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This study investigated the impact of thinking instruction on students' metacognition and thinking behavior. Higher-order thinking occurs when individuals use their underlying metacognitive strategies which increase the probability of achieving a desirable result. The study was designed as a case study of an intervention and a posttest-only control group design was adopted. Participants consisted of students with a variety of majors were recruited from a medium-size university located in southern Taiwan. Two classes of the Developing Thinking course, totaling 78 students, comprised the group receiving the intervention, while 196 students in six General English classes comprised the comparison group. The intervention students were introduced to thinking skills, facts and opinions, question stems, and thinking from different perspectives. The quantitative results show strong evidence that the thinking instruction exerts statistically significant positive effects on students' metacognition. Qualitative evidence also shows improvements in cognitive awareness with students demonstrating a more consistent application of thinking skills, an increased ability to think critically with thinking dispositions cultivated, and most importantly, a transfer of thinking behavior across the curriculum and in their personal lives. The researcher suggests the value of introducing thinking instruction to promote critical thinkers.

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Metacognition is an essential construct in cognitive development. Metacognitive research has contributed to the field of critical thinking (Coutinho et al., 2005; Ku & Ho, 2010; Magno, 2010; Schroyens, 2005), problem solving (Artzt & Armour-Thomas, 1992; Jausovec, 1994; Swanson, 1990), critical reading (Chen, 2019; Zhang, 2001), and the psychology of teaching creative skills (Hargrove, 2012). The empirical studies have identified the importance of metacognitive skills or strategies in cognitive development, in part icular, in developing high cognitive thinking. There is no doubt that metacognition is a core component in various forms of high cognitive thinking. Also, equipping students with high cognitive thinking is one of the main goals in higher education. Empirical studies (Arum & Roksa, 2011) showed that students' critical thinking skills hardly improved during college studies. Further research (Abrami et al., 2015) has shown that students need explicit instruction to improve their thinking skills. The present study argues that it would be ideal if students can be equipped with high cognitive thinking while enhancing their metacognition. One issue raised here is that whether the explicit teaching of higher-order thinking enhances metacognition. To the best of the author's knowledge, no empirical study has conducted an explicit instruction of higher-order thinking and examined its impact on metacognition in the higher education sector. Thus, to fill the research gap, the present study aims to further examine the impact of the teaching of high cognitive thinking on metacognition.

Literature Review

Metacognition

Metacognition has been one of the most concentrated concepts in the field of educational psychology. It is the executive function which guides how an individual uses different learning strategies and makes decisions about the allocation of cognitive resources. Metacognition is simplified as thinking about thinking. Flavell (1976, p. 232) first conceptualized metacognition as “one’s knowledge concerning one’s own cognitive processes or anything related to them.” That is, metacognition refers to the ability to reflect upon, understand and control one’s learning (Flavell, et al., 2002). It is fundamental and essential in all learning.

Metacognition is often conceptualized as comprising two dimensions: knowledge of cognition and regulation of cognition (Flavell, 1976). Knowledge of cognition contains three components that facilitate the reflective aspect of metacognition. First, declarative knowledge involves what one knows about oneself, the characteristics of existing tasks, and the nature of strategies. The second component, procedural knowledge, refers to knowing how to use strategies. The third component, conditional knowledge, is knowing when and why to employ strategies, for example, understanding which strategies are most suitable for different tasks to achieve the desired goals (Jacobs & Paris, 1987). Regulation of cognition refers to selecting proper approaches and organizing processes of how to effectively conduct the strategies to control cognitive processes. It contains five strategies that support the control aspect of learning, including planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation (Baker, 1989). Knowledge of cognition and regulation of cognition are theorized to be related to each other (Schraw & Dennison, 1994); they supplement each other and are both essential for optimal performance (Schraw, 1998). Students can become proficient in their use of strategies when they gain more knowledge about the nature of strategies and understand in what kind of situation a particular strategy should be applied (Pressley, et al., 1998).

Higher-order thinking

Higher-order thinking refers to the mental processes of analysis, synthesis, evaluation described in Bloom et al.'s (1956) taxonomy of the cognitive domain. Teaching thinking is an important part of the educational curriculum in many countries and a desirable goal in higher education (Halx & Reybold, 2006). Fisher (1998) has postulated that thinking can be developed through training, implying that students may become active thinkers when the pedagogy used in classrooms allows them to think independently, critically and creatively. According to Sousa (2001), teachers do not teach the brain to think, but thinking skills (e.g., memorisation, comprehension, comparison, assessment skills) certainly can be taught at all levels to improve learners' achievement. More specifically, students would make an important development in higher-order thinking if teachers in the classroom regularly utilise a thinking model like Bloom's taxonomy (Sousa, 2006). It is worthy to note that while emphasizing the importance of higher-order thinking, lower-order thinking (knowledge, comprehension, and application) is not disparaged. In the process of using higher-order thinking, lower-order thinking is also activated as a pre-requisite of higher-order thinking.

Vygotsky (1978) claimed that a mechanism for individual cognitive development is social interaction. It allows the occurrence of socio-cognitive conflicts which contributes greatly to cognitive development. During social interaction, different perceptions, ranging from simply having different degrees of schemata to holding completely contradictory perspectives, arise and are readjusted. Learners are forced to externalise their thoughts, making their ideas explicit to themselves and to others. Following this, the continuous commenting, justifying and arguing provides them with opportunities to discover and fill the gaps in their knowledge structures, correct misunderstandings, recognise and resolve discrepancies in information, and then readjust conflicting viewpoints (Mugny & Doise, 1978). This is where students proactively use their higher-order thinking.

Thinking skills can be taught through integration with major subjects or as an isolated subject. The skills can be seen as learning strategy, in which cognitive abilities such as memorisation, comprehension, deductive reasoning, inference and creativity are used. As argued by McGuinness (1999), integrating thinking skills in subject content may be the most effective approach for the development of thinking skills. In contrast, if they are to be taught in isolation, as pointed out by Jones et al. (1987), they might not transfer across the curriculum, especially with less proficient learners.

Metacognition and higher-order thinking

Higher-order thinking occurs when learners utilise their cognitive skills which raise the probability of an intended outcome (Kuhn & Dean, 2004). Halpern (1998) asserted that metacognition is the capability to utilise knowledge to rule and enhance thinking skills. Specifically, fostering learners' higher-order thinking is facilitated by metacognition. When conducting higher-order thinking, individuals employ specific metacognitive strategies such as monitoring their thinking process, checking whether the progression is achieving a desirable aim, and making decisions about the expenditure of cognitive effort and time. Preus (2012), investigating a junior high school which implemented higher-order thinking instruction using qualitative research methods, found that both students' higher-order thinking and metacognition were fostered.

Metacognition plays a vital role in critical thinking (Akama, 2006). Empirical studies have shown the relationship between metacognition and thinking skills. Orion and Kali (2005), investigating the impact of an earth-science learning program on learners' scientific thinking skills using qualitative analysis, found that metacognition associates closely with thinking skills. Kuhn and Dean (2004) asserted that epistemological understanding is as a metacognitive development; in a study of argumentative discourse in the context of a debate, they found that metacognition was explicitly applied to achieve critical thinking. For example, to clarify and understand an opponents' argument and construct one's counterargument requires the debater to go through deep-level processing which is an essential part of metacognition. Metacognitive operations help the individual to plan and monitor during the process of debating and control the debating behaviours. Also, Mason and Santi (1994) revealed that metacognitive activities which allowed learners to reflect upon what, why, how and when they knew about an idea were correlated with more advanced argumentative skills. Akama's (2006) study, examining the relations among self-efficacy, goal setting, metacognitive experiences, and performance, found that metacognition plays a vital role in critical thinking. In the study of Magno (2010), using self-report assessment methods to explore the role of metacognitive skills in developing critical thinking computed by the structural equations modeling, found that the factors of metacognition are significantly related to the factors of critical thinking. Ku and Ho's (2010) study, investigating the use of metacognitive strategies during on-going critical thinking processes using think-aloud procedures, further found that the effective use of metacognitive strategies is an essential factor contributing to critical thinking performance; good critical thinkers use more high-level planning and evaluating strategies.

Research questions

The present study aims at filling the existing research gap in the field of metacognition and thinking instruction in the higher education sector. It attempts to enhance learners' metacognition through conducting thinking instruction. The investigation is based on the proposition that teaching learners thinking skills and guiding them to think promotes the application of metacognitive strategies; while employing thinking skills to achieve a desirable goal, metacognitive strategies facilitate the occurrence of thinking skills. The two research questions are as follows:

1. What is the effect of the thinking instruction on learners' metacognition?
2. How does the thinking instruction impact on learners' thinking behaviour?

Methods

Research design

The current study was designed as a case study of an intervention. To evaluate the effect of the thinking instruction on metacognition, a posttest-only control group design was adopted. A posttest-only control group design involves at least two groups, one of which does not receive the intervention, and the data are collected on the outcome measure after the intervention and compared between groups to determine whether the intervention is effective. It is simple and straight forward. This design can be considered as the two last groups of the Solomon Four-Group Design, and it can be seen that it controls for testing as main effect and interaction (Campbell & Stanley, 1963). The Solomon four-group design employs a combination of pretest-posttest design (two groups) and posttest-only control design (two groups) that attempts to take into account the influence of pretesting on subsequent posttest results. However, it suffers from the complexity of the research design like the resources and time to use four research groups and the complexity of statistics involved. Due to the time and research group constrains, the present study used a posttest-only control group design.

Participants

The target students for the study were recruited from a university in southern Taiwan. Two classes of the Developing Thinking course, totaling 78 students (55% female), comprised the group receiving the thinking instruction, while 196 students (42% female) in six General English classes comprised the comparison group. General English was a required subject in the university and all students needed to take and complete the course. These English classes were offered at School of Liberal Education. Both the intervention and comparison students (mostly 18 and 19 years old) had a variety of majors, including accounting, finance, fashion design, information management, computer simulation and design, marketing management, applied Japanese, and recreation management. It needs to be pointed out that both the intervention and comparison students might occasionally practice thinking skills integrated in their major subjects.

Thinking instruction

Thinking instruction in the present study is referred to as instruction aimed at teaching higher-order thinking skills. Thinking skills were taught as an isolated subject and the intervention was conducted in a Developing Thinking course which was a two-credit optional course offered at School of Liberal Education. The intervention lasted 18 weeks, with two class-hours per week. The students' native language, Chinese, was used as the medium language of instruction. The aim of the course was to equip students with higher-order thinking skills. The intervention students were introduced to six thinking levels of Bloom's

Taxonomy (1956), facts and opinions, questioning skills with Morgan and Saxton's (1994) question stems, and thinking from multiple perspectives. The theory of Bloom's taxonomy of cognitive domain was first explained to students and each thinking skill was demonstrated, followed by task execution. Then, thinking tasks with higher-order questions (analysis, synthesis, evaluation) embedded to stimulate higher-order thinking skills were conducted. At the end of the semester, students were required to debate; they were assigned debate topics in advance and worked in groups outside of class.

To build-in the concept of socio-cognitive conflicts into this study, the instruction in the development of thinking skills was designed to allow students to express their opinions with supporting evidence in a social context, to justify the ideas of other group members, and to argue and reason with each other in both large class and small group discussions as well as in a debate.

Data collection and procedure

To measure the extent to which the teaching of thinking impacts on the participants' metacognitive awareness, the present study adopted Schraw and Dennison's (1994) metacognitive awareness inventory. Metacognitive awareness inventory data were collected from both the intervention and comparison groups at the end of the semester to compare the differences in students' metacognitive awareness between the two groups. This self-report questionnaire consists eight scales, including declarative knowledge (8 items), procedural knowledge (4 items), conditional knowledge (6 items), planning (7 items), information management strategies (9 items), monitoring (7 items), debugging strategies (5 items), and evaluation (6 items) with a total of 52 items. The items were rated on 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

The present study further examined the effect of the thinking instruction on students' thinking behaviour. Observational data were collected from observations during the debate. The students not actively participating in the debate were considered observers and were required to provide observational feedback using a peer-evaluation form, containing questions like whether the main arguments support the debating topic, whether questions made to challenge the other side are appropriate, whether the response to the questions makes sense and whether the arguments are supported by evidence. The participants were divided into groups of four with two groups debating at a time. One debate lasted 50 minutes, containing 10 minutes (five minutes for each group) for both groups to present their main arguments of the topic, 30 minutes (15 minutes for each group) for asking questions to challenge the other side, and 6 minutes (3 minutes for each group) for summarizing each groups' main arguments by taking the opponents' argument into account. The debating groups decided which debater to assign to answer questions depending on the type of questions asked. Forty-three observers recorded their observation and provided feedback and comments.

Questionnaires regarding the impact of thinking instruction on students' perceived thinking behaviour were also collected from the intervention group. The questionnaire consisted of two questions: (1) whether students think more frequently than before they took the course and (2) how the thinking instruction impacts on their use of thinking by providing examples.
Fifty-nine intervention students responded to the questionnaire at the end of the semester.

Analysis

To examine the validity of the scales' factor model, confirmatory factor analysis was performed using Amos 22. The model fit (X^2) decreased from 2680.02 to 957.24 by removing 18 items as shown in Table 1. During the modification process, the modification index (MI) is used to aid in the selection of items to add to the model to improve the fit. In addition, to examine the reliability of the adopted metacognition scale, composite reliability (CR) were computed for the eight scales: declarative knowledge (CR = 0.76), procedural knowledge (CR = 0.76), conditional knowledge (CR = 0.71), planning (CR = 0.78), information management strategies (CR = 0.81), monitoring (CR = 0.77), debugging strategies (CR = 0.68), evaluation (CR = 0.71). The results indicated that the upper-level latent variable (metacognitive awareness) explained the lower-level latent variables of eight metacognitive awareness types (declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, monitoring, debugging strategies, and evaluation). The goodness-of-fit indices (GFI) of the modified factor model (GFI = 0.83, $AGFI$ = 0.80, $RMSEA$ = 0.06, X^2/df = 1.92) showed a statistical adequacy between the factor model and data, and the standardized coefficients (β) and squared multiple correlation coefficients (R^2) of each item also reached a satisfactory level: the β values obtained were between 0.55 and 0.73 ($p < .001$), while the R^2 values obtained were between 0.30 and 0.53.

Table 1.

Model summary of before and after removing 18 items

scales	items	Before removing			After removing		
		Std. Coef.	*t*	*CR*	*Std. Coef.*	*t*	*CR*
declarative knowledge	meta5	.47	7.38***	0.76	---	---	0.76
	meta10	.63	10.39***		.66	12.06***	
	meta12	.51	8.00***		.57	10.09***	
	meta16	.56	8.97***		.59	10.46***	
	meta17	.52	8.21***		---	---	
	meta20	.57	9.16***		.65	11.66***	
	meta32	.55	8.72***		.64	11.42***	

	meta46	.46	7.15***		---	---	
procedural knowledge	meta3	.51	8.16***	0.70	.58	10.32***	0.76
	meta14	.65	10.72***		.71	13.25***	
	meta27	.66	11.05***		.65	11.84***	
	meta33	.62	10.18***		.71	13.11***	
conditional knowledge	meta15	.42	6.97***	0.67	---	---	0.71
	meta18	.66	11.24***		.72	13.30***	
	meta26	.55	9.20***		---	---	
	meta29	.52	8.72***		.63	11.29***	
	meta35	.52	8.66***		.65	11.77***	
planning	meta4	.52	8.50***	0.75	.62	11.34***	0.78
	meta6	.59	9.72***		.60	10.83***	
	meta8	.44	7.06***		---	---	
	meta22	.58	9.66***		.70	13.06***	
	meta23	.56	9.26***		.65	11.89***	
	meta42	.49	7.90***		---	---	
	meta45	.61	10.19***		.65	12.05***	
information management strategies	meta9	.44	6.95***	0.76	---	---	0.81
	meta13	.50	7.99***		---	---	
	meta30	.59	9.74***		.65	11.76***	
	meta31	.50	8.06***		.63	11.31***	
	meta37	.25	3.81***		---	---	
	meta39	.48	7.64***		.56	9.78***	
	meta41	.48	7.66***		.59	10.39***	
	meta43	.58	9.47***		.63	11.32***	
	meta47	.49	7.75***		.56	9.82***	
	meta48	.61	10.04***		.65	11.82***	
monitoring	meta1	.57	9.35***	0.76	.70	12.91***	0.77
	meta2	.47	7.53***		---	---	
	meta11	.46	7.45***		---	---	
	meta21	.51	8.33***		.62	11.07***	
	meta28	.70	12.03***		---	---	
	meta34	.56	9.14***		.69	12.66***	
	meta49	.66	11.25***		.70	12.91***	
debugging strategies	meta25	.48	7.27***	0.74	---	---	0.68
	meta40	.69	11.37***		.73	13.10***	
	meta44	.56	8.78***		.65	11.41***	
	meta51	.63	10.18***		.55	9.31***	
	meta52	.63	10.03***		---	---	
evaluation	meta7	.26	3.93***	0.72	---	---	0.71
	meta19	.49	7.82***		---	---	
	meta24	.57	9.25***		.63	11.35***	
	meta36	.66	11.12***		.73	13.48***	
	meta38	.61	10.16***		.65	11.80***	

	meta50	.68	11.55***	---	---
Model fit		$\chi2$ = 2680.02 (1246) $\chi2$ / *df* = 2.15, *RMSEA* = 0.07 *CFI* = 0.72 *GFI* = 0.68 *AGFI* = 0.65 *NFI* = 0.58		$\chi2$ = 957.24 (499) $\chi2$ / *df* = 1.92, *RMSEA* = 0.06 *CFI* = 0.90 *GFI* = 0.83 *AGFI* = 0.80 *NFI* = 0.81	

*$p < .05$. **$p < .01$. ***$p < .001$. *Std. Coef.* = standardized coefficient. *t* = the computed test statistic. *CR* = composite reliability. *X2/df* = model fit and model complexity. *RMSEA* = root mean square error of approximation. *CFI* = comparative fit index. *AGFI* = adjusted goodness of fit index. *NFI* = normed fit index.

The descriptive results of metacognitive awareness were computed using independent-samples t-test in the statistical program SPSS 22 (Statistical Package for the Social Sciences, version 22) to compare the differences on metacognitive awareness between the intervention and comparison groups. The differences between the two groups in the overall metacognition and the eight scales were examined, including declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, monitoring, debugging strategies, and evaluation.

The intervention students' responses towards the questionnaire regarding the impact of thinking instruction on their use of thinking were first analysed using 'open coding' (Merriam, 2009). The author worked with a trained researcher on the coding, discussing the coding remarks using a sample of the questionnaire data. The author and the researcher then individually marked the data. The coding units were tallied. The interrater reliability reached a satisfactory agreement of 90.1%. The discrepancies in the initial coding results were discussed and a mutual agreement was reached. They then looked through the remarks, attempting to identify the themes through an iterative process to examine commonalities and differences in the remarks. Having identified the themes, they then categorised the remarks into the themes individually. The interrater reliability for the theme classification reached 95.7%. The same processes were used for analysing observational feedback with a satisfactory interrater reliability.

Results

Metacognitive awareness

The descriptive results of metacognitive awareness show that the mean scores of the overall metacognition and the eight scales (declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, monitoring, debugging strategies, and evaluation) of the intervention group were higher than the comparison group as demonstrated in Table 2. There was a significant difference in overall metacognition ($p < .001$), meaning that the intervention students had significantly higher metacognitive awareness than the comparison students did as revealed in Table 3. There were also significant differences in declarative knowledge ($p < .001$), procedural knowledge ($p < .001$), conditional knowledge ($p < .001$), planning ($p < .001$), information management strategies ($p < .001$), monitoring ($p < .001$), debugging strategies ($p < .001$), and evaluation ($p < .001$) between the two groups, indicating that the intervention group had much higher awareness of their thinking and a perceived use of strategies than the comparison group did. Furthermore, the test effect size (ES) is included to demonstrate the practical significance of the test; Cohen's *d* is used as the measurement index. According to the results illustrated in Table 3, Cohen's *d* values are between 0.71 and 0.90, indicating a large effect size; there is a significant difference between the intervention and comparison groups.

Table 2.

Descriptive results of metacognitive awareness

	Intervention			Comparison		
	n	x̅	SD	n	x̅	SD
Overall metacognition	78	3.61	0.70	196	3.04	0.52
Declarative knowledge	78	3.59	0.74	196	3.08	0.61
Procedural knowledge	78	3.66	0.77	196	3.08	0.60
Conditional knowledge	78	3.56	0.86	196	2.99	0.69
Planning	78	3.61	0.78	196	2.96	0.60
Information management strategies	78	3.61	0.72	196	3.14	0.57
Monitoring	78	3.52	0.81	196	2.86	0.66
Debugging strategies	78	3.85	0.77	196	3.30	0.66
Evaluation	78	3.53	0.88	196	2.88	0.70

N = the sample size. x̅ = mean. SD = standard deviation.

Table 3.

Analysis of independent-samples t-test and Cohen's d on the comparison of metacognitive awareness

	t	*p-value*	*Cohen's d*
Overall metacognition	6.53	.000 ***	0.90
Declarative knowledge	5.85	.000 ***	0.74
Procedural knowledge	5.94	.000 ***	0.82
Conditional knowledge	5.25	.000 ***	0.73
Planning	6.67	.000 ***	0.91
Information management strategies	5.05	.000 ***	0.71
Monitoring	6.97	.000 ***	0.86
Debugging strategies	5.95	.000 ***	0.75
Evaluation	5.88	.000 ***	0.81

t = the computed test statistic. *p-value* = the *p*-value corresponding to the given test statistic and degrees of freedom. ***$p < .001$. *Cohen's d* = an appropriate effect size for the comparison between two means.

In the questionnaire data, students also described their ability to be aware of what they were thinking about and choosing a helpful thought process. The statements regarding students' knowledge of cognition and regulation of cognition were extracted to complement the above statistical results of metacognitive awareness.

Knowledge of cognition

Students provided examples to illustrate their awareness of *declarative knowledge*, what they knew about themselves and the nature of strategies they learned. One student stated:

> *I like to challenge various types of thinking activities and questions. It's a great way to train my brain to think critically.*

One student demonstrated his grasp of *procedural knowledge* as below.

> *I think about the application of the law from the perspectives of the government and the citizens.*

Having learned how to use thinking skills, students understood which strategies were most appropriate for a certain task in order to achieve the desired goal. The following is an example of *cognitive knowledge*, comprehending the appropriate time and reason for applying thinking skills.

> *When debating, I would stand in my opponent's shoes and think about what he might say. In this way, I analysed and figured out how my opponent was going to challenge me. Therefore, I was able to construct my rebuttal to fight back immediately. I also use this strategy while playing chess and it's very useful.*

Regulation of Cognition

Moreover, students described how they selected appropriate approaches and organised the process of conducting thinking skills. Questionnaire data provided evidence of a use of *planning*. Students organised their thinking to allow them to better figure out the possible solutions to the problem, as a student stated:

> *There were many final assignments that I needed to submit at the same time. I first analysed and compared the workload of and what I was good at in relation to the assignments, so that I reached the goal efficiently [to complete and submit the assignments in time].*

Examples of a use of *information management skills* were also reported by students. They stated that thinking instruction facilitated memorisation as well as coding the ideas that occurred in their minds. A sample of this skill is as follows:

> *I simplified the meaning of the passage by conducting visual thinking, one thinking skill used to aid memorisation. The picture appeared in my mind helped my memorisation.*

Students further articulated how they monitored their own learning, thinking, and affective reaction. Below is an example of *monitoring*.

> *I realised that I got angry during discussion when my peers' ideas were different from mine. At that moment, I waited until I had calmed down.*

Students also declared a use of *debug*. When encountering something they did not understand, they would think it over to figure out what it was. Overall, students commented on the effectiveness of thinking instruction. They found thinking skills useful in terms of learning and solving problems as well as reflecting on the work they had done. Below is an example of *evaluation*.

> *It [thinking instruction] allows me to look for a more effective and efficient work mode or a better way to do things.*

Impact on thinking behaviour

Observational data show that students critically justified whether the debating groups built sound arguments. The observers identified that some arguments made were invalid because the participants did not establish sufficient support for the argument, while some arguments were strongly supported with facts and statistics. Also, students were aware that the evidence of some of the arguments lacked clear support from a verifiable source and had expressed reservations concerning the validity of the evidence. In addition, even when the argument was made, without a strong reason or logical explanation, the observers would not consider the argument cogent.

The observers further critically identified the aspects which the debating groups did not take into account. They listened to the arguments, analysed the arguments, and assessed whether the arguments were sufficient to support the proposition. The observers also critically assessed whether the questions made to challenge the other side were appropriate or necessary. It was also found that the debating groups sometimes dropped a particular question they had prepared because the arguments against that particular question had already mentioned by the other side. Instead, the debating groups would ask another question prepared according to what arguments had been made by the other group, so that they had a better chance to win the debate. A sample comment is as follows.

> *The first question the positive side asked was very good because it hit the nail on the head. It was difficult for the negative side to rebut.*

Observers listened attentively to the responses to the questions, justifying whether the counterarguments were in support of the argument. One student wrote the following:

> *At the end, the negative side was confused about their own arguments. The refutation of the counterarguments made by the negative side, instead of backing up their own issue, supported the issue of the positive side.*

Impact on perceived thinking behaviour

The questionnaire data regarding the impact of the Developing Thinking course on their use of thinking revealed that 83 percent of the respondents claimed that they perceived a more frequent use of thinking skills after the intervention. Some had encountered the thinking skills taught before. However, they learned to apply and organise their thinking skills when confronted by a problem.

Students also learned to think critically and challenge the reliability of sources of information. They claimed that they no longer uncritically accepted information or opinions. They tried to prove whether the information was valid and reliable and to identify the unreasonable views. The skill of thinking critically was applied to students' lives, study, and work. A sample comment is as follows:

> *While reading the news, I no longer consider an event merely from the perspective shared by news sources. I would look for other relative information to help understand the whole affair before evaluating the event reported.*

Thinking outside the box is another skill students developed. The majority of students claimed that they learned to think differently and unconventionally, and solve problems by considering multiple perspectives; they became more flexible. They broke their stereotype of thinking patterns and concepts. They tried to figure out solutions to the problems by exploring alternative views, for example, standing in the shoes of the other person, and taking other people's opinions into account. They also no longer solved problems instinctively. This allowed students to view events more objectively. Such thinking patterns reflect on their lives, study, and work.

Quite a large number of data also showed that students' thinking dispositions developed. Students were more willing to take a more flexible approach to problems by exploring alternative views, and adopting new perspectives. The data provided evidence that students had learned to question the information they received, require reasons and evidence to support a statement made, and monitor their own thinking/learning processes. Students claimed that they tried to understand an event comprehensively by collecting the relative information or listening to alternative viewpoints before making a judgment. An example of this approach is as follows:

> *During class/student club meeting, I can think critically and figure out the unreasonable viewpoints shared by my peers.*

The data also showed thinking transfer occurred. Most students were aware that they could apply thinking skills learned to other domains like their major subjects, class/student club meetings, work places, and their daily lives. They noted that it was useful to utilise the thinking skills in their learning. A sample response is as follows:

> *I major in fashion design and hope that the abstract ideas that I have can be clearly sorted out and recorded. Thinking skills I learned in this course are very useful to record my ideas. The instantaneous flash of inspiration no longer goes away without recording.*

Discussion

The present study revealed that the intervention students were significantly better in metacognitive awareness than the comparison students at post-test. This finding supports the idea of Swartz (2003), when conducting teaching methods which facilitate high cognitive thinking, students benefit dramatically from considering their thinking processes. The finding also supports Preus's (2012) study, students' higher-order thinking and metacognition were fostered through higher-order thinking instruction. It can be explained by the fact that when students operate higher-order thinking skills, multiple metacognitive skills are activated. Metacognition facilitates higher-order functioning like reasoning, analysis, evaluation, and synthesis. Through regulation (e.g. planning, monitoring, debugging, evaluating), individual students make use of their metacognitive knowledge (acquired knowledge which is used to control cognitive process) to improve intellectual performance (Ku & Ho, 2010). As Magno (2010) argues, to allow metacognition to occur, there must be an awareness of all cognitive processes; that means, the processes like declarative knowledge, procedural knowledge, conditional knowledge, planning, information management, monitoring, debugging strategy, and evaluation operate at an executive level. For instance, when students start to prepare an argument for the debate topic, they need to monitor whether they fully comprehend the information collected (monitoring), manage information (information management) and plan how to formulate the argument (planning and procedural knowledge), try different ways to demonstrate the argument (debugging), and evaluate the appropriateness of the argument to the debate topic (evaluation). When students are required to think critically, their metacognition is stretched and they apply multiple metacognitive skills to arrive at an appropriate argument. This suggests that when higher-order thinking skills are required in the thinking task, the individual student can identify and apply multiple metacognitive skills to reach the goal.

Evidence has shown that students in this study thought more frequently and critically. They critically evaluated the performance of the debating groups, including arguments, omission of key arguments or information, questions, responses as well as applying these thinking skills to their daily life events. This indicates that students, to a certain extent, have mastered higher-order thinking skills. It can be explained by the fact that students, as stated above, have good metacognitive skills to facilitate the application of higher-order thinking skills. The finding of the study is in agreement with Chen's (2015) findings which showed that learners' higher-order thinking was enhanced through a higher-order thinking approach.

Students learned to think outside the box and their thinking dispositions developed. They became more flexible, able to consider new perspectives, to explore alternative views, to probe problems, to question the given, to demand justification, to be metacognitively aware (Tishman, et al., 1993). The finding of the present study supports Facione et al.'s (1995) argument that, in developing high cognitive thinking, thinking disposition is reinforced. The finding further supports Bell and Loon's (2005) finding that the engagement in the use of reasoning skills, solving problems, and making decisions reinforces thinking dispositions. Students were equipped with thinking skills. Yet, if the disposition to think had not been developed, students would not show an increased use of thinking skills and to think critically. As Tishman at al. (1993) argued that the ability to think does not necessarily guarantee that individuals will utilise thinking skills unless there is a disposition, tendency to explore, inquire, take intellectual risks and think critically.

The questionnaire data also provided evidence of students' perceived ability to apply thinking skills learned in this intervention to other domains. The result is encouraging although the data analysis used only students' reports: the reliability of this finding needs to be considered. This finding is in contrast to Jones et al.'s (1987) assertion stating that thinking skills taught in isolation might not transfer across the curriculum. The result can be explained by the fact that the intervention used real-life examples and feedback, so that students learned to recognise when and what thinking skills were needed in a particular situation (Ritchhart & Perkins, 2005); it allows students to better take on higher-order thinking skills and transfer to other fields. The result of the present study supports those of Hunter-Grudin's (1985) and Zohar and Nemet's (2002) work. In addition, the finding is consistent with Miri et al.'s (2007) work that students were capable of transferring higher-order thinking skills across domains.

The ultimate goal of teaching thinking is transfer (Reece, 2005). It can be argued that thinking instruction is deemed to have failed when learners are not able to apply thinking skills learned in class to tasks outside of the classroom. Though transfer within and across discipline subjects can be difficult, this study showed that students were able to apply skills learned in the classroom to other subject areas and work places thus demonstrating the possibility of the transfer of higher-order thinking skills.

Overall, it is argued that thinking skills and metacognitive awareness are perhaps the most essential and fundamental skills involved in developing complex thinking processes. One such process is design thinking (Brown, 2008). Design thinking is an innovative and human-centred mindset that employs collaborative multidisciplinary teams to generate user-focused products. In the last decade, it has been applied beyond the sphere of design work to that of education. It is a methodology that aims to tackle complex problems, involving five phases: empathising, defining, ideating, prototyping and testing. To successfully implement design thinking, arguably, it requires metacognitive technique and thinking skills to set the goal, analyse and define the problems, figure out multiple solutions to the problems and evaluate the workability of the solutions. This process can be less demanding for students who have greater metacognitive awareness and thinking ability, while students with less metacognitive awareness and thinking ability might find the process of completing the five phases rather challenging. Therefore, equipping students with metacognitive thinking and thinking skills arguably better prepares students for a 'real world' tasks, involving problem solving and decision making. For instance, during the covid-19 pandemic, students might encounter various problems like university closure, financial problems, online learning, and rescheduling internships. To cope with the problems, students need to actively utilise thinking skills and metacognition to come up with viable solutions to these kinds of problems.

Conclusion and recommendations

This paper contributes to fill the research gaps by conducting thinking instruction to the university students. Findings from the present study shed light on how the explicit teaching of thinking skills positively influences learners' metacognitive awareness and thinking behaviour. The study has generated important insights and contributes to the existing literature on thinking instruction and metacognition.

This study obtains snapshots of the effectiveness of thinking instruction and reveals that thinking instruction has a significant positive impact on students' metacognitive awareness and thinking behaviour like justifying, identifying, and assessing. Thinking instruction also has a positive effect on learners' perceived thinking behaviour, such as thinking more frequently, thinking critically, thinking outside the box, developing thinking dispositions, and thinking transferring.

The findings of the study have some pedagogical implications. First, fostering students' thinking ability is one main goal of higher education; yet, how thinking skills can be integrated into discipline subjects has not been instructed explicitly. This study has revealed how explicit teaching of thinking skills enhances students' metacognition and thinking behaviour. It is recommended that instruction in subject courses is constructed to incorporate higher-order thinking through a use of higher-order questions or tasks with higher-order questions embedded. It arguably helps students think critically and fulfils the goal of higher education. Second, to successfully implement explicit thinking skills instruction, it is essential to use real life examples while designing thinking tasks, so that transfer can occur. Third, for thinking tasks to be effective, teachers must view teaching as a process of developing and enhancing students' learning ability; the teacher's main role is as a facilitator. Fourth, at the beginning of training students to think, students might take a longer time to respond to the questions or to come up with a solution. Teachers need to wait patiently for the responses, otherwise student confidence can be destroyed. Finally, with regard to the implementation of thinking tasks, it could be difficult for teachers who are not familiar with the concept of higher-order thinking skills to design thinking tasks and carry out the teaching. The problem may be resolved with proper teacher training programmes. These suggestions are based on the experience gathered through this study.

Furthermore, thinking instruction can be taught online. The outbreak of Covid-19 led many universities around the world to move the teaching arena from a traditional classroom to an online platform. The intervention of the present study was carried out in a traditional classroom. It can also be implemented through synchronous online teaching, and it is suggested that the teaching content be divided into small units to better enable students to comprehend key components of the course. Conducting thinking tasks is time-consuming, and this can be facilitated by online discussion forums using social media after class. Online discussion forums allow sufficient time for students to express their thoughts and opinions and to have those ideas validated through group mediated feedback. It is strongly recommended that small group discussions instead of whole class discussions be conducted because this helps reduce time spent in reading and responding to other postings and reveal who actually participates in the discussion. Though online small group discussions can be effective and efficient, student postings need to be monitored, either by the teacher or by teaching assistants, so that the discussions will not become superficial or artificial (Clark, 2003). Teachers' specific and timely feedback is also essential to guide students to meet the task objectives and to prepare them for the next steps in their learning.

With a posttest-only control group design, considerable caution must be applied when interpreting the results. Future researchers are encouraged to use this study as a pilot and address the research limitation by using a pretest-posttest design. Also, future investigation into the extent to which teaching thinking in isolation enhances the transfer of thinking skills to other domains is recommended.

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Reference

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research*, *85*, 275–314. http://doi.org/10.3102/0034654314551063

Akama, K. (2006). Relations among self-efficacy, goal setting, and metacognitive experiences in problem solving. *Psychological Reports*, *98*, 895–907.

Artzt, A. F., & Armour-Thomas, E. (1992). Development of a cognitive-metacognitive framework for protocol analysis of mathematical problem solving in small groups. *Cognition and Instruction*, *9*, 137-175.

Arum, R., & Roksa, J. (2011). Limited learning on college campuses. *Society, 48*, 203–207. http://doi.org/10.1007/s12115-011-9417-8

Baker, L. (1989). Metacognition, comprehension monitoring, and the adult reader. *Educational Psychology Review, 1*, 3-38. http://doi.org/10.1007/BF01326548

Bell, R., & Loon, M. (2015). The impact of critical thinking disposition on learning using business simulations. *The International Journal of Management Education, 13*, 119-127. http://doi.org/10.1016/j.ijme.2015.01.002

Bloom, B. S., Engelhart, M. D., Furst, E.J., Hill, W. K., & Krathwohl, D. (1956). *Taxonomy of educational objectives: The classification of educational goals, Handbook I: Cognitive domain.* Longman.

Brown, T. (2008). Design Thinking. *Harvard Business Review*, *86* (6), 84-92, 141.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research*. Rand McNally & Company.

Chen, M.-H. (2019). Can L2 Less-proficient Adult Learners Become Skilled Readers?. *International Journal of Teaching and Learning in Higher Education*, *31*(1), 1-10.

Chen, M.-H. (2015). Fostering L2 speaking and thinking through a HOT approach. *Curriculum & Instruction Quarterly*, *18*(4), 193-225.

Clark, T. (2003). Disadvantages of collaborative online discussion and the advantages of sociability, fun and cliques for online learning. In *Proceedings of the 3.1 and 3.3 working groups conference of the International Federation for Information Processing: ICT and the Teacher of the Future, 23*, 23-25.

Coutinho, S., Wiemer-Hastings, K., Skowronski, J. J., & Britt, M. A. (2005). Metacognition, need for cognition and use of explanations during ongoing learning and problem solving. *Learning and Individual Differences, 15*, 321–337.

Facione, P. A., Sánchez, C. A., Facione, N. C., & Gainen, J. (1995). The disposition toward critical thinking. *The Journal of General Education, 44*, 1-25.

Fisher, R. (1998). *Teaching thinking: Philosophical enquiry in the classroom*. Cassell.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), *The Nature of Intelligence* (pp. 231-236). Erlbaum.

Flavell, J. H., Miller, P. H., & Miller, S. A. (2002). *Cognitive development* (4th ed.). Prentice-Hall.

Halpern, D. F. (1998). Teaching critical thinking for transfer across domains: Dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist, 53*, 449-455.

Halx, M. D., & Reybold, L. E. (2006). A pedagogy of force: Faculty perspectives of critical thinking capacity in undergraduate students. *The Journal of General Education, 54*, 293-315.

Hargrove, R. A. (2012). Assessing the long-term impact of a metacognitive approach to creative skill development. *International Journal of Technology and Design Education, 23*, 489-517. http://doi.org/10.1007/s10798-011-9200-6

Hunter-Grundin, E. (1985). *Teaching thinking: An evaluation of Edward de Bono's classroom materials*. Schools Council.

Jacobs, J. E., & Paris, S. G. (1987). Children's metacognition about reading: Issues in definition, measurement, and instruction. *Educational Psychologist, 22*, 255–278. http://doi.org/10.1080/00461520.1987.9653052

Jausovec, N. (1994). Metacognition in creative problem solving. In M. Runco (Ed.), *Problem finding, problem solving and creativity* (pp. 77-95). Ablex Publishing.

Jones, B. F., Palincsar, A. S., Ogle, D. S., & Carr, E. G. (Eds.) (1987). *Strategic teaching and learning: Cognitive instruction in the content areas* (pp. 92-110). Association for Supervision and Curriculum Development.

Ku, K. Y. L., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. *Metacognition and Learning, 5*, 251-267. http://doi.org/10.1007/s11409-010-9060-6

Kuhn, D., & Dean, D. (2004). Metacognition: A bridge between cognitive psychology and educational practice. *Theory into Practice, 43*, 268-274.

Magno, C. (2010). The role of metacognitive skills in developing critical thinking. *Metacognition and Learning, 5*, 137-156. http://doi.org/10.1007/s11409-010-9054-4

Mason, L., & Santi, M. (1994). *Argumentation structure and metacognition in constructing, shared knowledge at school*. AERA annual meeting, New Orleans, LA, United states.

McGuinness, C. (1999). *From thinking skills to thinking classrooms: A review and evaluation of approaches for developing pupils' thinking*. HMSO.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. Jossey-Bass.

Miri, B., David, B., & Uri, Z. (2007). Purposely teaching for the promotion of higher-order thinking skills: A case of critical thinking. *Research in Science Education, 37*, 353-369. http://doi.org/10.1007/s11165-006-9029-2

Morgan, N., & Saxton, J. (1994). *Asking better questions: Models, techniques and classroom activities for engaging students in learning*. Pembroke.

Mugny, G., & Doise, W. (1978). Socio-cognitive conflict and structure of individual and collective performances. *European Journal of Social Psychology, 8*, 181-192.

Orion, N., & Kali, Y. (2005). The effect of an earth-science learning program on students' scientific thinking skills. *Journal of Geoscience Education, 53*, 387-394.

Preus, B. (2012). Authentic instruction for 21st century learning: Higher order thinking in an inclusive school. *American Secondary Education, 40*(3), 59-80.

Pressley, M., Wharton-McDonald, R., Mistretta-Hampton, J., & Echevarria, M. (1998). The nature of literacy instruction in ten grade 4/5 classrooms in upstate New York. *Scientific Studies of Reading*, *2*, 159–194.

Reece, G. J. (2005). Critical thinking and cognitive transfer: Implications for the development of online information literacy tutorials. *Research Strategies, 20*, 482-493. http://doi.org/10.1016/j.resstr.2006.12.018

Ritchhart, R., & Perkins, D. N. (2005). Learning to think: The challenges of teaching thinking. In. K. J. Holyoak & R. G. Morrison, (Eds), *The Cambridge Handbook of Thinking and Reasoning* (pp. 775-802). Cambridge University Press.

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science, 26*, 113–125. http://doi.org/10.1023/A:1003044231033

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*, 460-475.

Schroyens, W. (2005). Knowledge and thought: An introduction to critical thinking. *Experimental Psychology, 52*, 163-164.

Sousa, D. A. (2001). *How the brain learns: A classroom teacher's guide* (2nd ed.). Corwin.

Sousa, D. A. (2006). *How the brain learns* (3rd ed.). Corwin.

Swanson, H. L. (1990). Influence of metacognitive knowledge and aptitude on problem solving. *Journal of Educational Psychology, 82*, 306-314.

Swartz, R. (2003). Infusing critical and creative thinking into instruction in high school classrooms. In D. Fasko (Ed.), *Critical thinking and reasoning* (pp. 293-310). Hampton Press.

Tishman, S., Jay, E., & Perkins, D. (1993). Teaching thinking disposition: From transmission to enculturation. *Theory into Practice*, *32*, 147-153.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Zhang, L. J. (2001). Awareness in reading: EFL students' metacognitive knowledge of reading strategies in an acquisition-poor environment. *Language Awareness, 10*, 268-288.

Zohar, A. & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching, 39,* 35-62. http://doi.org/10.1002/tea.10008