

COGNITIVE ABILITY AND ACADEMIC ACHIEVEMENT OF UNDERGRADUATES

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This study aims to identify cognitive ability and academic achievement of undergraduates in Universiti Teknologi Malaysia. In this study, cognitive ability is a combination of critical thinking, creative thinking, metacognition, and knowledge. A total of 336 undergraduates had participated in this study. Inferential analysis was used to explore the relationship between cognitive abilities and academic achievement of the respondents. The findings showed significant relationship between all cognitive abilities except knowledge and academic achievement. The multiple regression results showed that critical thinking, creative thinking, and metacognition has significant predictive power on undergraduates' academic performance with $F(3,332) = 185.909$, $p < 0.001$. Critical thinking has the highest predictive power ($\beta = 0.491$) while creative thinking has the lowest predictive power ($\beta = 0.221$) on academic achievement. Future study can be done by applying group difference in order to understand more about the development of cognitive abilities among undergraduates.

INTRODUCTION

The world today is changing and transforming at a very fast pace. Every nation needs to prepare their citizens to survive the stiff competition globally. In light of this, it was stated in the Tenth Malaysia Plan 2011-2015 that Malaysia aspires to produce a future generation with high innovation, high skill-levels in both technical and professional fields and strong levels of productivity to compete in this technological-based world (RMK-10, 2010). This change has created an impact on universities to produce graduates who have more than just the academic skills. Besides that, rapid changes had taken place, especially in technology and industrial sectors and thinking skills should be highlighted in educational goals so that the graduates are able to process new information instead of just gaining raw knowledge (Mahyuddin *et al.*, 2004).

University acts as the centre of higher education to develop students with high cognitive ability in intellectual, critical, creative and other higher-level skills besides nurturing qualities identified with employability (UNESCO, 2011). In year 2012, MOHE gave autonomy to five main public universities in Malaysia, which are Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM) and Universiti Teknologi Malaysia (UTM) by emphasizing eight agendas in order to have a competitive, creative, and flexible learning environment (Utusan Malaysia, 2012). One of the agendas is to rev up the innovative human capitals to develop the country. Innovation

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is inseparable from individuals' cognitive abilities and intelligence (Jackson *et al.*, 2006). Therefore, cognitive abilities should be highlighted in higher education curriculum in order to produce graduates with high survival skills to survive and success in this challenging era nowadays.

Although the universities are aware of the importance of cognitive abilities, but the role of cognitive development and cognitive ability among students in higher education remained as a topic of discussion and research. The previous research showed cognitive ability is vital in producing graduates who are able to generate new ideas or solutions to meet the requirements or solve the problems in practical ways. When discussing about cognitive ability, all should know Cattell-Horn-Carroll Theory of Cognitive Abilities (CHC Theory). CHC theory is the most widely accepted theory of human cognitive abilities derived from two theories, which are Horn-Cattell Gf-Gc theory (Cattell, 1941; Horn, 1965) and Three-Stratum theory (Carroll, 1993). CHC theory is studied the structure of human cognitive abilities and intelligent factors and the impacts of these factors to the learning process.

There are nine broad cognitive abilities in CHC Theory to explain how human cognition and intelligent works. Although all broad cognitive abilities has its own functions for the mental development of a person, but this study is only focusing on cognitive processes that applied by a person when facing a practical problem, or in other word, the thinking skills applied by an individual during problem solving. This study has focused on three components that had been studied frequently in the field of higher education, which are critical thinking, creative thinking, and metacognition. Learners should be equipped with critical thinking to make precise justification and generate reasonable solutions towards the attainment of problem solving (Wang, 2009; Watson and Glaser, 1994). Meanwhile, creative thinking enables the students to generate new ideas or concepts by connecting the existing ideas or concepts (Abedi, 2000). Besides that, students require metacognition to plan, organize, and evaluate their own cognition process during the problem solving in same or different contexts (Lai, 2011).

RESEARCH OBJECTIVES

The objectives of this research are the following:

1. To identify the level of cognitive abilities among undergraduates in UTM.
2. To identify the level of academic achievement among undergraduates in UTM.
3. To identify the relationship between cognitive abilities and academic achievement of undergraduates in UTM.
4. To investigate the contribution of cognitive abilities to academic achievement among undergraduates in UTM.

COGNITIVE ABILITY

The study of cognitive ability had continued more than a decade, but there is no general definition of cognitive ability. There are many other terms that shared the same meaning with cognitive ability, such as intelligence, g factor, mental ability or IQ and being interchangeably used by different researchers and contexts. In general, cognitive ability is the ability to process mental information in order to understand intended end results and also perform a task efficiently (Carroll, 1993). Carroll (1993) stated that cognitive ability can be explained by two words, which are 'cognitive' and 'ability'. Ability is commonly referred as 'able to do' in various contexts, such as drawing ability, speaking ability. Cognitive ability enables learners to understand the existing problem and solve it by using various kinds of cognitive process. Cognitive ability is directly or indirectly related to learning with the aids of knowledge and regulation (Shell *et al.*, 2007).

CHC theory is studied the structure of human cognitive abilities and intelligent factors and the impacts of these factors to the learning process. The CHC model consists of nine broad abilities, namely fluid intelligence (Gf): the ability to solve novel problems using unfamiliar information or procedures, quantitative knowledge (Gq): the ability to deal with mathematical knowledge or numerical symbols, crystallized intelligence (Gc): the ability to use knowledge obtained in the past to solve problems, reading and writing ability (Grw): the ability to perform basic reading and writing skills, short-term memory (Gsm): the ability to hold and use information in the short duration, long-term storage and retrieval (Glr): the ability to hold and retrieve out stored information in the process of thinking after a period of time, visual processing (Gv): the ability to analyze visual memory, auditory processing (Ga): the ability to recognize and analyze of the difference of sounds and lastly, processing speed (Gs): the ability to automatically perform cognitive task under high focus condition.

CRITICAL THINKING

Critical thinking is used to identify a problem and make inferences by using logical and deductive reasoning with the available information towards the solution of the problem (Pither and Soden, 2000). Critical thinking acts as problem solving that is essential for people in both academic and also daily life applications. People must equip with critical thinking in order to analyze information, construct arguments and identify phenomena from different point of views (Wang, Woo, and Zhao, 2009). People with higher critical thinking will have a better chance to success in academic instructions and occupations that required high analytical thinking skills (Watson and Glaser, 1994). In this study, critical thinking is defined by the cognition process used to analyze, evaluate, and solve a problem in logical and reasonable ways.

Although there existed a lot of definitions for critical thinking, but Watson and Glaser (1994) concluded that critical thinking consists of five main aspects, which are inference, recognition of assumption, deduction, interpretation, and evaluation of argument. Inference is the ability to discriminate the degree of truth or falsity of inferences concluded from the information given. Meanwhile, recognition of assumptions is used to recognize unstated assumptions or presuppositions based on the statements given. Deduction is the ability to draw conclusions from the information with given statements or premises. Interpretation is required to provide evidence and make conclusions or generalizations from the given information. Lastly, evaluation of arguments enables learners to differentiate between arguments that are strongly correlated, weak correlated or even irrelevant.

CREATIVE THINKING

Creativity is a cognitive process to generate new ideas or concepts by connecting the existing ideas or concepts (Naderi *et al.*, 2009). Creative thinking includes cognitive skills like flexibility, originality, elaboration, brainstorming, modification, associative thinking and others to figure out a variety of solutions and select most appropriate solution towards problem solving (Anwar *et al.*, 2012). In this study, creative thinking is the generation of ideas that are new as well as useful, productive, and appropriate in one or multiple contexts. Fluency is the ability to generate different ideas. Flexibility is the ability to create different categories of ideas, and to perceive an idea from different points of view. Originality is the ability to generate new and unique ideas that none existing by others before. Lastly, elaboration is the ability to expand one idea into a better idea.

METACOGNITION

Metacognition enables learners to aware our own cognitive processes during the problem solving process (Young and Fry, 2008). Metacognition is the method of inventing or selecting a particular mental process to solve a problem or accomplish a task. Learners will select the path of mental process towards the solution during problem solving. Metacognition is commonly defined as a learning strategy learnt by the students in order to solve the similar problem in different contexts (Lai, 2011). In this study, metacognition is defined as cognitive ability used to plan, organize, and evaluate their thinking process in problem solving.

Metacognition generally is divided into two main categories, cognitive knowledge and cognitive regulation (Lai, 2011). Cognitive knowledge is knowledge about the learners' own cognitive strengths and limitations that may affect their cognition. Cognitive regulation is the process of monitoring mental strategies in order to accomplish a task. Cognitive regulation is the actual activities involved in learning in order to maximize the learning outcomes. Cognitive regulation promotes self-regulated learning and self-correction where learners are able to learn without

depending on others and able to realize own mistakes. Cognitive regulation includes three mental processes, monitoring, planning, and evaluating. Planning is the ability to investigate and select the most appropriate strategies with the existing resources. Monitoring is the ability to aware and test own comprehension and task performance. Lastly, evaluation is the ability to revise and revisit the strategies applied.

METHODOLOGY

This study involved a total of 336 undergraduates from Universiti Teknologi Malaysia. Questionnaires had been used in this research to investigate the level of students' cognitive abilities, which are critical thinking, creative thinking, and metacognition. Watson-Glaser Critical Thinking Test (WGCTA) was used to identify critical thinking level. Meanwhile, Abedi Creativity Test (ACT) and Metacognition Awareness Inventory (MAI) were adopted to identify participants' creative thinking and metacognition level respectively. The results of pilot study ($n = 50$) showed high coefficient of Alpha Cronbach reliability for WGCTA and ACT with 0.813 and 0.866 respectively. On the other hand, medium coefficient of Alpha Cronbach reliability for MAI with 0.619. On the other hand, participants' academic achievement was measured by using their cumulative grade point average (CGPA), ranged from 0 to 4.

RESULTS

The data was analyzed via Statistical Package for Social Sciences (SPSS) version 22.0 to identify the relationship between cognitive abilities and academic achievement. At first, the relationship between every sub component of cognitive abilities and academic achievement had been analyzed independently. Afterwards, the relationship of critical thinking, creative thinking, and metacognition to academic achievement had been identified, followed by the overall contribution of these three cognitive abilities towards academic achievement.

TABLE 1: LEVEL OF RESPONDENTS' SUB COGNITIVE ABILITIES

| <i>No</i> | <i>Cognitive Abilities</i> | <i>Mean</i> | <i>S. D.</i> |
|-----------|----------------------------|-------------|--------------|
| 1 | Inference | 0.573 | 0.269 |
| 2 | Recognition of Assumptions | 0.552 | 0.256 |
| 3 | Deduction | 0.513 | 0.255 |
| 4 | Interpretation | 0.599 | 0.254 |
| 5 | Evaluation of Arguments | 0.558 | 0.249 |
| 6 | Fluency | 0.666 | 0.093 |
| 7 | Elaboration | 0.675 | 0.114 |
| 8 | Originality | 0.663 | 0.104 |
| 9 | Flexibility | 0.657 | 0.130 |
| 10 | Planning | 0.647 | 0.260 |
| 11 | Monitoring | 0.619 | 0.267 |
| 12 | Evaluating | 0.577 | 0.292 |

TABLE 2: INTERCORRELATIONS BETWEEN COGNITIVE ABILITIES AND ACADEMIC ACHIEVEMENT (CGPA)

| Cognitive Abilities | IF | RA | DE | IN | EA | FL | EL | OR | FX | PL | MO | EV | CGPA |
|--------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Inference (IF) | - | .529** | .620** | .220** | .362** | .136* | .085 | .134* | .019 | .121* | .142** | .054 | .473** |
| Recognition of Assumption (RA) | .529** | - | .638** | .223** | .365** | .136* | .056 | .114* | .020 | .150** | .211** | .017 | .472** |
| Deduction (DE) | .620** | .638** | - | .193** | .344** | .147** | .045 | .126* | .003 | .193** | .219** | .108* | .518** |
| Interpretation (IN) | .220** | .223** | .193** | - | .260** | .076 | .009 | .098 | .001 | .053 | .006 | .054 | .297** |
| Evaluation of Argument (EA) | .362** | .365** | .344** | .260** | - | .084 | .012 | .137* | -.018 | .164** | .170** | .049 | .388** |
| Fluency (FL) | .136* | .136* | .147** | .076 | .084 | - | .380** | .570** | .397** | .148** | .079 | .033 | .326** |
| Elaboration (EL) | .085 | .056 | .045 | .009 | .012 | .380** | - | .659** | .769** | .088 | .070 | .000 | .233** |
| Originality (OR) | .134* | .114* | .126* | .098 | .137* | .570** | .659** | - | .654** | .109* | .111* | .048 | .299** |
| Flexibility (FX) | .019 | .020 | .003 | .001 | -.018 | .397** | .769** | .654** | - | .105 | .090 | .034 | .247** |
| Planning (PL) | .121* | .150** | .193** | .053 | .164** | .148** | .088 | .109* | .105 | - | .547** | .314** | .514** |
| Monitoring (MO) | .142** | .211** | .219** | .006 | .170** | .079 | .070 | .111* | .090 | .547** | - | .301** | .477** |
| Evaluating (EV) | .054 | .017 | .108* | .054 | .049 | .033 | .000 | .048 | .034 | .314** | .301** | - | .341** |
| CGPA | .473** | .472** | .518** | .297** | .388** | .326** | .233** | .299** | .247** | .514** | .477** | .341** | - |

*p < 0.05, **p < 0.01

Table 1 shows the overall mean distribution and standard deviations of respondents' cognitive abilities. Among all of sub components of cognitive abilities, elaboration from creative thinking has shown the highest mean of 0.675. Meanwhile, the findings showed that deduction of the respondents had achieved the lowest among all sub cognitive abilities, given the mean 0.513.

Table 2 shows the intercorrelations between cognitive abilities and academic achievement of the respondents. The findings showed each of the cognitive abilities had significant relationship with academic achievement independently. All cognitive abilities had positive relationship to academic achievement but there are some cognitive abilities only have weak relationship with academic achievement, which are interpretation ($r = 0.297$), elaboration ($r = 0.233$), originality ($r = 0.299$), and flexibility ($r = 0.247$).

On the other hand, Table 3 shows the intercorrelations between three main cognitive abilities, namely critical thinking, creative thinking, and metacognition to academic achievement of the respondents. The results show that respondents' creative thinking is the highest with a mean of 0.666 while critical thinking is the lowest with a mean of 0.559. Besides that, an average CGPA of undergraduates in UTM is 3.39. All critical thinking, creative thinking, and metacognition showed positive significant relationship to academic achievement where critical thinking has the strongest positive correlation ($r = 607$), followed by metacognition ($r = 574$), and lastly creative thinking ($r = 0.327$).

TABLE 3: INTERCORRELATIONS BETWEEN CRITICAL THINKING, CREATIVE THINKING, METACOGNITION AND ACADEMIC ACHIEVEMENT

| | <i>M</i> | <i>SD</i> | <i>CT</i> | <i>CC</i> | <i>ME</i> | <i>AA</i> |
|---------------------------|----------|-----------|-----------|-----------|-----------|-----------|
| Critical Thinking (CT) | 0.559 | 0.182 | -- | 0.111* | 0.206** | 0.607** |
| Creative Thinking (CC) | 0.666 | 0.091 | | -- | 0.116* | 0.327** |
| Metacognition (ME) | 0.615 | 0.210 | | | -- | 0.574** |
| Academic Achievement (AA) | 3.39 | 0.282 | | | | -- |

* $p < 0.05$, ** $p < 0.01$

Table 4 shows simultaneous Multiple Regression results for cognitive ability in predicting academic achievement. The combination of cognitive ability to predict undergraduates' academic achievement was statistically significant with $F(3,332) = 185.909$, $p < 0.001$. Critical thinking was the best predictor with $\hat{\alpha}$ value of 0.491 while cognitive strategy was the least predictor with $\hat{\alpha}$ value of 0.221 to academic achievement. Overall, all cognitive abilities significantly predicted academic achievement and highly predict 62.3% of the variances in academic achievement of undergraduates.

TABLE 4: SIMULTANEOUS MULTIPLE REGRESSION RESULTS FOR COGNITIVE ABILITY IN PREDICTING ACADEMIC ACHIEVEMENT

| | <i>Unstandardized Coefficients</i> | | <i>Standardized Coefficients</i> |
|-------------------|------------------------------------|-----------------------|----------------------------------|
| | <i>B</i> | <i>Standard Error</i> | β |
| Critical Thinking | 0.760 | 0.053 | 0.491** |
| Creative Thinking | 0.681 | 0.104 | 0.221** |
| Metacognition | 0.602 | 0.046 | 0.447** |
| Constant | 2.142 | 0.074 | - - |

$R^2 = 0.627$, Adjusted $R^2 = 0.623$, $F(3,332) = 185.909$, $p = 0.000 < 0.001$

* $p < 0.05$, ** $p < 0.01$

DISCUSSION

The aim of this study is to investigate the cognitive ability of undergraduates in UTM and the role of cognitive abilities in their academic achievement. The research findings showed that all the cognitive abilities, critical thinking, creative thinking, and metacognition play a role in predicting undergraduates' academic achievement. Furthermore, all of the sub components of cognitive abilities also showed a significant positive relationship with academic achievement, although some of them only have weak ($r < 0.3$) correlation. The results supported by several previous researches about cognitive abilities. Previous studies showed that these three constructs, which are critical thinking (Alias and AbdHadi, 2010), creative thinking (Naderi *et al.*, 2009; Anwar *et al.*, 2012; Alias and AbdHadi, 2010), metacognition (Sendurur *et al.*, 2011; Young and Fry, 2008) had correlated positively with the academic achievement of the students.

Rohde and Thompson (2006) argued that cognitive ability is able to predict academic achievement but not perfectly. This result explained that there must be other variables have an effect on academic achievement. On the other hand, the findings on critical thinking and creative thinking are consistent with the study of Alias and AbdHadi (2010). Their study obtained Chi-square results that showed a significant relationship between both critical and creative thinking styles and academic achievement, $\chi^2 = 9.314$, $df = 3$, $p < 0.05$. However, it showed that undergraduates with creative thinking style will score better in their academic where it was opposite with current study result where critical thinking ($\beta = 0.491$) predict better than creative thinking ($\beta = 0.221$) on academic achievement. Young and Fry (2008) had found a positive relationship between metacognition and academic achievement. This can be explained by that learners with better metacognition are able to manage and plan their cognitive strategy in order to have better performance in academic (Sendurur *et al.*, 2011; Lai, 2011).

CONCLUSION

In general, the present study has shown that cognitive abilities have the predictive power to academic achievement with $F(3,332) = 185.909$, $p < 0.001$, revealed the

role of cognitive abilities in undergraduates' academic achievement. All cognitive abilities: critical thinking, creative thinking, metacognition have their own roles to enhance undergraduates' academic achievement. Therefore, cognitive abilities must be emphasized in tertiary education in order to have innovative workforces that able to hasten the development of our country. However, the low predictive power of creative thinking to academic achievement had been spotted. Future study can be done on investigating the unrevealed factors to the low predictive power of creative thinking. Further study should involve both undergraduates and graduates in order to identify whether the cognitive abilities will improve upon age or education level. Future research also can involve the investigation of personal background for better understanding about cognitive abilities.

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