Critical Thinking Skills Among Post-Graduate Students Across Curriculum in Myanmar Institutes of Education

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Abstract

The primary objective of this study was to investigate the post-graduate students' critical thinking skill. Then, critical thinking disposition of post-graduate students was explored. In addition, to examine their brain dominance was of next interest. Moreover, the strong predictors of critical thinking skill were investigated. Design of this study was cross sectional in nature. Both qualitative and quantitative approaches were used in this study. This study was conducted at Yangon Institute of Education and Sagaing Institute of Education, Myanmar. The total of 326 post-graduate students from YIOE and SIOE participated in this study. Critical Thinking Skill Test, Critical Thinking Disposition Inventory (CTDI) and Brain Dominance Test (BDT) were used as the research instruments. Alpha reliability for CTST, CTDI and BDT revealed at 0.64, 0.88 and 0.86 respectively.

In this study, 72.6 % of post-graduate students were found to be disposed positive on overall scale of CTDI. On the other hand, only 27.4 % of post-graduate students were ambivalently disposed towards critical thinking. Majority of students have high disposition towards critical thinking. Gender related difference revealed on truth-seeking sub-scale. Looking across the seven sub-scales, percentages of positive endorsement on critical thinking self confidence, open-mindedness, and cognitive maturity sub-scales were less than other four sub-scales.

Concerning the brain dominance, the majority of post-graduate students who disposed positively towards critical thinking were left brain thinkers. Concerning the critical thinking, 25.8% were found to be advanced skilled thinkers, 46.9% were skilled thinkers, and the rest 27.3% can be classified as unskilled thinkers. Moreover, differences in level of education were found on overall test as well as interpretation sub-scale. According to the backward multiple regression analysis result, strong predictors of critical thinking skill were analyticity, cognitive maturity, inquisitiveness and level of education. Based on the empirical results, a model of critical thinking skill was developed.

Key Terms: Critical thinking skill, Critical thinking disposition, Brain dominance, Whole brain thinking

Introduction

Education plays a major role in societal development of the future. The future society may face a great number of changes in social, cultural, political, economic, technology and so forth. Ongoing changes shape future society. Educators must rethink to cope with rapid changes in the new millennium. By the start of the 20th century, education was available for all children and focused on the 3Rs: simple reading, writing and arithmetic.

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The task of the educators was relatively straightforward. The role of learners played merely a passive recipient. In the 21st century, teachers could no longer predict exactly what kinds of knowledge and skills will help their learners' lifespan. There are various kinds of challenges that teacher educators today would have to face. Teachers should respond to these challenges by promoting students' thinking skills rather than rote memorization of facts. According to Tsui (2002), higher-order cognitive skills, such as the ability to think critically and creatively, are invaluable to students' future; individuals should be prepared to tackle a multitude of challenges that they were likely to face in their personal lives, careers, and duties as responsible citizens. Moreover, by instilling critical thinking in students, they will become independent lifelong learners. This is one of the long-term goals of the educational enterprise.

In the 21st century, the nature of employment is also changing and the global shift of economic markets is making for a different view of what it means to have a well educated and well reasoned workforce. It is obvious that teachers, as part of their professional duties, should be encouraging thinking in school as well as fostering mastery of the curriculum. Most important of all, teachers might consider what type of thinking is crucial for this complex world. Then, they might also be practiced to enhance their critical thinking themselves. Finally, they must cultivate their children how to think. According to Potter and Alexander (2005), education is more than what happens in schools. The task of educators is to draw out their pupils' curiosity about the world, to nourish their achievements, and to equip them for lifelong learning. Learning is more than the exchange of information. According to Porritt (2005), education is not a matter of transmission of knowledge or concepts or ideas. To be exact, education seeks to increase the intellectual capital of this world. Therefore, excellence in thought must be systematically cultivated.

Significance of the Study

John Dewey (1933) stated that learning to think is the central purpose of education. There is an urgent question which needs to answer: Are school administers and teachers being prepared to think critically and to guide students how to think? Concerning this, in 1997, Kishore Mahbuani, a senior official in Singapore, posed a challenging question at a conference; Can Asians think? It was a remarkable moment of self-doubt. Asians have always been proud of how well they educate their children. Although, Asians score highest in science and mathematics in worldwide comparisons, Asian students were too busy memorizing deadening answers to learn to think. But from Tokyo to Taipei and Singapore, governments were, now, realising that their children were so overstressed and over tested that

they were ill equipped for the information age, where thinking and creativity hole a premium (Elliott et al, 1999).

Michael Scriven (1987) stated that training in critical thinking should be the primary tasks of education. Educators are not alone in recognizing the importance of critical thinking. The demands of employment in a global economy, and personal decision making in a complex and rapidly changing society require people who can reason well and make good judgments. As some countries move toward a technology-based economy facing world-wide competition, employers demand workers who can think flexibly and analytically, integrate information from a variety of sources and perspectives, and make profitable decisions efficiently. Our society needs citizens who can fair-mindedly evaluate the relevance of different perspectives on complex problems. For students, workers, and citizens, critical thinking is an essential tool for performing successfully in a complex and rapidly changing world (as cited in Scriven and Paul, 1987).

However, in 1985, Richard Paul, a major leader in the international critical thinking movement, argued that, from the earliest days, education in the United State has emphasized passive learning, lower-order training, and indoctrination. If students just pass the exam by memorizing the facts of any field of study or get any degree without thinking critically, they will not become truly educated persons (Paul, 1993).

So, it is the clearly time for the educators in Myanmar to be aware of the need to inculcate the habit of critical thinking in every academic discipline and at every level of education. Although several critical thinking studies have been conducted in previous years throughout the world, research related to critical thinking and brain dominance was rare, especially in the field of teacher education and teacher training in Myanmar. Therefore, this study tried to explore the post-graduate students' critical thinking skills and critical thinking dispositions in Myanmar context.

To fulfill this need, current study tried to identify and explain critical thinking and brain dominance of selected post-graduate students in the contexts of teacher education. Majority of post-graduate students at the two Institutes of Education are in-service teachers and the rest are pre-service teachers. The rationale of this study was deeply rooted in the idea that teachers are the key change-agent in producing a thinking generation. If teachers are going to be the mediator and change-agent in the classroom and the change element that is being concerned here is the thinking skills, it will be very important for educators to find out whether teacher trainees or teachers are adequately prepared for critical thinking skills in their profession.

Review of Related Literature

In fact, during the last decades, many psychologists have put forward theories and definitions to explain the meaning of thinking. Thinking is a process of formulating knowledge and understanding which involves mental activities in the human brain (Mok Soon Sang, 2003). From a neuroscience perspective, instruction and learning are very important parts of brain development and psychological development processes (Bransford et al, 2000).

According to Roger W Sperry, the human brain has two very different ways of thinking. Anatomically speaking, the brain is split into two halves or -- more technically – hemispheres. These halves are commonly called the right brain and left brain, but should more correctly be termed hemispheres. Each hemisphere seems it should be completely identical to each other, but they're not really. The left side of brain actually controls the action of right side of the body and vice versa (Bransford et al, 2000).

According to Hopkins (1984), education system is mainly the region of the left hemisphere of the brain and that the functions of the right hemisphere are little understood and perhaps neglected in education system. A balanced brain makes a balanced person - combining sequential thinking with a holistic approach, or linear thinking with intuition, enables him/her to fully comprehend issues and solve problems. Whole-brained people have the best of both hemispheres. Truly critical thinkers will find ways to incorporate the talents of both brain hemispheres to maximize their personal effectiveness (Wagner, 2009).

The critical thinker asks questions, defines problems clearly and accurately, examines the evidence, analyzes assumptions and biases, avoids emotional reasoning, avoids oversimplification, considers alternative interpretations, and tolerates uncertainty (Wade, C. & Tavris, C., 1996). Besides, critical thinking is dependent upon a person's disposition to use it (Paul and Nosich, 1992). Disposition to think critically can be defined as consistent willingness, motivation, inclination and an intention to be engaged in critical thinking while reflecting on significant issues, making decisions and solving problems (Facione et al. 1995, Facione, 1997). Critical thinking dispositions are approaches to life that contribute to critical thinking (Facione, 1990a). Tendencies to approach intellectual tasks in certain adaptive ways have been called thinking dispositions (Martinez, 2000).

From the time of Socrates to contemporary concerns about the need for an educated citizenry and quality work-force, the ability to think critically and to reason well has been regarded as an important and necessary outcome of education. In this regard, during the last

decades, a blossoming body of research concerning critical thinking at every level of education in every academic discipline has been accumulated.

Purpose of the Study

The primary objective of this study is to investigate the post-graduate students' critical thinking skills and critical thinking dispositions. And then, to examine their brain dominance is next of interest. Finally, this study explored the interrelationship between students' critical thinking skills, critical thinking dispositions and brain dominance.

Scope and Procedure

This study was conducted at Yangon Institute of Education (YIOE) and Sagaing Institute of Education (SIOE) in Myanmar. This study aims to survey the critical thinking skills, critical thinking dispositions and brain dominance of post-graduate students. The instruments used in this study were Critical Thinking Disposition Inventory (CTDI), Brain Dominance Test (BDT), and Critical Thinking Skill Test. Post-graduate students' critical thinking skills, critical thinking dispositions and brain dominance were investigated across disciplinary clusters of the two Institutes of Education in Myanmar. With the permission of administrative personnel of two Institutes, all the post-graduate students of Doctoral program, Master program, and Post-graduate Diploma program who enrolled in 2010-2011AY were included as the sample in this study. Then, three questionnaires were administered to the participants.

Operational Definition of Critical Thinking

The ability to explain, evaluate, analyze, and interpret via logico-inferential modes of reasoning.

Methodology

Design of this study is cross sectional in nature. Both qualitative and quantitative approaches were used in this study. In addition, for purposes of empirical exploration, the ten research questions motivating this study should be expressed as follows.

Research Questions

1. Is there any relationship between critical thinking skills (CTS), critical thinking disposition (CTD) and Brain Dominance?
2. Is there any difference in CTS of post-graduate students from two Institutes of Education?
3. Is there any difference in CTD of post-graduate students from two Institutes of Education?
4. Is there any difference in CTS among post-graduate students by grade level?
5. Is there any difference in CTD among post-graduate students by grade level?
6. Is there any difference in CTS among post-graduate students by discipline?

7. Is there any difference in CTD among post-graduate students by discipline?
8. Is there any difference in CTS among post-graduate students by gender?
9. Is there any difference in CTD among post-graduate students by gender?

Sample of the Study

Two Institutes of Education such as Yangon Institute of Education (YIOE) and Sagaing Institute of Education (SIOE) were purposefully selected for this study. All students who enrolled in post-graduate classes during 2010-2011 AY at the selected Institutes were included in the sample. The total of 326 post-graduate students participated in this study. Among the sample, 87 (26.7%) were drawn from Educational Administration and Supervision, 42 (12.9%) from Pedagogic Methodology, 42 (12.9%) from Educational Guidance and Counselling, 29 (8.9%) from Educational Test and Measurement, 22 (6.75%) from MA (TEFL), 14 (4.29%) from Dip. in ELTM, and 90 (27.6%) from PGDMA program.

Data Collection Procedures

With the permission of administrative personnel of two Institutes of Education, three questionnaires were administered to the participants during 2010-2011 AY at two Institutes of Education. Then, descriptive statistics and inferential statistics were applied to the data set in order to interpret and report the results.

Data Analysis and Results

After developing the instruments of Brain Dominance Test (BDT), Critical Thinking Disposition Inventory, and Critical Thinking Skills Test, differences in critical thinking skills, differences in critical thinking disposition and differences in brain dominance of post-graduate students were examined at two Institutes of Education. In addition, differences across disciplines, difference between Institutes, gender related difference, differences between grade level, and differences between types of trainee were further investigated. And then, inter-correlation among critical thinking skills, critical thinking disposition and brain dominance were also explored.

Brain Dominance of Post-graduate Students

Concerning brain dominance, 27.9% of post-graduate students were found to be whole brain thinkers, 65.6% were left-brain thinkers, and the rest 6.4% were right-brain thinkers. Looking across the disciplines, 58.62% of students from Educational Administration and Supervision cluster can be said to be left-brain thinkers, 5.74% were right-brain thinkers, and the rest 35.6% were whole brain thinkers. Similarly, percentage of students who prefer left-brain mode of thinking from each disciplinary cluster was larger than that of whole-brain

mode and right-brain mode. Again, the participant students in both Institutes were provided with more learning opportunities that enable them to develop left side of the brain.

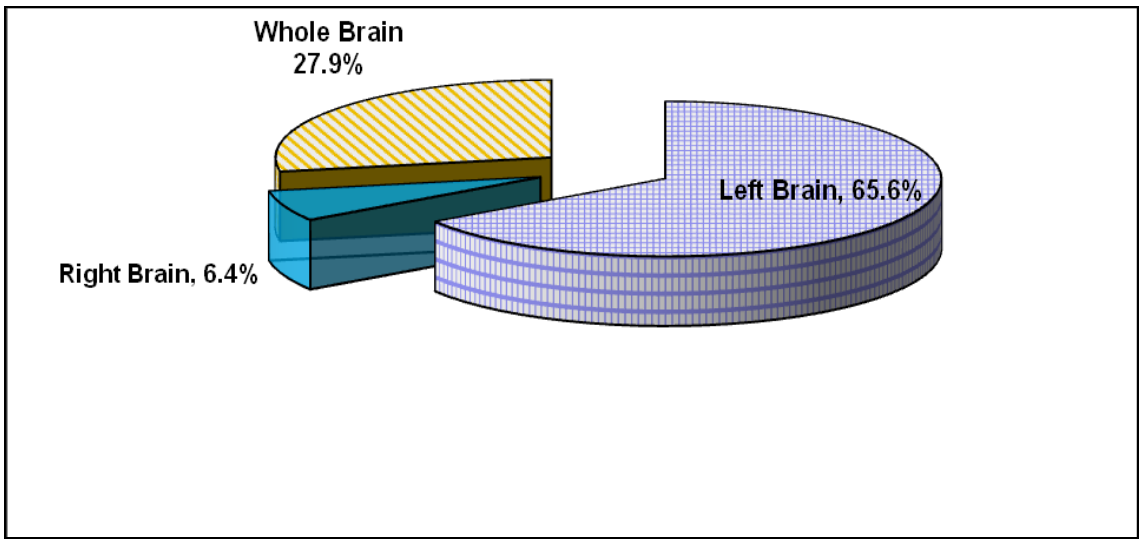


Figure 1 Brain Dominance of Post Graduate Students

Concerning gender, nearly 65% of students were found to be left brain thinkers. It can reasonably be said that both male and female were provided same learning opportunities that enable them to enrich more left hemisphere style thinking. The results evidently showed that the participant students in this study were provided with less learning opportunities that enable them to develop right side of the brain.

Critical Thinking Disposition of Post-graduate Students

In this study, 72.6% of post-graduate students were found to be positive on overall disposition towards critical thinking. On the other hand, only 27.4 % of students were found to be disposed ambivalently towards critical thinking. No student can be said to be disposed negatively on overall scale of CTDI. It is remarkable that majority of participant students relied positively on the overall attribute of critical thinking disposition. The total mean score of all students was 280.9 on overall scale of CTDI in this study. It can reasonably be concluded that post-graduate course work prominently enhance students' motivational aspect of critical thinking.

Except the two disciplines of English Language Teaching and Multimedia Art, about 90% of post-graduate students from each Educational Administration and Supervision, Guidance and Counselling, Pedagogic Methodology, and Educational Test and Measurement clusters were found to be positively disposed on truth-seeking scale whereas nearly 45% of participant students from each English Language Teaching, and Multimedia Art clusters were found to be disposed positively.

Table 1 Percentages of Post-graduate Students' Responses on Seven Sub-scales of CTDI in each Discipline

Discipline	Positively Disposed (%)						Ambivalently Disposed (%)						Negatively Disposed (%)					
	AS	PM	GC	ETM	ELT	DMA	AS	PM	GC	ETM	ELT	DMA	AS	PM	GC	ETM	ELT	DMA
T	96	94	87	89	46	45	4	6	13	11	51	50	0	0	0	0	0	5
O	48	32	39	42	51	72	47	58	56	58	49	26	5	10	5	0	0	2
A	96	94	87	89	95	96	12	13	12	7	5	3	0	0	0	0	0	1
S	94	92	90	79	90	87	6	8	10	21	10	12	0	0	0	0	0	1
CT	34	32	49	33	40	50	62	60	44	63	38	39	4	8	7	4	22	11
I	75	74	75	86	57	75	25	26	25	14	40	24	0	0	0	0	3	1
CM	40	55	39	43	84	73	53	33	34	36	11	26	7	12	26	21	5	1
CTD	71	59	76	64	73	80	29	41	24	36	27	20	0	0	0	0	0	0

AS = Educational Administration & Supervision, PM = Pedagogic Methodology, GC = Educational Guidance & Counselling, ETM = Educational Test and Measurement, ELT= English Language Teaching, DMA=Multimedia Art, T=Truth-Seeking, O=Open-mindedness, A=Analyticity, S=Systematicity, CT=CT self confidence, I= Inquisitiveness, CM= Cognitive Maturity, CTD = Critical Thinking Disposition Inventory

On the one hand, nearly 50% of students from English Language Teaching, and Multimedia Art cluster were found to be disposed ambivalently on truth-seeking scale. Furthermore, only 5% of students from Multimedia cluster were disposed negatively. It may be reasonably concluded that participant students from Educational Administration and Supervision, Guidance and Counselling, Pedagogic Methodology, and Educational Test and Measurement clusters can be said to be more strongly endorsing to seek the truth than that of English Language Teaching, and Multimedia Art clusters.

Concerning the open-mindedness, the percentage of students' endorsement in positive category from Multimedia Art cluster was found to be larger than that of other five clusters. Looking across the other five clusters, nearly 30% to 50% of participant students were found to be disposed positively on open-mindedness attribute. It can reasonably be said that participant students from Multimedia Art cluster may perform more with tolerance towards the opinions of others, knowing that often they all hold beliefs which make sense only from their own perspectives.

Relating to the analyticity and systematicity attributes, about 80% to nearly 96% of students from each disciplinary cluster were found to be disposed positively whereas very small proportion of students from each cluster found to be ambivalently disposed. Except the Multimedia Art cluster, no student was found to be negative endorsement. It may reasonably

be said that large body of sample strongly showed the endorsement of being organized, orderly, focused and diligent in seeking relevant information.

Regarding the critical thinking self-confidence, proportions of students' positive endorsement in this attribute were found to be relatively low, showing the percentages of 34%, 32%, 49%, 33%, 40%, and 50%. Moreover, percentages of students who disposed ambivalently on critical thinking self-confidence can be said to be relatively higher than other six attributes. In addition, percentage of students' negative endorsement on critical thinking self-confidence was found to be somewhat larger than other attributes of showing the zero percentage. It can reasonably be concluded that participant students in this study showed less confidence in thinking critically.

Concerning the Inquisitiveness sub-scale, except the English Language Teaching cluster, over 70% of students from each of five disciplinary clusters disposed positively whereas 57% of students from English Language Teaching cluster disposed positively. It can reasonably be explained that the larger proportion of post-graduate students from most clusters showed the high intellectual curiosity.

On the other hand, except the English Language Teaching cluster and Multimedia Art cluster, percentage of students' positive endorsement was found to be relatively small on cognitive maturity sub-scale. In addition, among the seven dispositional attributes, percentage of ambivalent endorsement on cognitive maturity sub-scale was some what larger than others. Furthermore, percentage of students' negative endorsement on cognitive maturity was found to be slightly larger than other attributes of showing the zero percentage. It can reasonably be said that participant students in this study are likely to be mistrustful of reason, or they tend to devalue. To be specific, they are likely to be hostile to the use of careful reason and reflection as a means to solving problems or discovering what to do or what to believe.

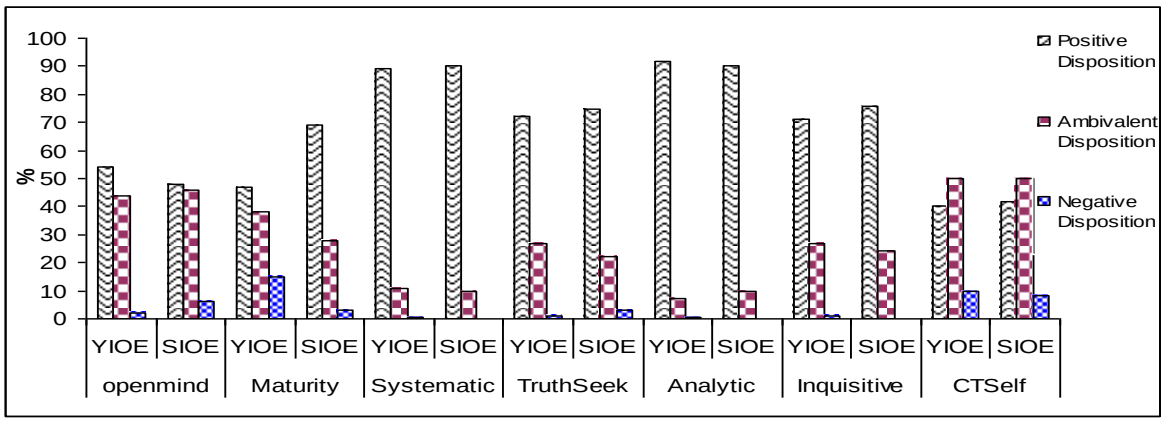


Figure 2 Percentages of Students' Disposition on Seven Sub-scales of CTDI at two Institutes

Looking across the Institution level, figure 2 shows the percentages of students' responses across seven sub-scales. The results of t-test confirmed the significant different mean scores in cognitive maturity between Institutes at 0.001 level. Participant students in this study were characterized as prudent in making judgment and are aware that multiple solutions can be acceptable (See Table 2).

Table 2 Comparison of Post-graduate Students' Responses on Critical Thinking Disposition Inventory at two Institutes

Sub-scales	Institute	Mean	SD	*t*	*p*
Cognitive Maturity	YIOE	35.43	4.9	**-4.2****	**0.000**
	SIOE	37.67	4.3		
CTDI Total	YIOE	278.6	15.6	**-2.5***	**0.01**
	SIOE	283.8	19.6		

Furthermore, the result of t-test confirmed the significant different mean score on overall scale at 0.05 level. This may be due to the fact that participant students from SIOE have more inclination and intention to be engaged in reflecting on significant issues, making decisions and solving problems. They also possess higher degree of motivation to accept the multiple solutions and differing opinions.

Concerning the gender, although a slight variation of mean scores exist in all sub-scales as well as overall scale, significant difference was found to be only on the truth-seeking scale, *t*= -2.1*, *p*= 0.03. Female's score was found to be significantly higher than male on this attribute. Except the truth-seeking scale, gender related significant difference was not found to be on other six sub-scales as well as overall scale.

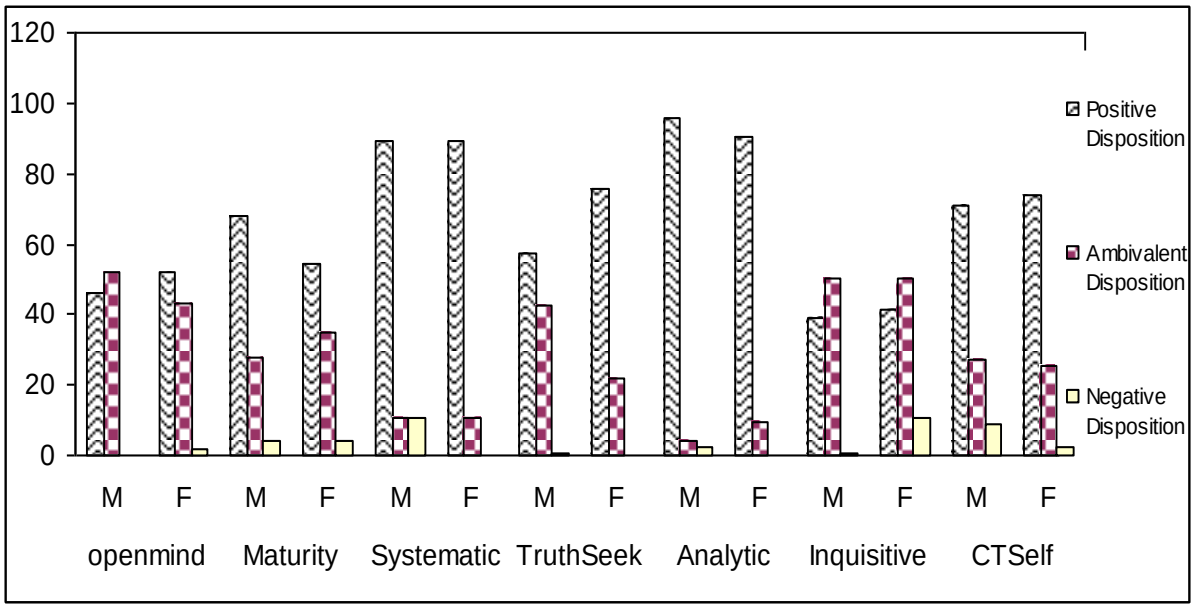


Figure 3 Percentages of Students' Disposition on Seven Sub-scales of CTDI by Gender

Relation between Critical Thinking Disposition and Brain Dominance of Post-graduate Students

In this study, 191 out of 285 post-graduate students can be said to be left-brain thinkers. Specifically, about 80% of left-brain thinkers (152 out of 191) were found to be disposed positively towards critical thinking. On the one hand, 75 out of 285 students can be said to be whole brain thinkers. Among the whole brain thinkers, 61% (46 out of 75) were found to be disposed positively towards critical thinking.

Table 3 Critical Thinking Disposition and Brain Dominance of Post-graduate Students

Brain Dominance	Positive Disposition	Ambivalent Disposition	Negative Disposition	Total
Right Brain	9(4.3%)	10(13%)	0	19
Whole Brain	46(22.2%)	29(37%)	0	75
Left Brain	152(73.4%)	39(50%)	0	191
Total	207	78	0	285

In addition, 19 out of 285 students were found to be right-brain thinkers, among them, 47% (9 out of 19) can be said to be disposed positively towards critical thinking. It can reasonably be said that majority of post-graduate students who disposed positively towards critical thinking can be said to be left-brain thinkers. The correlation between left-brain and critical thinking disposition is higher than correlation between right-brain and critical thinking disposition. This finding is consistent with the previous neuroscience research.

Critical Thinking Skills of Post-graduate Students

Evaluation skill and inference skill were found to be higher than other three critical thinking cognitive skills whereas analysis skill can be said to be the lowest stand among other skills. It can reasonably be said that participant students in this study have reasonably high degree of evaluation and inference skills while they possess the limited ability of analysis skill. On the other hand, their interpretation skill and explanation skill can be said to be pretty good.

Looking across the discipline, Table 4 shows the differences of students' response on five sub-scales and overall scale of Critical Thinking Skills Test (CTST). Despite a slight variation of mean score exists, no significant difference was found among post-graduate students' overall score as well as sub-scale score on critical thinking skill test by different discipline (F=0.731, p=0.601). Significant difference was found only on the interpretation sub-scale of CTST (F=5.6, p=0.000*).

Table 4 Mean Comparison of Post-graduate Students' Critical Thinking Skill across Discipline

Sub-scales /Discipline	AS	ETM	GC	PM	ELT	DMA	*F*	*p*
Critical Thinking Skill (21items)	18.31	18.34	18.82	18.3	18.1	17.44	.731	.601
Evaluation Sub-scale (3 items)	4.8	4.8	4.7	4.5	4.5	5.1	1.85	.102
Explanation Sub-scale (4 items)	5.3	5.4	5.6	5.5	4.9	5	0.83	.529
Analysis Sub-scale (3 items)	1.25	1.35	1.44	1.56	1.55	1.23	0.81	0.51
Inference sub-scale (6 items)	5.2	5.1	5.3	5.2	5.7	5	1.72	0.12
Interpretation sub-Scale (5 items)	2.8	2.9	3	3	2.8	2.3	**5.6****	**0.000**

** The mean difference is significant at the P < 0.001 AS=Educational Administration & Supervision, ETM= Educational Test& Measurement, GC= Educational Guidance & Councelling, PM=Pedagogic Methodology, ELT= English Language Teaching, DMA= Multimedia Art

In addition, to examine the highly significant differences across disciplines, Post-hoc Test was executed by Tukey HSD method and it became apparent that the mean score of Multimedia Art cluster was significantly lower than that of other clusters in interpretation sub-scale. It can reasonably be said that participant students from Multimedia Art cluster have limited ability to make explicit, through the contextual meanings of words, ideas, and events, to make a reasonable judgments (See Table 4 & 5). Concerning the across disciplinary effects on critical thinking, McDonough (1997) found that there was no disciplinary effects on critical thinking test scores.

Table 5 Post-Hoc Analysis of Post-graduate Students' Critical Thinking Skill across Discipline by Tukey HSD Method

Attribute	(I) Discipline	(J) Discipline	Mean Difference (I-J)	p
Interpretation Sub-scale	DMA	AS	-0.57*	.001
		ETM	-0.61*	.034
		GC	-0.73*	.001
		PM	-0.68*	.002
		ELT	-0.52	.062

*. The mean difference is significant at the 0.05 level

Looking across the overall scale and five sub-scales, gender related difference was not found in post-graduate students' critical thinking skills. It can reasonably be said that male and female participants were provided the same learning opportunities that enable to enhance their critical thinking cognitive skills.

Table 6 Gender Related Difference on Critical Thinking Skill Test

Attributes	$\bar{X}_M$	SD_M	$\bar{X}_F$	SD_F	t	p
Critical Thinking Skill (21items)	18.76	4.03	18	4.34	1.15	0.25
Evaluation Sub-scale (3 items)	4.8	1.5	4.8	1.2	0.32	0.74
Explanation Sub-scale (4 items)	5.6	2.6	5.2	2.3	1.11	0.26
Analysis Sub-scale (3 items)	1.5	0.6	1.6	0.6	-0.27	0.78
Inference sub-scale (6 items)	5.3	1.3	5.2	1.3	0.28	0.78
Interpretation sub-Scale (5 items)	2.9	0.9	2.7	1	1.5	0.12

$\bar{X}_M$ = Males' mean score, $\bar{X}_F$ = Females' mean score, SD_M =Standard deviation of males, SD_F =Standard deviation of females

Concerning the type of thinker, 17 out of 50 (34%) of male students and 67 out of 276 (25%) of female students can be said to be the advanced skilled thinkers whereas 23 out of 50 (46%) of male and 130 out of 276 (47%) were referred to as skilled thinkers. On the other hand, 20% of male and 28% of female were unskilled thinkers. This may be due to the fact that both male and female students in this study were provided with some degree of learning experiences and opportunities that enable them to develop the critical thinking skills.

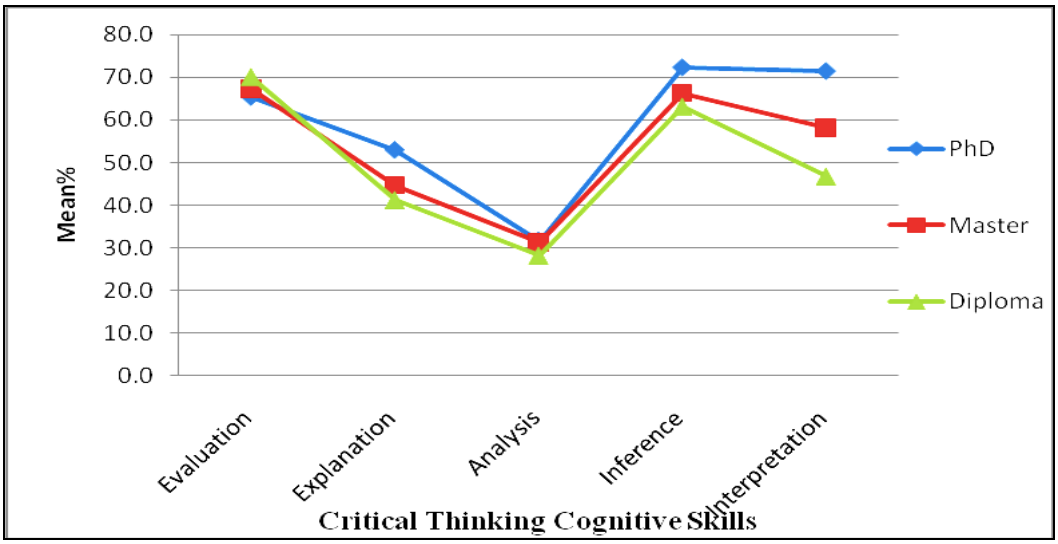


Figure 4 Mean Comparisons of Critical Thinking Cognitive Skill by Level of Education

Concerning the level of education, significant difference was found on the overall scale of CTST as well as interpretation sub-scale. Regarding the doctoral level candidates, inference skill, interpretation skill and the evaluation skills were high among five critical thinking cognitive skills. Again, doctoral level students' mean score of interpretation skill was significantly higher than that of both master level students and diploma level students whereas the doctoral level students' mean score on overall scale was significantly higher than that of diploma level students'. Similar result was found between students from master and diploma program. This may be due to the fact that doctoral level students were provided more learning opportunities and experiences in thinking concern with formulating the research

hypothesis, planning and conducting various research, analysing and interpretation of data, and making inferences than master level and diploma level students.

Table 7 ANOVA Results of Post-graduate Students' Critical Thinking Skill by Level of Education

Construct	PhD	Master	Diploma	F	p
Critical Thinking Skill (21 items)	20.28	18.32	17.41	3.46*	0.03
Evaluation Sub-scale (3 items)	4.57	4.72	5.06	2.78	0.06
Explanation Sub-scale (4 items)	6.35	5.37	4.95	2.73	0.06
Analysis Sub-scale (3 items)	1.65	1.64	1.55	1.51	0.22
Inference sub-scale (6 items)	5.78	5.31	5.04	2.42	0.09
Interpretation sub-Scale (5 items)	3.57	2.91	2.34	17.57**	0.000

* The mean difference is significant at the 0.05 level.

** The mean difference is significant at the 0.001 level.

Regarding the master level students and diploma level students, the mean score of master level students was significantly higher than that of diploma level students. It can reasonably be said that master level students were offered more learning activities and experiences in conducting research, analysing and interpretation of data, making inferences and presenting the result in logical order than diploma level students.

Table 8 Post-Hoc Analysis of Critical Thinking Skill among Level of Education by Tukey HSD Method

Attribute	(I) Level	(J) Level	Mean Difference (I-J)	p
CTST Total	PhD	Diploma	2.87*	.049
Interpretation Sub-scale	PhD	Diploma	1.22**	.000
		Master	0.65*	.034
	Master	Diploma	0.56*	.000

Looking across the level of education, 42.8% of doctoral level students, 26.4% of master level students, and 22% of diploma level students can be identified as advanced skilled thinkers. In addition, proportion of skilled thinker across doctoral, master and diploma level were 42.8%, 46.6% and 48%, respectively. The percentage of advanced skilled thinkers from doctoral level students was greater than that of master level and diploma level. Therefore, it is evident that critical thinking skills of sample students in this study become more skilful and advanced as their education level gets higher.

Looking across the institution level, the mean scores of participant students from YIOE were greater than those of SIOE on all five sub-scales as well as overall scale of Critical Thinking Skill Test. In addition, significant differences were found on overall test and three sub-scales such as explanation, inference, and interpretation. Concerning the evaluation skill, mean difference between two institutes was marginal, p=0.05. In addition, significant difference was not found to be only on the analysis skill.

Table 9 Mean Comparison of Post-graduate Students' Critical Thinking Skill between two Institutes

Construct	SIOE	YIOE	t	p
Critical Thinking Skill (21 items)	16.8	19.4	4.74**	0.000
Evaluation Sub-scale (3 items)	4.6	4.9	1.9	0.05
Explanation Sub-scale (4 items)	4.8	5.6	2.83*	0.005
Analysis Sub-scale (3 items)	1.5	1.6	0.163	0.87
Inference sub-scale (6 items)	4.8	5.6	3.2**	0.000
Interpretation sub-Scale (5 items)	2.5	2.9	3.85**	0.000

* The mean difference is significant at the 0.05 level.

** The mean difference is significant at the 0.001 level.

It can reasonably be said that students from YIOE were provided more teaching learning activities which call for the development of critical thinkers than students from SIOE. Furthermore, post-graduate students from YIOE were offered more experiences in participating academic debate, group discussion, conducting small-scale research, projects and assignments concerned with academic writing focus on critical reasoning than that of post-graduate students from SIOE.

Brain Dominance and Critical Thinking Skill of Post-graduate Students

Concerning the brain dominance and post-graduate students' critical thinking skill, the mean score of whole-brain thinkers was higher than that of left-brain thinkers and right-brain thinkers. In other word, the mean score of right-brain thinkers was lower than that of whole-brain thinkers and left-brain thinkers. Although a slight variation of mean score exists, no significant difference was found among the left brain thinkers, right brain thinkers and whole brain thinkers. Whether a person is a left-brain thinker or a right-brain thinker, there is no better or winning side to be. These are two halves that make a much better whole (LoCicero et al, 2005).

Table 10 Post-graduate Students' Critical Thinking Skills by Brain Dominance

Brain Dominance	N	Mean	SD	F	p
Right Brain Thinkers	21	17.85	5.3	0.241	.786
Whole Brain Thinkers	91	18.37	4.5		
Left Brain Thinkers	214	18.03	4.1		
Total	326	18.11	4.2		

Critical Thinking Disposition and Critical Thinking Skill of Post-graduate Students

Concerning the critical thinking disposition and critical thinking skill of post-graduate students, although the mean score of positive thinkers was slightly greater than that of ambivalent thinker, no significant difference was found between positive thinkers and ambivalent thinkers. Actually, thinking critically is not an easy task. Thinking disposition is the precursor of critical thinking. According to Facione (1990a), first, one's overall disposition toward critical thinking might be conceived of as the nurturing ground on the basis of which one decides to attempt to use one's critical thinking skills. In turn, successes in the use of critical thinking skills might reinforce one's disposition toward critical thinking.

Table 11 Post-graduate Students' Critical Thinking Skills by Critical Thinking Disposition

Disposition	N	Mean($\bar{x}$)	SD	t	p
Ambivalently dispose	78	17.76	4.17	-.498	0.619
positively dispose	207	18.04	4.23		
Total	285	17.97	4.21		

The operative relationships might occur between specific combinations of critical thinking dispositional attributes and specific sets of critical thinking skills. Hence, open-mindedness and inquisitiveness might lead one to ask interpretive and analytical questions. Cognitive maturity and critical thinking self-confidence might lead one towards more sophisticated inferences and judicious explanations. Truth-seeking might lead toward more effort in conjecturing alternatives or in honest self-correction (Facione, 1990b).

Predictors of Critical Thinking Skill

Concerning the interrelationships between brain dominance and critical thinking disposition, Table 12 shows the significant correlation among brain dominance and seven sub-scales and overall scale scores of CTDI. In addition, internal consistency reliabilities of Brain Dominance Test, and seven sub-scales as well as overall scale of Critical Thinking Disposition Inventory are also described. The value of Cronbach's alpha for Brain Dominance Test and Critical Thinking Disposition Inventory were 0.86 and 0.88, respectively. It can reasonably be said the fact that these two instrument possess the high reliabilities.

Concerning the seven sub-scales, internal consistency reliabilities of Open-mindedness, Cognitive Maturity, Sysmtematicity, Truth-seeking, Analyticity, Critical Thinking Self-confidence, and Inquisitiveness sub-scales were 0.321, 0.457, 0.395, 0.464, 0.355, 0.627, and 0.542, respectively. Inter-correlation among seven-sub-scales and overall scale of Critical Thinking Disposition Inventory were ranging from 0.248** to 0.716, and they were significantly correlated at 0.001 level. The correlation between Critical Thinking Disposition

Inventory and Brain Dominance was significant at 0.001 level, r = 0.473. It can be said that these two tests were fairly correlated (See Table 12).

Table 12 Relationships among Brain Dominance, Level of Education, and Seven Sub-scales and Overall Scale of Critical Thinking Disposition Inventory

	2	3	4	5	6	7	8	9
1.Brain Dominance	.473**	.294*	.225*	.268**	.353*	.258**	.272**	.289**
2.CTDI		.581**	.584**	.704**	.433**	.641**	.716**	.712**
3.Open-minded			.294**	.319**	.354**	.376**	.248**	.249**
4.Cognitive Maturity				.308**	.271**	.348**	.358**	.253**
5. Sysmtematicity					.282**	.368**	.435**	.442**
6.Truth Seeking						.314**	.322**	.344**
7. Analyticity							.424**	.393**
8. CT self								.494**
9. Inquisitiveness								1
10.Level of Education		.346*	.331*	.321	.443**	.335**	.353	.524

**Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
O= Open-mindedness, CM= Cognitive Maturity, S = Sysmtematicity, TS = Truth Seeking, A = Analyticity, CT = Critical Thinking Self-confidence, I = Inquisitiveness.

To identify the best model for predicting the critical thinking disposition of post-graduate students, backward elimination multiple regressions was used. The best model explains the most variance when only meaningful and significant predictors of the dependent variable remain in a model (Pedhazur, 1982). Significant variance in critical thinking disposition was explained by brain dominance. Regression analysis revealed that model significantly explained the critical thinking disposition, F= 22.9, p=0.001. R^2 for model was 0.139 and adjusted R^2 was 0.132. Table 24 displays the intercept, unstandardized regression coefficient (B), and standardized regression coefficient β for model. According to the result, brain dominance contributed 13.2% variance to critical thinking disposition. By applying multiple regression analysis presented above, the resultant model for critical thinking disposition can be defined as in the following equation concerned with brain dominance.

$CTD = 260.3 + 7.927X_{\text{Brain Dominance}}$

Table 13 Regression Analysis for Prediction of Post-graduate Students' Critical Thinking Disposition

Variables	*B*	*B*	*t*	*R*	R^2	*Adj* R^2	*F*
Significant predictor of CTD	260.3						
1.Brain Dominance	7.923	0.473	5.88**	0.37	0.139	0.132	22.9**

P** < 0.001, p* < 0.05

Concerning the relationships between level of education, critical thinking skill, and sub-scales of Critical Thinking Skill Test, Table 13 shows the significant correlation among variables. Correlation between critical thinking skill and level of education was significant, r=0.538*. Internal consistency reliability for Critical Thinking Skill Test was 0.636. Internal consistency reliability for five sub-scales of CTST such as Evaluation, Explanation, Analysis, Inference, and Interpretation were 0.401, 0.365, 0.451, 0.392 and 0.342, receptively. Inter-correlation among five-sub-scales and overall scale of Critical Thinking Skill Test were ranging from 0.461 to 0.876, and correlation were significant at 0.001 level (See Table 14).

Table 14 Interrelationships among Level of Education, Sub-scales and Overall Scale of CTST

Variables	α	2	E	Ex	A	In	It
1. Level of Education		.538*	.328*	.322*	.412*	.319*	.313**
2. Critical Thinking Skill	0.636	1	.568**	.876**	.461**	.565**	.751**

**. Correlation is significant at the 0.01 level (2-tailed). E= Evaluation, Ex= Explanation
*. Correlation is significant at the 0.05 level (2-tailed). A= Analysis, In= Inference, It= Interpretation

To identify the best model for predicting the critical thinking skill of post-graduate students, backward elimination multiple regressions was used. Significant variance in critical thinking skill was explained by level of education, cognitive maturity, analyticity, and inquisitiveness. Level of education, cognitive maturity, analyticity, and inquisitiveness yielded the model best explaining variance in critical thinking skill of post-graduate students. Regression analysis revealed that the model significantly explained the critical thinking skill, $F= 4.5$, $p<0.001$. R^2 for the model was 0.089 and adjusted R^2 was 0.086. Table 18 displays the intercept, unstandardized regression coefficient (B), and standardized regression coefficient β for model.

According to the result, level of education, cognitive maturity, analyticity, and inquisitiveness contributed 8.6 % variance in shared variability to critical thinking skill. By applying multiple regression analysis presented above, the resultant model for critical thinking skill can be defined as in the following equation concerned with level of education, cognitive maturity, analyticity, and inquisitiveness.

$$CTS = 22.7 + 1.28X_{educationlevel} + 0.37X_{analyticity} + 0.35X_{cognitivematurity} + 0.31X_{inquisitiveness}$$

According to Table 14, one point increase in the value of cognitive maturity is expected to be accompanied by an increase of 0.35 points on critical thinking skills when other variables held the constant. On the other hand, one point increase in the value of analyticity is

expected to be accompanied by an increase of 0.37 points on critical thinking skills when other variables held the constant.

Table 15 Summary of Regression Analysis for Prediction of Post-graduate Students' Critical Thinking Skill

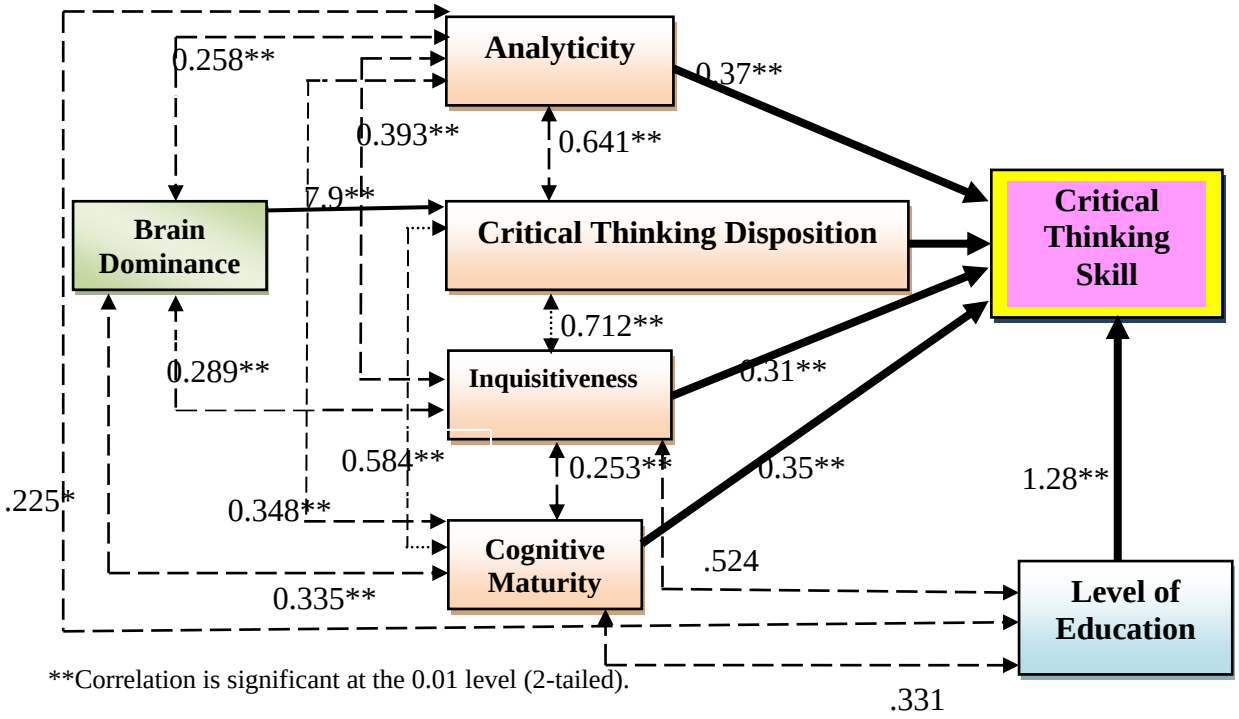
Variables	*B*	*β*	*t*	*R*	R^2	*Adj* R^2	*F*
Significant predictors of CTS	22.7						
1. Cognitive Maturity	0.35	0.37	2.68*	0.298	0.089	0.086	4.5**
2. Analyticity	0.37	0.39	2.53*				
3. Inquisitiveness	0.31	0.32	1.98*				
4. Level of Education	1.28	0.25	2.36*				

In addition, one point increase in the value of inquisitiveness is expected to be accompanied by an increase of 0.31 points on critical thinking skills when other variables held the constant whereas one point increase in the value of level of education is expected to be accompanied by an increase of 1.28 points on critical thinking skills when other variables held the constant. The effect size β is strongest for analyticity followed by cognitive maturity, inquisitiveness and level of education. According to multiple regressions analysis results described in Table 12 Table 13, Table 14 and Table 15, the model of critical thinking skill was developed (See Figure 5).

According to Critical Thinking Skill Model, brain dominance leads to critical thinking disposition which results in critical thinking skill. Specifically, dominance of brain pushes individual's preference mode of thinking urging interest, inclination, and intention, which lead to critical thinking disposition, which brings about acquisition of critical thinking skill. In this model, doted lines with double arrow between supporting variables show the degree of relationship between variables whereas hard lines with arrow show the regression coefficients of supporting variables. According to Figure 5, level of education, cognitive maturity, analyticity, and inquisitiveness are strong predictors for critical thinking skill while brain dominance is the strong predictor for critical thinking disposition.

To be specific, higher the level of education attained, greater the development of critical thinking skills achieved. It can reasonably be said that education as the means of developing the learners' greatest critical thinking abilities. Again, Critical Thinking Skill Model explains that one's critical thinking skills is strongly depend upon his or her three types of critical thinking dispositions; analyticity, inquisitiveness, and cognitive maturity. if a person possesses the disposition of being alert to potentially problematic situations and anticipating possible results or consequences, he will become good critical thinker. If a student is curious and eager to acquire knowledge and learn explanations even when the applications of the knowledge are not immediately apparent, she can be identified as critical thinker. If the one

has strong cautiousness in making, suspending, or revising judgment, he can be recognized as good critical thinker.



**Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 5 Critical Thinking Skill Model

Conclusion

The primary purpose of this study is to investigate the post-graduate students' critical thinking skills. And then, this study sought to determine the extent to which post-graduate students' disposition to think critically. Furthermore, to examine their brain dominance is of next interest. Finally, this study explored the interrelationship between students' critical thinking skills, critical thinking disposition and brain dominance. A total of 326 post-graduate students from Yangon Institute of Education and Sagaing Institute of Education participated in this study.

Concerning the brain dominance, 65% of participants were found to be left-brain thinkers while minorities of participant students were found to be right-brain thinkers. Again, participant students' critical thinking disposition was explored across disciplinary clusters, gender, types of trainee and between institutes. Interestingly, majority of post-graduate students show high motivation, inclination to overall attribute of critical thinking disposition as well as four out of seven sub-scale of critical thinking disposition. Next, critical thinking skills of post-graduate students were examined. The results revealed that critical thinking skill of doctoral level candidates was significantly higher than that of diploma level and

master level students. Similarly, master level students' mean score on interpretation sub-scale was significantly greater than that of diploma students. Concerning the training effect, mean score of in-service teacher trainees on interpretation skill was greater than that of pre-service teacher trainee.

Finally, predictors of critical thinking disposition and strong predictors of critical thinking skill were confirmed by backward multiple regression analysis. Regression analysis revealed that brain dominance was the best predictor for critical thinking disposition. In addition, level of education, analyticity, cognitive maturity, and inquisitiveness skill were the strong predictors for critical thinking skill. Among them, analyticity skill was the strongest predictor for critical thinking skill.

Results evidently show that the link between thinking and education is obvious. To say exactly, one cannot learn well without thinking well. Here, no one can deny the fact that teachers play a crucial role in bringing about national development as they are responsible for producing well-qualified human resources necessary for national development. The task of teachers in the 21st century is not as straight forward as in the 20th century. In this new millennium, the world is changing rapidly in science and technology and the changes has the greatest influence on business, economic, educational, environmental, cultural and social trends of the future. Therefore, it is clearly the time for teacher educators to be aware that children should be provided with the learning opportunities that enable them to become thinking generation who can reasonably, wisely, confidently, and open-mindedly, face the challenges of 21st century.

Discussion and Recommendation

All the participants in this study were prospective teachers by profession. In addition, some of them were in-service teacher trainees and some were pre-service teacher trainees. In this study, the results revealed that one-fourth of participant students can be described as advanced skilled thinkers whereas 46.9% were found to be skilled thinkers, and the rest 27.3% were unskilled thinkers. Results highlighted that Institutes of Education should gear more on the development of advanced skilled thinkers. Myanmar, like other countries whether developed or developing, needs citizens who can evaluate and reason well, from different perspectives, regarding global issues, cultural diversity, social conflicts, political issues, and international affair.

In an increasingly unpredictable and fast changing world, each country tries to invest in the education of the young children to ensure that they become thinkers and learners so that the country's chances are maximized and its future secure (Htoo Htoo Aung, 2002). In this regard, thinking critically is an important and necessary outcome of education. Critical thinking is cited as an important issue in education today. Attention is focused on good thinking as an important element of life success (Huitt, 1998; Thomas & Smoot, 1994).

Htoo Htoo Aung (2002) stated that schools should be encouraged to focus on mental processes, which will help students to become thinking and creative individuals. To help students learn to think should be one of the major objectives in classroom instruction. Good thinking goes beyond the awareness of a selected set of strategies or techniques for problem solving and learning.

The educational system should not only be concerned with basis competencies; simple computation, reading and writing but also be based on the learning to solve complex as well as real life problems, reading to interpret complex passage and writing creatively as well as argumentatively. Solving problems in real world and making worthwhile decisions is valued in a rapidly changing world. Changing world demands above mentioned abilities in all citizens, and schools should seek the ways to cultivate thinking skills in all students. This implies that critical thinking skills must be inculcated in the school program from basic education to higher education. Students must come to think of themselves as able and obligated to engage in critical analysis and problem solving throughout schooling (Resnick, 1987).

Halpern (1999) asserted that thinking skills can be taught using examples from various disciplines, thereby helping students to improve their thinking in a way that is transferable across disciplines. Clark and Biddle (1993) asserted that thinking strategies cannot be taught by a teacher standing at the front of the room. There must be active interaction between the students, the instructor, and instructional materials (Paul, 1990). According to Facione (1990b), critical thinking development is a combination of what is taught and how. There is a necessary partnership that must exist between teachers and students in order for learning to take place.

In addition, Browne and Freeman (2000) asserted that there are four primary elements to a classroom that promote critical thinking: frequent student questions, developmental tension, contingency of conclusions, and active learning. One of these characteristics alone does not promote critical thinking; it is the combination of all of them that fosters such development. According to Dewey, thinking does not occur spontaneously but must be "evoked" by "problems and questions" or by "some perplexity, confusion or doubt." Paul (1985) pointed out that thinking is not driven by answers but by questions. Paul ascertained that students who ask quality questions are really thinking and learning. If we, as educators, want students to think, we must stimulate and cultivate thinking with questions. Paul (1990) and Brookfield (1987) also pointed to probing questions as an effective tool in stimulating independent thinking. But, the instructor must listen carefully to students' responses in order to draw out reasons, evidence, connections, and examples. The instructor should be as specific as possible, relating questions to current events and familiar situations. Teacher and student might generate questions about dilemmas, unusual problems, and different approaches should elicit answers that have not been learned in their textbooks. Sincere feedback should provide immediately and specifically, and corrective information should inform learners of their progress.

Fraenkel (1980) offered six types of questions, which are recall questions, descriptive questions, explanatory questions, summarizing or synthesizing questions, judgmental questions and open-ended questions (as cited in Htoo Htoo Aung, 2002). Crow (1989) suggested that students must be given ample opportunity to practice critical thinking skills. For example, instructors can foster critical thinking through persistent questioning and encouraging students to do the same. Constantly eliciting responses helps students to develop an investigative nature that is a key component of critical thinking.

Teacher should give students more responsibility for their learning. Every education system might emphasize on the development of critical thinkers, intellectual thinkers and future of wise thinkers in order to face the problems of complex world and the demand of the work place. The expansion of basic education and higher education should be a powerful force for change. Perhaps most importantly, in today's information age, thinking skills are viewed as crucial for educated persons to cope with a rapidly changing world. Many

educators believe that specific knowledge will not be as important to tomorrow's workers and citizens as the ability to learn and make sense of new information (Gough, 1991).

Appropriate teaching strategies and learning environments facilitate students' thinking disposition. Teaching thinking means more than inculcating particular thinking skills, it means teaching students to be disposed to think critically in appropriate contexts. Useful learning strategies include rehearsal, elaboration, organization, and metacognition. Lessons should be specifically designed to teach specific learning strategies. Direct instruction (teacher-centered presentations of information) should be used sparingly. Presentations should be short (up to five minutes) and coupled with guided practice to teach sub skills and knowledge. Small group activities such as student discussions, peer tutoring, and cooperative learning can be effective in the development of thinking skills. Activities should involve challenging tasks, teachers' encouragement to stay on task, and ongoing feedback about group progress (King et al, n.d.). According to Sousa (2006), students are not actually taught to think because children are born with the brain organizational structure that originates thinking.

Regarding the brain dominance, results evidently showed that both YIOE and SIOE geared more on left-brain modes of thinking. Concerning the brain-based learning, the brain has two quite distinct ways of processing information attributable to its two hemispheres. The complexity of the brain and the ways in which it processes information are much greater than the simplicity implied by the two hemispheres. However, an understanding of the processing modes of the two hemispheres serves as a useful starting point in understanding the nature of mental processing in learning (Atkin, 1999).

Recent innovations in science have allowed an unprecedented look into the way the brain works. The exciting learning about brain function and its effects on learning have the potential to revolutionize teaching and learning. Brain research has provided new knowledge about the many ways that humans learn. Brain-based learning has resulted from educators and researchers applying the findings of brain research to guide teaching practice. Brain-based teaching involves the implementation of carefully-designed principles with due consideration of their impact before, during, and after each lesson (Townsed, 2005.)

Most people activate and suppressed their hemispheres, one at a time, when they were reading or drawing, thinking critically or creatively, reading technical material or stories. These two minds are characterised as rational and intuitive, the rational faculties depending predominantly upon left hemisphere processes, the intuitive (immediate knowing of the environment) on the right (Ornstein 1986). The processing modes have become known as 'right brain' processing and 'left brain' processing. Not everyone actually uses the left side of their brain for analytical processing and the right side for intuitive processing (Atkin, 1999).

People use two distinctly different forms of processing information -- a holistic, pattern making process called 'right brain' processing which focuses on the forest, and a logical, analytical processing called 'left brain' processing which focuses on the trees. However, nowadays, in Myanmar, educators and teachers must recognize that right hemisphere processing is of paramount importance for learning with meaning. In practice, since meaningful learning for students is indispensable in this competitive world abundant with material and information, educators today should exert their effort to implement education system that mainly focus on developing the right hemisphere of the learners to enable them to make right decisions out of various alternatives and overcome the challenges of this complex world.

In any situation, two hemispheres act distinctly different, but perform complementary modes of processing. Effective learning with meaning involves integration of feeling, experiencing, thinking (analytically as well as intuitively) and acting -- integration of our many ways of knowing. Individuals differ in the way they favour or prefer the different ways of processing -- the different ways of thinking and knowing. Individuals have preferred thinking styles. Herrmann’s terms, individuals show different brain dominance patterns. Dominance simply indicates a leading mode or modes. However, unfortunately, it is apparent that students in Myanmar are rarely provided with learning opportunities that can foster their intuitive thinking. Teaching learning activities are prepared with little emphasis on developing right hemisphere of students. Course guidelines and curricula are very theoretical in nature and are designed, showing weaknesses on promoting right mode of thinking. Actually, frequent review of school curricula and conducting timely refresher courses for

teachers of all education levels are of urgent need to keep up with the rate of fast changing world.

It has been documented that reinforcement of active learning tasks improves brain efficiency. So, educators should create classroom environment which involves active learning tasks; applying information in such activities that require making decisions, investigating, creating debates, conducting research, doing experiments, solving real-world problems, addressing students open-ended problems, and offering students an opportunity to analyse their findings and error patterns. According to Sousa (1998), brain research confirmed that this type of active learning activates the area of the brain responsible for higher-order thinking (cited in Hardiman, 2001). Sousa (2006) supported Bloom's Taxonomy as an organizational structure that is compatible with the manner in which the brain processes information to promote comprehension.

Effective learning, problem solving and performing involve applying the appropriate style of processing to the task. If a learner is highly inclined towards one mode of processing - one quadrant or one side of the whole brain model, or the limbic versus the cerebral, he will tend to approach tasks in that mode even when it's not the most appropriate mode - even when it's not likely to lead to success. The art of being an effective learner and 'doer' is having the ability to draw on the appropriate mode for the task. Part of the art of being an effective teacher is to engage the learner in the appropriate thinking modes for the task. People who claim that their school or college learning was characterised by rote learning did not necessarily want to learn in this fashion - they didn't know how to learn in any other way. The evidence is quite clear that people are not always in their right mind (Atkin, 1999).

Atkin (1999) stated that learning which involves the integration of experiences, feelings, reflections, and actions is integral to being human. Often learners have already had experiences which are fundamental to learning but have not engaged in a process of conscious reflection which enables them to build up their mental map of the experience. The most effective learners, learners who have internalised what they have learned and can transfer their learning to new situation; have generally engaged whole brain processing in the learning process. The right brain processing mode is non-verbal and sometimes relatively subconscious and it is quite possible that individuals who are learning effectively are not

aware that what is going on inside their minds is not necessarily going on in the minds of other learners.

To be effective for all learners, teaching needs to ensure that learners iterate around the whole brain processing model. Learning experiences need to be designed deliberately to engage personal relevance. Reflection processes which help the learner make connections and develop patterns and relationships must be developed in parallel with the language and symbols which can be used to represent them. Opportunities must be provided for the learners to express their learning in a variety of modes and to actively try out their mental maps in their own world (Atkin, 1999).

Limitations of the Study

The design of this study was cross-sectional in nature but selected institutions for this study were only two Institutes of Education. Both institutes were concerned with teacher education and teacher training programme. To confirm the across disciplinary differences, more different disciplinary clusters should be selected as the sample institutions including Institutes of Medicine, Institute of Economics, University of Arts and Science, and so on. In addition, gender related difference was not found in this study. To examine the gender related difference, even though equal sample size was more desirable. The proportion of female participants involved in this study was more than that of male due to the very low percentage of pre-service and in-service teacher trainees who enrolled in both institutes.

Suggestions for Future Research

As the data collection method, cross-sequential design is more preferable to classify the effectiveness of instructional strategies, course work, and curriculum on the development of critical thinking skill over time. In addition, effectiveness of specific course should be examined by using the combination of discipline-specific critical thinking skill tests and experimental research design. If possible, discipline-specific critical thinking skill test and brain dominance test should be applied under the umbrella of neuroscience research by accompanying the electronic devices such as magnetic resonance imaging (MRI), electroencephalographic (EEG), positron emission tomography (PET) and other advanced technology.

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