NEO Five Factor Inventory, Conscientiousness subscale; Group A is the direct instruction predominant group. Group B is the balanced training group. Group C is the inquiry-based instruction predominant group.

[a] Possible range of NCS scores = 18 - 90. Possible range of Openness scores = 8 - 40. Possible range of Conscientiousness scores = 12 - 60. Possible range of WGCTA scores = 0 - 80. Possible range of HCTAES-open-ended scores = 0 - 38. Possible range of HCTAES-close-ended scores = 0 - 52. Possible range of HCTAES total scores = 0 - 90.

Table 3

Effects (b^*s) of Training Conditions, and Thinking Dispositions on Students' Critical Thinking Performance and Thinking Dispositions

	WGCTA	HCTAES			Dispositions		
Predictor	Total	Open-ended	Close-ended	Total	NCS	Conscientiousness	Openness
1.Pre-training	.334***	.468***	.413***	.506***	.596***	.722***	.655***
Training Effect							
2. Direct Instruction Predominant (Group A)	-.011	.183**	.064	.131*	.087*	.060	.075
3. Balanced (Group B)	.119*	.111*	.029	.065	.076*	.010	.108**
4. Inquiry-based Instruction Predominant (Group C)	.061	.226***	.023	.125*	.065	-.023	.078*
Dispositions							
5. NCS	.182**	-.004	.062	.038		.053	.126***
6. Conscientiousness	.016	.077	.041	.057	.073**		.022
7. Openness	-.068	-.028	-.004	-.017	.195***	-.037	
Interactional Effects							
1 x 2	-.128***		.216***				
1 x 3			.229***				
1 x 4			.189***				
3 x 6			.096**				
3 x 7			-.095**	-.094**			-.096***
4 x 5					-.093**		-.095**
Total R^2	.460***	.524***	.488***	.558***	.781***	.735***	.773***

Note. For all critical thinking performance measures, $n_{\text{group A}} = 242$, $n_{\text{group B}} = 155$, $n_{\text{group C}} = 169$, $n_{\text{control}} = 85$. Non-significant interactions are omitted. HCTAES = Halpern Critical Thinking Assessment Using Everyday Situations. WGCTA = Watson-Glaser Critical Thinking Appraisal. NCS = Need for Cognition Scale-Short Form. Openness = NEO Five Factor Inventory, Openness to Experience, Idea facet. Conscientiousness = NEO Five Factor Inventory, Conscientiousness subscale.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Appendix A

Course Content of Chinese Version of Halpern's (2007) Critical Thinking Teaching Package

The critical thinking teaching package (Ku et al. 2011), adopted from Halpern (2007), consists of four modules: (1) Argument Analysis, (2) Evaluating Causal Claim, (3) Understanding Mental Models, and (4) Decision-making Skills.

Table A1

Modules of Critical Thinking Teaching Package

Module	Components
1	• Understanding of critical thinking • Identifying the structure of a valid argument • Evaluating the strength of reasons • Identifying imbedded assumptions • Importance of counterarguments • Identifying invalid arguments
2	• Distinguishing fact, opinion and argument in real-life examples • Distinguishing correlation and causal relationship • Evaluating product claims with scientific methods • Analyzing common fallacies
3	• Understanding mental models and how they affect our decision • Strategies to avoid mental models
4	• Understanding the process of effective decision-making • Understanding principles of systematic decision-making

Appendix B

Example of Scenario Provided for Group Discussion/ Debate and Class Activities

Sample Scenario: The Fate of the Island

You live in a backward and remote island nation. For the past a hundred years or so, people on the island are self-sustained, living on farming and herding. Neighbouring the small island is a big, prosperous and advanced nation. Recently, using their instruments, specialists in that nation detected that within three weeks, the small island will be hit by intense earthquakes. The quakes could last months, generating a tsunami that will drown the entire island.

When the neighboring nation received the news, they sent a warning to your island. They urged you and your people to leave immediately. The nation also agreed to temporarily accommodate the island's inhabitants. Your livestock, however, were forbidden to enter. The island government accepted this arrangement and asked its people to take shelter in the neighboring nation for at least a few months. This was met with strong objection from the local people on the island. They claim for hundreds of years people here had used animal behavior and weather changes to predict earthquakes, which had always been accurate. They predicted no earthquakes in the region around the island any time soon. They also considered the technology in the neighboring nation unreliable. Moreover, if they left behind all livestock and farmland for months, everything would have died before the people could come back. The next year's provisions will be all but gone.

Scenario Discussion

The discussion should guide students to make a rational and informed decision on whether a full

evacuation of the island's inhabitants is necessary.

Extended Thinking

Guiding students to utilize decision-making skills to become a smart consumer of medical services.

Transfer and Application

Guiding class to apply the techniques acquired from this scenario to discuss:

(1) "How is people's understanding of health affected by economic, social and other factors?"

(2) "In what ways is people's understanding of public health affected by health information, social expectations, personal values and beliefs in different cultures?"