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Author(s)	Kong Siew Lang
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Effects of a Cognitive-Infusion Intervention on Critical Thinking Skills and Dispositions of Pre-service Teachers

KONG Siew Lang
National Institute of Education
Nanyang Technological University
Singapore

ABSTRACT

This study examined the effects of the Cognitive-Infusion Intervention on critical thinking skills and dispositions of the pre-service teachers in Singapore. Quasi-experimental 2 x 2 factorial pretest-posttest design was employed. The two factors are treatment condition [experimental vs. control], and education programme grouping [Post Graduate Diploma in Education (PGDE) vs. Diploma in Education (DipEd)]. The study aims to find out whether there will be any improvement in their critical thinking skills (measured by Watson-Glaser Critical Thinking Appraisal: Watson & Glaser, 1980), and critical thinking dispositions (measured by California Critical Thinking Dispositions Inventory: Facione et al., 2000). Results show that participants who have gone through the Cognitive-Infusion Module (CIM) scored significantly higher ($p<.05$) in the overall critical thinking skills and the sub-skills of 'inference', 'deduction' and 'recognition of assumptions'. The PGDE experimental group also scored significantly higher in the overall critical thinking dispositions ($p<.05$) as well as the dispositions of 'analyticity' ($p<.01$) and 'inquisitiveness' ($p<.01$). Implications of the study are discussed.

Keywords

Infusion; Critical Thinking Skill; Critical Thinking Disposition; Teacher Education

INTRODUCTION

The concern for teaching thinking skills is penetrating the education system everywhere in the world. All levels of society agree that thinking skills are crucial for one to remain relevant and proficient in this fast-paced and competitive world. In the era of massive information and technology explosion as such, there is an urgent need for pupils to learn in 'thinking schools', where teachers emphasise skilful thinking. Learning by heart and rote learning are no longer sufficient. High quality learning and thinking require more than the transmission of facts and the routine application of familiar procedures (McGuinness, 1999). Moreover, model answers for exams may not be relevant to the real world 'questions' or problems. To be a skilful thinker, one needs to learn meaningfully, think flexibly and be able to make reasoned judgments. It is crucial to ensure that the young generation is able to think independently, generate creative initiatives and solve unexpected problems, while remaining intellectually proficient. We cannot assume that students will spontaneously pick up these skills without being taught explicitly.

In such a context, teachers play a crucial role in moulding the next generation of effective citizens in a rapidly changing world. If teachers are expected to create such dynamic classroom environment, they need to be trained in their pre-service or in-service courses. It is presumptuous to believe that teachers should know what to do as long as they were informed of the philosophy of the thinking programme. According to Martin (1984), one of the critical elements in training teacher for a thinking programme is the explicit discussion of the cognitive and metacognitive processes during their teacher training.

Research has shown that the more explicit the teaching of thinking is, the more students will learn the processes of thinking and their applications (Swartz & Parks, 1994). Focusing

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on thinking skills in the classroom is important because it supports active cognitive processing which makes for better learning (McGuinness, 1999). The learning of thinking skills will be even more meaningful when it is reinforced in the lessons taught, with curriculum content as its context. When thinking skills are infused and weaved into the lesson instruction, students are able to gain a deeper understanding of the content they are learning, resulting in meaningful and transferable knowledge. Research elsewhere has shown that methods employed by teachers play an important role in the knowledge development of the students (e.g., Underbakke, Borg & Peterson, 1993). Embedded cues in teacher's questionings that indicate the level of thinking, and quality of syntax used are reflected in the student's responses (Costa, 1991). Studies have also indicated that students score higher on critical thinking tests (Wee, 1984) and standardised achievement tests (Redfield & Rousseau, 1981) when teachers adopt higher-order cognitive questioning techniques.

In order to impart thinking skills effectively to students, there has to be, first of all, a paradigm shift in the teacher's attitude, knowledge and practice pertaining to the teaching thinking movement (Ruggiero, 1988). Implementation of thinking programme at school level would require some form of training for teachers, usually through in-service training (Chua & Leong, 1998). At the same time the pre-service teacher education programme needs to be reviewed in response to the needs created by the thinking skills movement. Therefore, it is timely for teachers in their pre-service training, to be exposed to the various thinking skills as well as their nature and importance of these higher-order cognitive processes. As depicted in Figure 1, in order to prepare teachers to teach thinking skills in the classroom context, their general thinking skills, thinking dispositions and attitudes, as well as cognitive schemata and core beliefs about thinking and learning need to be revisited.

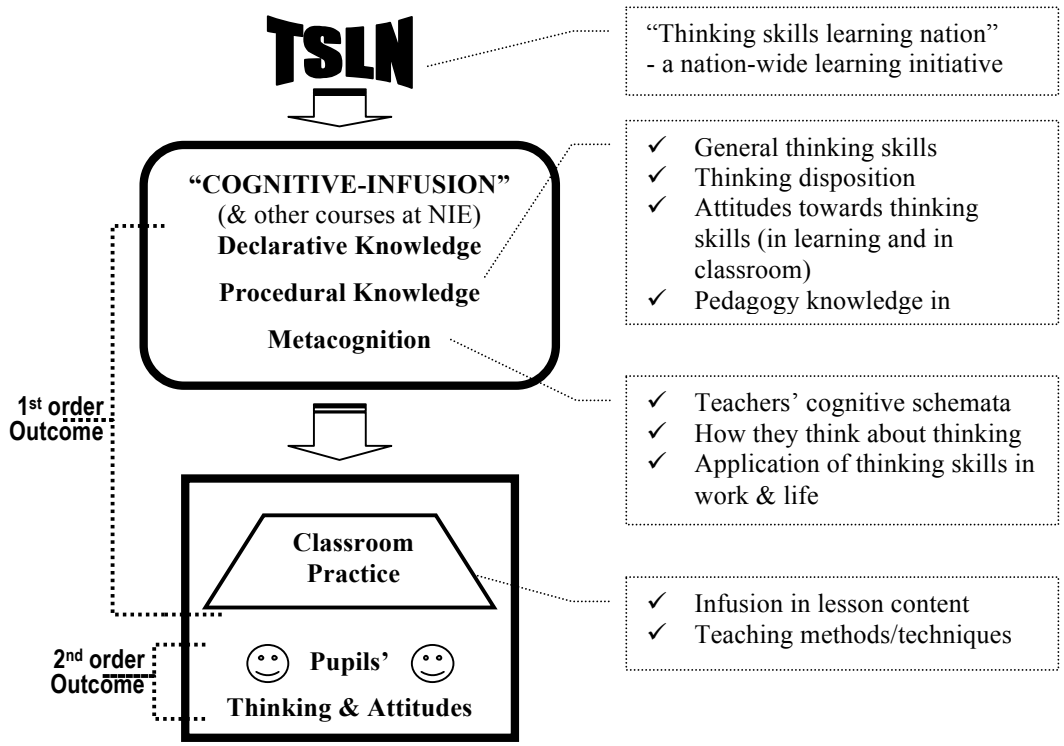

Figure 1: Means-Ends Model for Teaching Thinking within Curriculum Content

These components are particularly important as current teachers encounter much more complex issues than before when dealing with school children. Being equipped with thinking skills will enable them to employ higher-order thinking skills in their lessons and, using metacognition, to better understand how they may teach their students to be more effective in complex thinking tasks such as decision making and problem solving. Ever since the thinking movement in 1980s, educational scientists and the general public alike have come to agreement that critical and creative thinking abilities should not be just another educational option; rather it should be an indispensable part of education (e.g., Norris, 1985). This has stimulated the creation of a variety of special programmes to bring the explicit teaching of thinking into the classroom. However, not much has been said, least researched, about programme to prepare pre-service teachers for carrying out the thinking programmes in the classrooms.

In Singapore, the concept of 'thinking schools learning nation' and 'teach less learn more' recognises that lifelong learning is essential for the individual and the society as a whole. In order to achieve 'thinking schools', 'thinking teachers' need to 'teach less', yet at the same time, provide knowledge acquisition skills to their students to 'learn more' independently. One of such skill is reasoning and higher-order thinking. If this generation is a legacy of the old educational system, then teachers and teacher-to-be need to be explicitly taught the same skills before they are expected to teach the next generation. Therefore, training teachers-to-be in the area of thinking skill is of paramount importance.

THE COGNITIVE-INFUSION INTERVENTION MODULE (CIM)

In order to prepare pre-service teachers for teaching thinking skills in schools, particularly teaching the same skills simultaneously with lesson content, the infusion approach was adopted in an elective module on effective thinking and learning. This intervention module is conceptualised based on the DASK (Disposition, Attitude, Skill, and Knowledge; shown in Figure 3) model, which is an extension of the ASK (Attitudes, Skills, and Knowledge) model of teacher education. The ASK model is shown in Figure 2. The ASK model mirrors the desired outcomes of the teacher education in Singapore (Tan & Gopinathan, 1999). Besides furnishing teachers with knowledge and skill for effective teaching, the ASK model also stresses the affective aspect such as attitudes and values.

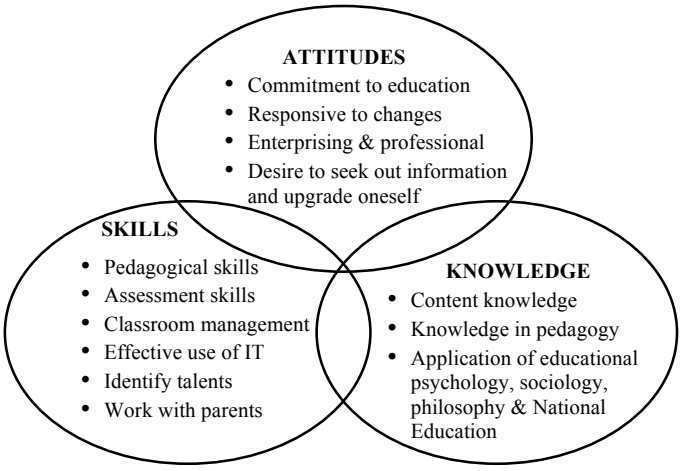

Figure 2. The ASK Model for Teacher Education (Source: Tan & Gopinathan, 1999)

However, preparing teachers to teach thinking skills requires more than the generic ASK components for effective teaching. The additional components fall on teachers' general

dispositions towards teaching thinking skills in the classroom, as well as their dispositions towards a particular approach of teaching thinking skills. There are times where the very core of a person's belief about teaching needs to be challenged. For example, in order for thinking activities to take place in the classroom, teachers must transfer the ownership of learning to the pupils. Teaching should not be treated as passive passing on of facts, but an active exploration on the part of the learners.

Therefore, besides the attitudes, skills, and knowledge components as depicted in the original ASK model, an additional component, the 'D' component (i.e., thinking disposition), needs to be included. This dispositional component is closely related to the affective dimension of a particular thinking skill, i.e., the willingness and inclination to think in that particular way. According to many theorists in thinking skills, a good and effective thinker comes with certain characteristics or dispositions. For example, Nisbet (1990) argued that since thinking requires effort and active involvement on the part of the thinker, attitudes and motivation towards the particular thinking play an important role in its usage. This means that knowing about effective thinking (both knowledge and skills) is not sufficient. One also needs to have the inclination and will to use that knowledge in real life problem solving and decision making. Such inclination and willingness can facilitate the development of the productive habits of thought.

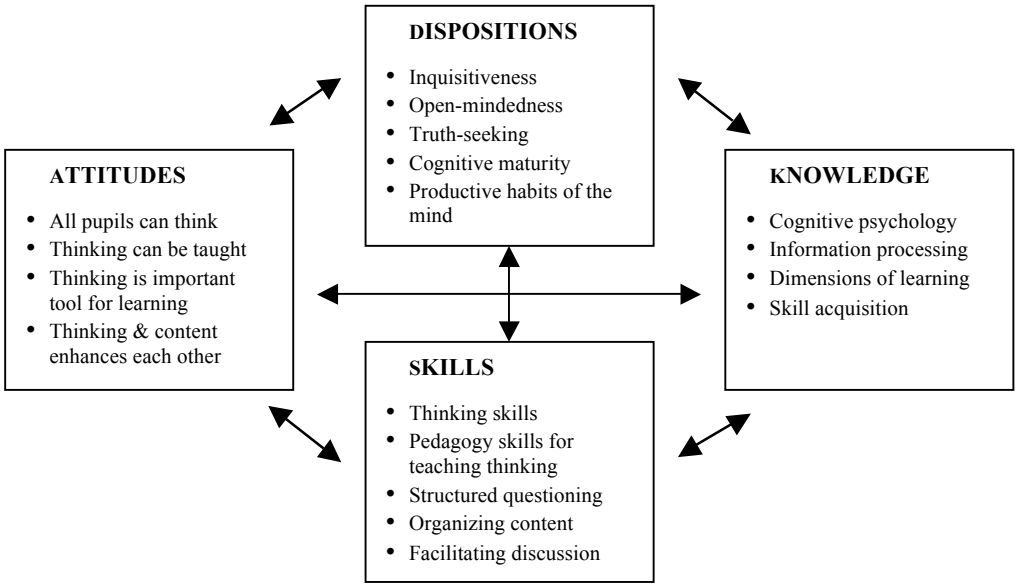

Figure 3. Components of the DASK Model

The DASK model (depicted in Figure 3) serves as the underpinning framework for the development of the CIM intervention. The conceptualisation of this module is based on the review of literature on thinking and teaching of thinking. The CIM curriculum attempts to integrate both the contents (i.e., concepts, principles, generalisations, problems, facts, definitions, etc) and processes (i.e., strategies and skills) without leaving out the motivational or affective dimension of teaching thinking. In other words, this thinking module covers both the theoretical and practical dimensions of teaching thinking. The main objective of CIM is to prepare pre-service teachers in NIE to teach thinking skills in the classroom context, and at the same time be effective thinkers themselves.

METHOD

Design and Participants

This study employed a 2 x 2 quasi-experimental pretest-posttest factorial design. The two factors were the treatment conditions (experimental - CIM; vs. control - non-treatment), and education programme grouping (Postgraduate Diploma in Education - PGDE; and Diploma in Education - DipEd: both groups were pre-service teachers for the primary school level). Overall, 136 pre-service teachers reading PGDE (N=27) and DipEd (N=109) took part in this study. Pretest was administered at the beginning of the experimental period. After a ten weeks session, the experimental process ended with a posttest. Participants in the experimental group (N=70) went through the CIM, whereas the control group (N=66) went through an alternative module, which was counselling skills. The study reported in this paper is part of a larger project which aims to evaluate the effect of CIM on trainees' cognitive changes and classroom practice. The research questions being investigated in this paper are: (1) What is the effect of the intervention module on the critical thinking (CT) skills of pre-service teachers? and (2) What is the effect of the intervention module on the CT dispositions of pre-service teachers?

Instrumentation

The Watson-Glaser Critical Thinking Appraisal (WGCTA) (Watson & Glaser, 1980), first published in 1942, is known to measure critical thinking ability in a general population and defines critical thinking in broad, non-specific terms. The WGCTA version used in this study was a 40-item test with 8 items in each sub-test. The five sub-tests are: *inference*, *recognition of assumption*, *deduction*, *interpretation*, and *evaluation*. The test/re-test reliability conducted with the local (i.e., Singapore) sample after adaptation was at .73.

The California Critical Thinking Disposition Inventory (CCTDI) was used to measure each participant's disposition towards critical thinking (Facione et al., 2000). It is currently the only standard instrument available to assess the affective and attitudinal dimension of critical thinking. The CCTDI is a 75-item inventory that consists of seven factors or scales. The seven factors are: *truth-seeking*, *open-mindedness*, *analyticity*, *systematicity*, *critical thinking self confidence*, *inquisitiveness*, and *cognitive maturity*. For the Singapore context, the alpha levels remain relatively stable, ranging from .52 to .86 on the seven sub-scales and .89 on the overall scores.

RESULTS

Critical thinking skills

Analyses of variance (ANOVAs) show that the experimental groups scored significantly higher on the overall WGCTA scores at level $p<.05$. This is true for both experimental groups of the PGDE and DipEd [$F(1,26)=4.35$; & $F(1,108)=5.35$ respectively]. For the PGDE group, the mean score of *inference* and *deduction* have also reached the level of significance at $p<.05$ [$F(1,27)=5.58$ & 5.78 respectively]. For the DipEd group, the mean score of *recognition of assumptions* has reached the level of significant at $p<.05$, $F(1,108)=5.24$. The mean differences for the rest of the sub-skills did not reach the level of statistical significance. Effect sizes for the significant changes were calculated [effect size = difference of experimental and control group/standard deviation of control group]. Cohen (1988) recommended standardised mean differences of .2, .5, and .8 for small, medium, and large effects. The effect sizes for the PGDEs were: 0.89 for WGCTA overall score, 0.82 for *inference*, and 0.81 for *deduction*; whereas for the DipEds: 0.45 for WGCTA overall score, and 0.4 for *recognition of assumptions*. The 2-way ANOVA results for treatment by programmes of study as measured by WGCTA show that there are significant main effects

for treatment of the WGCTA overall scores (F=6.83; p<.01). This means the experimental group of both PGDE and DipEd trainees have scored higher at the WGCTA posttest than the control group. In terms of the effects of CIM on pre-service teachers from different programmes of study, the PGDE scored higher than the DipEd trainees in the overall WGCTA (F=9.94; p<.01). Similar trends are also found with the CT sub-skills of *deduction* (F=5.08; p<.05) and *interpretation* (F=5.20; p<.05).

Critical thinking dispositions

The overall CCTDI posttest mean scores of the PGDE and DipEd experimental groups show an increase of 8.94 and 5.76 points respectively. Except for the *cognitive maturity* for the DipEd trainees, all sub-scales scores of the experimental groups have also increased. ANOVAs show that the PGDE experimental groups scored significantly higher for the overall CCTDI (F=6.79; p<.05) [effect size = 0.89], sub-scales of *analyticity* (F=11.22; p<.01) [effect size = 1.4], and *inquisitiveness* (F=9.52; p<.01) [effect size = 1.16]. The mean differences for the rest of the CT disposition sub-scales did not reach the level of statistical significance. The 2-way ANOVA results for the treatment groups by programmes of study as measured by CCTDI show that there is significant main effect for treatment of the CCTDI overall (F=7.46; p<.01) and the sub-scales of *analyticity* (F=11.64; p<.01), *inquisitiveness* (F=6.50; p<.05) and *cognitive maturity* (F=3.77; p<.05). There is also significant interaction between treatment conditions and programmes of study for the CCTDI overall scores (F=6.41; p<.05). Significant interactions are also found in the sub-scales of *analyticity* (F=6.97; p<.01), *critical thinking self-confidence* (F=5.33; p<.05), and *inquisitiveness* (F=10.47; p<.01).

Overall, results show that the CIM intervention has significantly impacted some of the CT sub-skills (i.e., *inference*, *recognition of assumption*, and *deduction*) and CT dispositions sub-scales (i.e., *analyticity*, and *inquisitiveness*). It was also found that the PGDEs have benefited more from the CIM intervention (CT Skills: *deduction*, and *interpretation*; CT dispositions: *analyticity*, *critical thinking self-confidence*, and *inquisitiveness*). However, the same intervention did not seem to have significant statistical effect on the rest of the aspects investigated. The possible reasons for the less then significant results will also be considered in the subsequent discussion.

DISCUSSION

The results of this study indicate that CT skills, particularly the sub-skill of *inference*, *deduction* and *recognition of assumptions*, can be learned and/or improved even at the adulthood level. This finding, which is similar to those of McKinnon and Renner (1971) and Lawson and Snitgen (1982), supports Sternberg's (1994) notion that thinking skills can be influenced at least to some degree. A significant change also implies that it is not too late for pre-service teachers to alter and improve their CT skills, particularly the abovementioned sub-skills. The curriculum tasks of CIM require trainees to draw conclusion based on their exiting understanding and theoretical knowledge taught. For example, to arrive at the conclusion about the relationship between the concepts of 'thinking' and 'learning', trainees were asked to reflect on their past learning experiences as well as theories of learning such as the cognitive perspective of meaningful knowledge acquisition. Such rigour in their exploration of the lesson content may have contributed to the positive changes in the CT sub-skills.

In terms of CT dispositions, significant differences were also found, for the PGDEs, in the sub-scales of *analyticity* and *inquisitiveness*. Although no significant difference, the posttest means of all the CCTDI sub-scales (except for *cognitive maturity* for the DipEds)

also indicated consistent gains for the experimental group as a result of exposure to the CIM intervention. A possible explanation for the PGDEs scoring significantly higher in the sub-scales of *analyticity* and *inquisitiveness* is that these two dispositions are closely related to the CT skills of *inference* and *deduction*. According to Facione et al. (2000), *analyticity* targets at one's inclination of being alert to potential problematic situations, anticipating possible results or consequences, and valuing the application of reason and evidence even if the problem at hand is challenging and difficult; whereas *inquisitiveness* measures one's intellectual curiosity. An inquisitive person strives to be well-informed and is curious and eager to acquire knowledge and learn explanations even when the applications of the knowledge are not immediately apparent.

During the CIM intervention, trainees were deliberately asked to uncover and re-examine their assumption and beliefs on the topic of thinking and teaching of thinking. At the same time they were also asked to provide explanation of their own belief, and later draw own conclusion regarding, for example, the role of thinking in learning. In the process, they were required to make plenty of reflective judgements, as well as analyse their beliefs against the theoretical knowledge presented in CIM. As a result, they learned the CT sub-skill of *inference* and *deduction;* thus became more inclined towards the CT dispositions of *analyticity* and *inquisitiveness*. This implies that in order for one to improve in a particular CT disposition, one needs to be aware of the value of that particular dispositional quality. In this study, the PGDEs of the experimental group were made aware of the need to be analytical and inquisitive (i.e., being well informed in drawing conclusion) in order to uncover their incorrect assumption about thinking skills and teaching of thinking. Due to such awareness, they became more inclined towards these dispositional qualities.

The treatment by programme interaction analyses indicated that the PGDEs, compared to the DipEds, scored significantly higher in the overall WGCTA. This indicates that CIM has a greater positive influence on PGDEs. Analyses on the CT sub-skills showed that the PGDEs also scored higher on the sub-skill of *deduction* and *interpretation*. The same trend were also found in the CT dispositions sub-scales of *critical thinking self-confidence*, and *cognitive maturity*. A possible explanation for such a trend is that the PGDEs had experienced tertiary education prior to joining the NIE, and during their three or four years of tertiary education, thinking skills such as making deduction and interpretation were emphasised. In this study, the tertiary educational background serves as a side factor for the effect of the CIM. Pascarella and Terenzini (1991) found that the greatest gains in CT occurred during the students' freshman year due to the need for more self-regulated learning approach, compared to a more spoon-feeding approach during high school.

Higher scores in the PGDEs may imply that their tertiary education has introduced them to value an analytical mind, be confident in their reasoning ability, as well as be inquisitive and mature cognitively when dealing with information. Going through CIM, in turn, has reinforced these dispositions and contributed to the greater positive influence at the posttest. The current higher education framework calls for information literacy, in which students are required to interact with information from a variety of sources. For example, information literacy constitutes objectives such as relating information to prior knowledge, synthesising information, and creating something original, whether the latter be in the form of an essay or presentation (Iannuzzi, 1998). Clearly, these objectives and tasks require learners to be alert of problematic situations (i.e., *analyticity*), trust one's own reasoning skills (i.e., *critical thinking self-confidence*), be curious and eager to acquire knowledge and learn explanations (i.e., *inquisitiveness*), and prudent in making, suspending, or revising judgement (i.e., *cognitive maturity*).

Many researchers (e.g., Costa, 2000; Norris & Ennis, 1989; & Swartz et al., 1998) have cited dispositions towards CT as an imperative aspect of self-directed learning paramount for

effective and meaningful learning in this information age. However, the persistent nature of the trainees' CT disposition may have strongly influenced the results of this study, thus showing statistical significant difference between the pretest and posttest means only for the sub-scales of *analyticity* and *inquisitiveness* in the PGDEs. As a Chinese proverb goes, 'it takes only three days to learn bad habits, but three years for good habits!' In this study, habits of thought that developed over the years are most probably the restraining forces for meaningful dispositional change to occur. Perhaps the 10 weeks sessions were not sufficient for dispositional change to take place.

One of the delimitation of this study which may have contributed to the results is the short duration of the CIM intervention. With only ten sessions of treatment, the duration may have been too short for meaningful CT change to occur. This tells us that trying to develop CT skills in a short period of time when human thinking is so complex and multifaceted is a challenging undertaking. Developing CT skills and dispositions requires time, especially when taking into account the existence of the hard core mental model or belief system and habits that oppose the principle of thinking process, i.e. a passive rather than an active processor of information.

Furthermore, considering CT as a cognitive skill, at the end of the CIM intervention, the trainees were probably at the acquisition stage or at most the internalisation stage of skill acquisition (Fits & Posner, 1967). A recent study has shown that the process of learning is strongly associated with 'impasses' (VanLehn, Siler, Murray, Yamauchi & Baggett, 2003). According to VanLehn et al. (2003, p.220), "an impasse occurs when a student gets stuck, detects an error, or does an action correctly but expresses uncertainty about it." Their study showed that an impasse motivates a student to take an active role in constructing a better understanding of the principle. In the case of this study, trainees may have learned some thinking skills but due to the limited time for practice, they remain at the internalisation stage of skill acquisition at the end of CIM. As such they may be experiencing a number of impasses and thus the learned thinking skills were not reflected in their WGCTA and/or CCTDI scores.

CONCLUSION

Going through CIM has brought about a significant improvement on the CT sub-skills of *inference* and *deduction* for the PGDEs; and *recognition of assumptions* for the DipEds. As for the CT dispositions, the sub-scales of *analyticity* and *inquisitiveness* for the PGDEs have also improved significantly. Such positive changes, although limited, has indicated that the infusion approach is effective for improving one's CT skills and dispositions. The findings of this study also provide the evidence that enhancing CT skills at adulthood is still possible. Another interesting finding is that the PGDEs have benefited more from the CIM intervention (CT Skills: *deduction*, and *interpretation*; CT dispositions: *analyticity*, *critical thinking self-confidence*, and *inquisitiveness*). Such a trend may call for teacher educator to employ different approaches when preparing the PGDEs and DipEds to teach thinking skills. The study also implies that in order to improve and develop CT skills, there is a need to, first of all, learn the skills; and then, practice the skills in meaningful context. When practice is involved, time is a crucial factor. More time may be needed for significant changes to take place, particularly in the case of the CT dispositions.

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