

**THE CHARACTERISTICS OF  
THE COLORED PROGRESSIVE MATRICES (CPM) AND  
THE ADVANCED PROGRESSIVE MATRICES (APM)  
IN THAI STUDENTS AGE 6-18 YEARS OLD:  
THE WESTERN REGION**



**A THESIS SUBMITTED IN PARTIAL FULFILLMENT  
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THE CHARACTERISTICS OF THE COLORED PROGRESSIVE MATRICES (CPM) AND THE ADVANCED PROGRESSIVE MATRICES (APM) IN THAI STUDENTS AGE 6-18 YEARS OLD: THE WESTERN REGION

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**ABSTRACT**

The purpose of this research was to study the characteristics of Colored Progressive Matrices (CPM) and Advanced Progressive Matrices (APM) and construct norms for Thai students aged 6-18 years in the Western region. Sample consisted of 1,393 students, of which 498 were 6-11 years old, and 895 were 12-18 years old.

Results revealed that the CPM might be easy for students aged 6-11 years with average item difficulty of .73, average discriminating power of .52, and high reliability of .92. A principal component analysis, followed by a series of varimax rotations of the principal component, was performed. The 7-factor solution provided the most interpretable factor structure. These factors were Balance, Creation, Distinguish, Continuity, Category, Connection, and Assembly, respectively. The APM like the CPM was found moderately easy for students aged 12-18 years with average item difficulty of .50, average discriminating power of .42 and high reliability of .87. Nine factors showed the most interpretable factor structure including Organization, Combination, Increase, Relation, Continuity, Remainder, Creation, Transformation, and Category, respectively.

Because of the fact that mean score of different sexes was non-significantly different at .05 while that of different ages and educational level was significantly different. Therefore, the intelligence quotient scores (IQs) norms of the CPM and the APM were constructed and classified by age and educational level.

**KEY WORDS:** COLORED PROGRESSIVE MATRICES / ADVANCED PROGRESSIVE MATRICES / INTELLIGENCE / AGE 6-18 YEARS OLD

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การศึกษาคุณภาพของแบบทดสอบเขาวัวปัญญา Colored Progressive Matrices (CPM) และ Advanced Progressive Matrices (APM) ในนักเรียนไทยอายุ 6 ถึง 18 ปี: ในเขตภาคตะวันตก (THE CHARACTERISTICS OF THE COLORED PROGRESSIVE MATRICES (CPM) AND THE ADVANCED PROGRESSIVE MATRICES (APM) IN THAI STUDENTS AGE 6-18 YEARS OLD: THE WESTERN REGION)

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#### บทคัดย่อ

การวิจัยครั้งนี้ มีวัตถุประสงค์เพื่อศึกษาคุณภาพของแบบทดสอบ Colored Progressive Matrices (CPM) และ Advanced Progressive Matrices (APM) และสร้างตารางเกณฑ์ปกติในกลุ่มนักเรียนอายุ 12-18 ปี ในเขตภาคตะวันตกของประเทศไทย กลุ่มตัวอย่างมีจำนวนทั้งสิ้น 1,393 คน แบ่งเป็นกลุ่มอายุ 6-11 ปี จำนวน 498 คน กลุ่มอายุ 12-18 ปี จำนวน 895 คน

ผลการวิจัยพบว่า แบบทดสอบ CPM ค่อนข้างง่ายสำหรับเด็กนักเรียนอายุ 6 ถึง 11 ปี ค่าความยากง่ายเฉลี่ยเท่ากับ 0.73 ค่าอำนาจจำแนกเฉลี่ยเท่ากับ 0.52 และมีค่าความเที่ยงสูงคือ 0.92. การวิเคราะห์องค์ประกอบ หลังจากทำการหมุนแกนแบบ varimax ได้ 7 องค์ประกอบที่สามารถอธิบายโครงสร้างขององค์ประกอบ คือ ลักษณะสมดุล (Balance) การตัดแปลงรูปภาพ (Creation) การจำแนกประเภท (Distinguish) ความต่อเนื่องของภาพ (Continuity) การจัดกลุ่ม (Category) ความเชื่อมโยง (Connection) และ การประกอบชิ้นส่วนภาพ (Assembly). แบบทดสอบ APM มีความง่ายระดับปานกลางสำหรับเด็กนักเรียนอายุ 12 ถึง 18 ปี ค่าความยากง่ายเฉลี่ยเท่ากับ 0.50 ค่าอำนาจจำแนกเฉลี่ยเท่ากับ 0.42 และค่าความตรงสูงคือ 0.87 พบ 9 องค์ประกอบที่สามารถอธิบายโครงสร้างขององค์ประกอบ คือ การจัดการอย่างเป็นระบบ (Organization) การรวมภาพ (Combination) การเพิ่มจำนวน (Increase) ความสัมพันธ์ของรูปภาพ (Relation) ความต่อเนื่องของภาพ (Continuity) การตัดแปลงรูปภาพและคงสภาพบางอย่างไว้ (Remainder) การตัดแปลงรูปภาพ (Creation) การเปลี่ยนแปลงรูปภาพ (Transformation) และการจัดประเภท (Category).

เนื่องจากคะแนนเฉลี่ยระหว่างเพศไม่มีความแตกต่างกันอย่างมีนัยสำคัญที่ 0.05 ขณะที่ กลุ่มอายุ และ ระดับชั้นเรียนที่ต่างกันมีคะแนนเฉลี่ยแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ดังนั้นจึงสร้างเกณฑ์ปกติของคะแนนเขาวัวปัญญา จำแนกตามอายุ และระดับชั้นเรียน

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## CHAPTER I

### INTRODUCTION

#### Background and Rationale

In psychological concept, many definitions of intelligence have been proposed; adaptive thinking or action (1), totality of mental processes involved in adapting to the environment (2), aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with the environment (3) and ability of thinking in abstract and problem solving (4).

The capacity of intelligence was measured by the intelligence tests. Clinically, results of intelligence tests are useful for diagnostic purpose of low intelligence and dementia patient. Moreover, database of child's ability is useful for educational purpose, in particular for potential development of students. Tests of intelligence emphasize the measurement of mental ability such as reasoning, remembering, and imagination. These abilities were first identified in the pioneered work of Alford Binet, a French psychologist who strongly interested in difference of mental abilities from one to another (5). The intelligence tests have been constructed and developed all a long time. Nowadays, two types of tests have been created for measurement of intelligence ability, 1) individual tests such as the Stanford-Binet form L-M, the Wechsler Scale and 2) group tests such as Multidimensional Aptitude Battery, the Cognitive Abilities Test etc. Before administration, consideration of two main characteristics of test is of necessity, reliability, that refer to its stability and consistency and validity that related to actual characteristics supposed to be measure by the test (6) (7). However, because of the fact that many tests constructed by western psychologist caused some culture biased that could effect test administration and test score, hence, in order to eliminate social or cultural advantages of disadvantages,.

culture fair test that could be administered to anyone from any country which speak any language. At this moment, some well-known culture fair tests are Davis-Eells Test of General Intelligence, RPM, and Cattell Culture-Fair Intelligence Test.

Widely used in several countries including Thailand, Raven's Progressive Matrices (RPM) is one of the culture fair tests designed to assess general intelligence; logical reasoning and recognition. Consisting of three forms; the Standard Progressive Matrices (SPM), the Advanced Progressive Matrices (APM) and the Colored Progressive Matrices (CPM), RPM is not affected by verbal ability and can be administered to anyone, without language influence, however, due to the fact that, culture of cognitive process must be considered, each nation has different cognitive structure. Accordingly, Piaget (8) (9) suggested that adaptation to environment by means of assimilation and accommodation. In fact, it is not fair and efficiency to compare test score with norm constructed from individuals of different culture. Therefore, when test is administered to population from different nation, standard score must be studied before creation of normative score for that group.

This research interest to study the characteristics of the Colored Progressive Matrices and the Advanced Progressive Matrices in Thai students aged between 6 to 18 years who studied in primary and secondary schools in the Western region of Thailand. Results from this study lead to creation of norms that can use to compare students with the same age or educational level in the Western region. Moreover, intellectual development may be different for children growing in difference geographic regions due to their own culture, language way of life and child caring practice. Therefore, results of this study will be integrated to recent study in other six region of Thailand including Central, North, Northeast, East, South, and Bangkok.

## **Research Objective**

1. To study the characteristics of CPM and APM in consider of reliability, validity, discriminating power, and item difficulty.
2. To construct norm of the CPM for the student ages 6 to 11 years and the APM for the student ages 12 to 18 years who live in the Western region of Thailand.

## **Scope of the Study**

### 1. The characteristic of test

The characteristics of test refer to item difficulty, item discrimination, reliability, and construct validity.

### 2. Population

Population of this study were student aged 6 to 18 years who study in primary and secondary schools in the Western region of Thailand.

### 3. The variables

Independent Variables; Demographic data: age, sex and educational level.

Dependent variables: Intelligence from the Colored Progressive Matrices and the Advanced Progressive Matrices

### 4. Tool

Raven's Progressive Matrices: the Colored Progressive Matrices and the Advanced Progressive Matrices

## **Benefit of Study**

1. Obtain the characteristic of CPM and APM in Thai student aged 6 to 18 years led to assure test quality in particular reliability and standard of test.

2. Obtained norms that can use to compare and classify the intelligent capacity of Thai population aged 6 to 18 years that will be useful for educational management and medical service.

### **Definition of Terms**

**Intelligence:** refers to abstract thinking, learning from experience, solving problem through insight, adjusting to new situation, focusing and sustaining one's ability to achieve a desired goal. This study mean observation ability, visual perception, thinking, and controversial ability. The standard index of intelligence is the Intelligence Quotient (IQ) score.

**Intelligence Quotient (IQ):** refers to the number which shows intellectual abilities obtained from measuring with intelligence test at the tested time. To know the level compared with others who are in the same age range or in the same educational level.

**Norms:** refer to an average score determined by applying the test to standardized sample. A test score converted to an equivalent standard score in normal distribution and transformed to percentile and IQ score.

## CHAPTER II

### LITERATURE REVIEW

This research studied the characteristic of the Colored Progressive Matrices and the Advanced Progressive Matrices in Thai students age 6 to 18 years in the Western region of Thailand. The literature reviews were as follow:

#### Concept of intelligence

1. Definition of intelligence
2. Intelligence theories
3. Factor influence intelligence

#### History of intelligence test development

1. Intelligence Test
2. Development of Culture Fair Tests

#### The Raven's Progressive Matrices

1. The three forms of the matrices
2. Scoring
3. Quality of tests
4. Norm of tests

## Concept of Intelligence

### 1. Definition of Intelligence

There were several definitions about what intelligence is. The idea summarizes in two concepts as:

First, a definition of intelligence is the capacity adapt to the environment. Alfred Binet (2), a French psychologist, defined intelligence as the totality of mental processes involved in adapting to the environment. Piaget (1) defined intelligence as adaptive thinking or action. Similarly, Wechsler's (3) defined as the aggregate or

global capacity of the individual to act purposefully, to think rationally, and to deal effectively with the environment.

The second of definition by Gardner was the ability to think in abstract and to solve a problem (4). Thorndike defined as the general tendency to display effective responses to an abstract or symbolic nature (10). In addition, Sternberg defined as the ability to think abstractly or to solve problems effectively (11).

Accordingly, the definitions of intelligence defined as the capacity to spend a reason, abstract thinking, learning from an experience, adaptive to environment, and planning to solve problem.

## 2. Intelligence Theories

Intelligence theories divided into four groups (12). These included Psychometric approach, Developmental theories, Information processing and Neurological-biological approaches were as follow.

### 2.1 Psychometric Approach

Psychometric theories were concept to use a statistical procedure by factor analysis. Theories in this were as Two-Factor Theory by Charles Spearman who was British psychologist (1) (13), this theory was based on score test analysis by statistical method. In order to make observe on score test of intelligence had related in mutual positive. The relation appeared by component of test called general intelligence. Spearman divided component of intelligence into two factors were as General Factor (g-factor) and Specific Factor (s-factor). General factor was based on each person, all of the person had a difference g-factor level, which had a high-level would perform efficiency task, in contrast if they had low level would perform poor task. Spearman believed, heredity was influence on this ability but the educational level was not influence on these. Specific Factor contributed to some of individual's specific skill as mathematic, language, music, art, or creative thinking. The intelligent evaluation interested to measure general ability because relation with all mental ability. The intelligence tests should be measure abstract relation that used ability to search a relationship and a correlation. Those concepts were a basic principle in human by an apprehension of experience, the education of relation, and the education

of correlation. This point, people perceived everything by experience and they had those experiences immediately. Thurston (1) (5) did not approve in one factor of general intelligence. He suggested Multiple Factor Theory that analyzed Spearman's general ability and determined factor into seven difference factors were as: verbal comprehension, number, perceptual, speed, spatial, word fluency, memory and inductive reasoning. These factors called the primary mental ability. Afterwards, Vernon (12) (14) suggested the Hierarchical Theory, stating that intelligence was integrated and unitary but comprised a number of both large and small specific abilities. His model was basic hierarchical, with the g factor at the top to indicate that it unified all the abilities occurring at lower levels refer to increasingly more specific and discretized ability such as verbal fluency, numerical reasoning, and creativity. In addition, Cattell (1) (14) presented Fluid and Crystallized Intelligence to realize the importance of g-factor. That he had synthesized Spearman's and Thurston's to suggest the two dimension of intelligence widely, that Fluid intelligence ( $g_f$ ) was the ability to cope a new problem quickly, which had inherited from heredity and Crystallized intelligence ( $g_c$ ) was the ability from learning and experience. However, Guilford had an opinion that, Factor Theory could not explain all the ability of human. He suggested the Structure of Intelligence (15) (16), which called the structured-of-intellect model, a combination of three dimensions as; operations 6 types (what a person did), contents 5 types (the material on which operation are performed) and product 6 types (the form in which the information is stored and processes).

Accordingly, theory in these group tried to explain the structure of intelligence what were, that used to construct the intelligence tests for measurement g-factor, some well known intelligence test was designed to measure Spearman's "g". It was said that Raven's Progressive Matrices, which was a non-verbal test. As well as, Cattell created intelligence test from his theory that was Fluid and Crystallized Intelligence called the Cattell Culture Fair Intelligence Test.

## 2.2 Developmental Theories

An important idea about the development of intelligence was the Cognitive Development by Piaget. (1) (8) (9) There were two basic functions; adaptation was the accord of thought with things, and organized was the accord of

thought with itself. He believed adaptation to environment is most important principle. In adaptation, individuals learn from the environment and learn to address changed in the environment. Adjustment consisted of two complementary process; assimilation and accommodation. Assimilation was the process of absorbing new information and fitting it into an already existing cognitive structure about what the world was like. The complementary process, accommodation involved forming a new cognitive structure in order to understand information. Piaget described four major stages of cognitive development. The first stage, sensory-motor period (birth to 2 years), infants used their sense and motor action to explore and understood the world. The second stage, preoperational period (2 to 7 years), preschools used their capacity for symbolic thought in developing language, engaging in pretend play and solving problem. The third stage, concrete operations (7 to 11 years), school age children acquired logical operations that allow them to mental classify and otherwise acted on concrete object in their heads. The last stage, formal operations, adolescents could think about abstract concepts and purely hypothetical possibilities and could trace the long-rang consequences of possible actions. In the contemporary period with Piaget, Vygotsky (8) suggested that basic to intelligence of internalization, which operation was the internal reconstruction of an external. In the same time, Burner (14) suggested the theory of intelligence development, which was similar in Piaget's theory but he emphasized the relation of the environment and the intelligence development. This environment was the culture, which was a stimulus to intelligence development.

Knowledge in the development of intelligence could use to evaluate the development that were conformed to the stage of age, that were an advantage for the medical service and the education to consider the ability or an abnormal mental development.

### **2.3 Information Processing**

A well known theory in this group was Sternberg's Triarchic Theory (1) (17) that emphasized three aspects of intelligence behavior:

a) Contextual Component: Sternberg believed that Analytical Intelligence based on the joint operation of three components. The first, meta-component: control, monitor, and evaluated cognitive processing that were executive

functions. The second, performance component: execute strategies assembled by the meta-components. And the last, knowledge acquisition components were the process to use in gaining and storing new knowledge.

b) Experimental Component: this involved insights, synthesis, and the ability to react to novel situations and stimuli. Sternberg believed that more intelligence individual would also move from consciously learning in a novel situation to automating the new learning so that they could often to other tasks.

c) Contextual: these involved the ability to grasp, understood and deal with everyday task, and reflect how the individual related to the external world about him or her.

Other theory was the Pass Theory (The Planning, Attention, Simultaneous, and Successive Theory) by Das. It was a modern theory in the line with Sternberg about information processing framework and based on Luria's analyses of brain structures (18). Luria described human cognition processes within the framework of three functional units. The function of the first unit was cortical arousal and attention, the second unit coded information using simultaneous and successive processes, and structuring of cognitive activities. The function of three unites were coordination to cope stimuli appropriately by the individual ability.

Theory in this group had explained the function of brain processing to understand adaptation process and solving problem that were the function of intelligence.

#### **2.4 Neurological-biological Approach**

Gardner (19) studied the development of children's the cognitive processes based on Piaget's work. However, his own work on the development of cognition, he came to view those of Piaget as too narrowly focused. He suggested a new framework for considering the gifts of children. Through studying other cultural definitions of intelligence, neurophysiology, anthropological studies, and his own experimentation and observation of children, Gardner devised eight categories of respective intelligence. There were linguistic, logical, mathematical, musical, spatial, bodily kinesthetic, interpersonal, intrapersonal, and naturalistic.

Accordingly, this idea could bring to evaluate the several ability of person widely. It had not limit of the ability in academic only that to consider the ability of person clearly, which were an advantage for encouraging potential from a real capacity of person.

## **2. Factors Influence Intelligence**

There were many factors to influence the intelligence of human. The evidence from many studies reported the influence of gene, environment, gender, age, and level of education, which these factors influenced to performance on the intelligence test. The reports were as follow.

### **2.1 Genes**

Cattell suggested Fluid intelligence was the ability to use one's mind actively to solve novel problem. This ability not usually taught and believed to be relatively free of cultural influence. These believe expressed the notion, as heredity would be influence to intelligence possibly. There were many studies in relation of heredity and intelligence quotient widely. The different intelligence was differed by passing on genes that explained the difference of person to perform in the intellectual. The study in the twins found identical twins obtained more similar IQ score than fraternal twins did, even when they had been raised apart all their lives. Moreover, the IQ score of adopted children, once they reached adolescence anyway, were more strongly correlation with those of their biological parents than with those of their adopted parents (1). Genetic influence on parental cognitive ability was more important than the mode of conception in determining the long-term intellectual ability of children (20). The twins who had history of reading problems to measure in word recognition, phonological decoding, orthographic coding, and phoneme awareness, to investigate the genetic etiology of reading disability further. The results indicated that reading and language deficits were significantly heritable and that differential genetic influences as a function of IQ were evident for measures of word recognition and phonological decoding (21). The intelligence results and the action times tended to indicate that average Mongoloid intelligence levels were a little higher than those of Caucasoid were, but the difference was relatively small as compared with other racial

differences (22). These reports showed influence of gene to intelligence but could not explain the entire of intelligence, which other factors had an effect to intelligence.

## 2.2 Environment

Flynn's study (23) (24) of IQ tests scores for different populations over the past sixty years, he discovered that IQ scores increased from one generation to the next for all of the countries for which data existed. These interesting phenomena called "the Flynn Effect." The countries from which data had been gathered to research the increase of IQ scores over time were: Australia, Austria, Belgium, Brazil, Britain, Canada, China, Denmark, East Germany, France, Israel, Japan, Netherlands, New Zealand, Northern Ireland, Norway, Sweden, Switzerland, United States of America, and West Germany. Research showed that IQ gains were mixed for different countries. In general, countries had seen generational increases between 5 and 25 points. The largest gains appeared to occur on tests that measured fluid intelligence (Gf) rather than crystallize intelligence (Gc). Flynn's Hypothesis that best fitted the results was that IQ tests did not measure intelligence but rather correlated with a weak causal linked to intelligence. Based on the presence of the effect on nonverbal tests such as the Raven's Matrices, Flynn believed that the increase was actually an increase in abstract problem solving rather than intelligence. Flynn favored environmental explanations for the increase in test scores.

Environment factors were a society, an economic, a culture, and a raise. These factors were effect in long life of human when their mother had begun pregnancy through to deliver an infant, who grew up to a child until they were old. The outcome of cognitive tests and educational achievements improved significantly with increasing birth weight (25).The birth weight of an infant how many depended on a behavior to take care themselves of mothers when they were pregnancy. In addition, the postnatal environment had an influence on the intelligent ability. Hay (26) studied in children aged 11 years old found the children of women who were depressed at 3 months postpartum had significantly lower IQ scores. They also had attentive problems and difficulties in mathematical reasoning. Moreover, the boys were more severely affected than the girls were, with the sex difference most pronounced on Performance IQ. From the study had exposed the extreme stress in childhood (27),

such as domestic violence. The children, whose mother reported experience of domestic violence in the previous five years and they exposed to high levels of domestic violence had IQ score that were, on average, 8 points lower than unexposed children were. These study shows the stress from the raise are an effect to the intelligent ability. In addition, the socioeconomic were an influence to the intelligent ability as follow, the study in an influence of housing on intelligence quotients of 373 children in an urban slum the Government of Delhi in the two types of accommodation, aged 3.5, and 5.5 years. The first group was living in the plot area and the second group was living in two large clusters of shanty houses. That find the children living in the permanent houses had a significantly better IQ than those in shanty houses. A review of the literature did not reveal a comparable study. Analysis showed that the most significant factors affecting IQ were malnutrition in the first 6 months of life and attendance of the child at pre-school (28). And the study of Pirot Kampiman (29) in the northeast region of Thailand by Colored Progressive Matrices and WISC-R found the children living in urban area had a significantly better mean of verbal IQ score than those in rural area.

According, genes and environment factors were an influence on the intelligence ability but could not specify what factor was more influence. In the example, the study in Russian twins aged 6 and 7 years. Results were as at age 6, genetic influences were much greater than those of shared environment but the magnitude of genetic influences decreased and the magnitude of shared environment influences increased substantially by age 7 years (30). Bartels et al. (31) suggested genetic influences seem to be the main driving force behind continuity in general cognitive ability, represented by a common factor influencing full-scale IQ at all ages. Shared environmental influences were responsible for stability as well as changed in the development of cognitive abilities, represented by a common factor influencing full-scale IQ at all ages and age-specific influences, respectively.

### **2.3 Gender**

Kellogy (32) viewed a gender differences in cognitive competences. Meta-analyzes of large number of studies had shown that female performed better than male on some tests of verbal abilities. On some tests of visual-spatial ability, males

performed better than females. Males also showed an advantage on mathematical tests. However, because male showed markedly more variability than did female, it was not possible to predict mathematical ability by knowing gender. These and other gender differences could reflect either socialization practices or biological evolution. Colom and Garcia-Lopez's study in 2002 (33), a total of 4072 high school graduates was tested in three measures of Fluid intelligence (PMA Inductive Reasoning Test, Advanced Progressive Matrices and Culture-Fair Intelligence Test). The results revealed that female outperformed male in the PMA Reasoning Test, that male outperformed female in the Raven, and that there was no sex's difference in the Culture-Fair Test. Consistent with the find of Manas Jintanadirokkun (34) who studied the normative scores of APM for the University of Thai Chamber of Commerce students. The results that male had a better mean score than female non-significantly. Lynn and Tse-Chan (35) studied sex differences on the progressive matrices: some data from Hong Kong, the results provided further confirmation that in later adolescence and among adult, male obtained significantly higher mean IQ score on the Progressive Matrices than female. Sunthorn Tanchee's report (36), he studied the intelligence norm on CPM for students aged 5 ½-11 years in the central part of Thailand. The result had found male had a significantly better mean score than female. Similarly, Sudaporn Palas (37) studied the intelligence norm on CPM for students aged 5-11 years in the northern region of Thailand. However, Caffarra et al. (38) report gender did not effect on performance significantly. Similarly, Sudanee Wuttiroh (44) reported that there was not difference in mean score between male and female in a study of the intelligence norm on CPM for students aged 5-11 years in the northeast region of Thailand. Consistent with a report of Sucheera Phatthrayuttawat et al. (40) that found gender identity did not effect to mean score on the CPM in Thai population at .05. Male obtained mean 29.02 standard deviation 7.82 while, female obtained mean 28.90, standard deviation 7.11, and skewed -1.96.

Consequently, gender could be influenced to IQ level. When studying in the intelligence might consider this factor.

## 2.4 Age

The mental ability had increase throughout the early portion of the life span. Older children generally knew more than younger children did. The correlation between mental-test scores at seventeen years of age with scores obtained in the previous years beginning at age one that the correlations with test performance at seventeen did not become stable until roughly age four. From this point on, the relationship became increasingly stronger, and by the age seven, there was already a very high. Bass and Tanyia (41) studied 379 children for Xhosa-speaking primary school pupils in the Grahams town region that the result showed a significant effect of age on test score from the Colored Progressive Matrices, where score increased with age as expected. Consistent with Sunthorn Tanchee's study (36) that reported a mean score of students aged 5 ½, 6, 6 ½, 7, 7 ½, 8, 8 ½, 9, 9 ½, 10, 10 ½, and 11 years in the central part of Thailand. They obtained mean of 18.03, 19.22, 21.71, 23.83, 24.64, 27.16, 29.34, 29.91, 30.82, 32.49, 32.83, and 33.14 respectively. This report showed that, score increased with age. Similarly, Sudaporn Palas (37), and Sudanee Wuttiroh (39) reported an effect of age on mean score of the Colored Progressive Matrices, where mean score increased with age. In addition, Caffarra et al (38) reported a significant effect of age on performance. Likewise, Panek and Stoner (42) reported a significant difference between age group on the Colored Progressive Matrices was obtained after partial out the effect of education.

## 2.5 Educational Level

Several researcher reported that the effect of education to mean score of tests. Cohan and Cohen's (43) study found that older children in a grade tended to score slightly higher than their younger classmates but importantly they found that children who were in a higher grade but were virtually the same age as children in a lower grade had higher IQ score. It was postulated this was due to the extra year of schooling. Similarly, Caffarra et al (38) reported a significant effect of education on performance. In addition to study in the different groups on the APM found difference of mean score. Sucheera Phattharayuttawat et al. (44) reported that the study in the Thai University students that obtained mean of 23.34, standard deviation 7.30, and skewed 1.63. Similarly, Chalitta Kaiyanan's report (45) that studied in Thai

undergraduate student in Bangkok, which they obtained mean of 23.59, standard deviation 4.60 skewed -.01. Both results were contrast Wattana Prohmpetch' report (46) that studied in high achievement high school students found student's mean of 27.55, standard deviation 4.69, and skewed -.379. Those results showed an effect of educational level to score on the intelligence tests.

## History of Intelligence Test Development

### 1. Intelligence Tests

In 1905, Alfred Binet (5) was commissioned by the French government to devise a test that would distinguish children of average intelligence from those who were below normal. The government wanted to establish special classes for retarded children, but feared that teachers would be unable to evaluate their students objectively. Thus, the Ministry of Education called on Binet to develop an objective assessment procedure. Binet and Simon responded with a test that became the forerunner of all modern tests of intelligence, which called "Binet-Simon test." Afterward, Terman (5) from Stanford University had revised Binet-Simon test version 1905 and published in 1916, called "Stanford-Binet Intelligence Scale"

Intelligence quotient (IQ) had begun to use for display of the intelligence function in compare with other. Lewis Terman instituted a numerical index to express intelligence as a ratio of mental age (MA) to chronological age (CA). This index, first suggested by the German psychologist, William Stern (47), the formula for the IQ was:

$$IQ = \frac{MA}{CA} \times 100$$

This formula had well known generally but it had two limits. The first, the test calculated the mental age was not increase over sixteen. Because the test comprised answers that could not to classify the intelligence in adult. Therefore, it was suitable formula for children. The second, in the children group, the scores were not equal distribution in the same age as 2 ½ years old, that were very difference, but the other age groups were few differences. That was the problem to compare intelligence in different ages. For solving this problem, the Standard-Binet revise version 1960 had

used Deviation IQ to calculate the standard score (Z) as a ratio of the individual scores ( $X$ ) minus the mean score of group ( $\bar{X}$ ) and the standard deviation (SD). The formula was as:

$$Z = \frac{X - \bar{X}}{SD}$$

Form this formula, a normal intelligence was 100. The distribution of IQ equal in the each ages that SD = 16, which could transform to IQ by formula as:

$$IQ = 100 + 16(Z)$$

Later, Wechsler (19), the American psychologist who created test to measure in verbal part and non verbal part for adult in 1939 and revised in 1955, called “The Wechsler Adult Intelligence Scale”(WAIS). Moreover, in 1949 he created test to measure in the children, called “The Wechsler Intelligence Scale for Children” (WISC). Wechsler was the first to use that formula in 1955 but Wechsler’s standard deviation was 15 less than Stanford-Binet’s in one point. The formula was as  $IQ = 100 + 15(Z)$ . When using this formula had found the score distribute in normal curve as; 34% of populations had IQ 100-115, 14% of populations had IQ 115-130 and 2% of populations had IQ above 130. In the reverse curve find as 34% of populations had IQ 85-100, 14% of populations had IQ 70-85 and 2% of population had IQ below 70.

Table 1 Intelligence quotient level from Wechsler scale (48).

Level	IQ
Very Superior	130+
Superior	120-129
High Average	110-119
Average	90-109
Low Average	80-89
Borderline	70-79
Mental Retardation	69

In current, many intelligence tests can divide into two types by the administration of test (49) as:

- a) Individual tests: WAIS, WISC, Stanford-Binet Intelligence Test and K-ABC
- b) Group tests: Multidimensional Aptitude Battery, The Cognitive Ability test and Scholastic Assessment

The advantages of individual test that involved various verbal and non-verbal subtests could combine to give an overall IQ. However, which also provided valuable separate subtest score and measures based on the behavioral response of the subject to the test item. Unlike, the groups test could administer to vary large number subject, simplified examiner role, scoring typically more object, representative samples often used leading to better established norms.

The intelligence tests, which well known in Thailand were:

- 1) The Stanford-Binet form L-M: for the subjects age 2-7 years
- 2) The Wechsler Intelligence Scale for Children-III (WISC-III): for the subjects age 6-16 years
- 3) The Wechsler Adult Intelligence Scale III (WAIS-III): for the subjects age 16-74 years
- 4) Kaufman Assessment Battery for Children (K-ABC): for the subjects age 2-6 to the 12-6 years
- 5) Raven's Progressive Matrices (RPM)

Accordingly, the first test through the forth test administer to the individual. However, RPM was the culture fair test that could administer to the individual or to the group. This test used less time than the first though the forth tests and could interpret quickly.

The matters of consideration employ the intelligence tests.

- 1) The standard of tests: the tests had developed the reliable quality. The test had the objectivity and the determined of administration and the scoring. Moreover, the test must explained as norm, mean, mode, media, percentile, and the standard score of norm group including reliability and validity of test (6).

The qualities that were possessed by good test tests as: (50)

a) High reliability, test-retest consistency, and internal consistency: 0.7 was a minimum figure.

b) Low standard error of measurement.

c) Good evidence of validity, especially construct validity, and high discriminating power.

2) Culture bias in tests (50) that the western psychologist who constructed most of intelligence tests. Therefore, the item contents of tests selected much more from the typical experiential background of certain groups than from that of other group. The typical experiences involving the acquisition of knowledge and skill were different for various subpopulations. Popham in Modern educational measurement, test bias existed whenever members of a subgroup were unfairly penalized, or given an advantage, because of their membership in the subgroup; the bias might appear in i) qualities of the test such as wording, ii) the way in which the test was administered, or iii) the manner in which the results were interpreted. Therefore, the employer might translate and reviewed the tests when to use it in the difference culture. The alternative tests when measured in the cross culture that to use the culture fair tests. The tests were without the acquisitions of experience in picture and language bias, which particularly those who did not speak English or had learning difference in reading or writing English. The culture fair tests were as Davis-Eells Test of General Intelligence, RPM, and Cattell Culture-Fair Intelligence Test.

## **2. Development of Culture Fair Test (51)**

The term culture fair test refers to tests that were not bias toward a particular cultural group. While it was technically impossible to develop a test that was completely free from cultural bias. Cultural bias existed in a test when members from one culture were discriminated against in their ability to answer the questions solely based on the culture in which they grew up. One of the first systematic, large-scale attempted to construct a culture fair test was the Davis- Eells Test of General Intelligence (1953). The Davis-Eells test assessed general reasoning ability by using cartoon picture of person in familiar situation, rather than relying on verbal or abstract

content. The test was designed for aged 5-12 years. However, there was evidence from research showed that test did not reduce the difference among subgroup performance on other intelligence tests.

A difference approach to culture fair testing was developed by Penrose and Raven, who published the Raven's Progressive Matrices Tests (1936). These tests were devised to assess Spearman's notion of a single general factor of intelligence common to all cognitive tests. The tests were administered individually or in groups, with no time limit. The instructions were very simple.

Cattell developed another type of culture fair test, based on his theory of fluid and crystallized intelligence. The Cattell Culture Fair Intelligence Tests (1949) were mostly no pictorial and nonverbal. The test was available in three levels that cover aged four through adult. Moreover, the Cattell test could be given individually or in groups, though the frequent and sometimes lengthy verbal instruction presented difficulties for large-group administrations.

A different approach to culture fair testing was the System of Multicultural Pluralistic Assessment (SOMPA) developed by Mercer (5) (51). Mercer's approach was to use a battery of instruments and compare the scores attained not only against a national norm group, but also against score of children from a similar background. The system was used with children five to eleven years of age. The test gathered information from several sources including the WISC-R and after an interview with the child's principle caretaker. The SOMPA assessment differed from the Cattell and the Davis and Eells tests in that it did not attempt to develop questions that were fair to all groups. On the contrary, SOMPA tried to take into account cultural and economic experiences that might influence performance on traditional IQ tests.

## **Raven's Progressive Matrices**

Raven's Progressive Matrices (52) based on observation and Spearman's theory to assess general factor as eductive ability. Eductive mental activity involves making meaning out of confusion; developing new insight; going beyond the given to perceive that which was not immediately obvious; forming constructs which facilitate the handling of complex problems involving many mutually dependent variables.

Progressive Matrices was designed to measure educative ability in a way which, while being crucially dependent on acquired constructs and symbols, would yield scores which would be as little contaminated as possible by interpersonal and group variation in familiarity with symbols carrying cultural meaning.

Maturation of educative ability, J.C. Raven distinguished at least five qualitative developments in the order of intellectual capacity:

Children were first able to distinguish identical figures from different figures, and later similar from dissimilar figures.

Some time after this, they were able to appreciate the orientation of a figure with respect to themselves and to other object in the perceptual field.

Next, they could compare analogous changes in the characters perceived, and adopted this as a logical method of reasoning.

Subsequently, they were able to analyze the perceived whole into its constituent elements, or character, and to distinguish between what was given and what they themselves contributed.

Finally, they were able to apprehend two or more discrete figures as forming a whole, or organized individual entity.

Raven's Progressive Matrices had been in use for over 60 years. During that time, the test had undergone a number of revisions and two new series were developed for particular purposes. The initial series of Standard Progressive Matrices (1938) was followed by the Colored Progressive Matrices (1947), extending the range of usefulness to include young children, old people and the intellectually impaired. To cater for higher abilities, the Advanced Progressive Matrices were developed, initially in 1941 but coming into restricted circulation in 1947. The type of item in tests was completing the matrices, two types of progression or relationship were established, one in the horizontal, one in the vertical direction. The examinee was required to pick the choice that correctly fills the missing of the matrix. The principles were determined to choose the answer in the matrices as; complete a pattern, complete an analogy, systematically alter a pattern, introduce systematic permutations, and systematically resolve figures into parts (14).

## **1. The Three Forms of the Matrices**

### **1.1 The Standard Progressive Matrices (SPM)**

SPM (52) was arranged into five sets (A, B, C, D and E), each of which began with simple problems and grew increasingly difficult; a person's speed of intellectual work could not be measure from the number of problem solved in fixed time. These covered the whole range of ability from low-scoring respondents and young children, through high-scoring adult, to those of old age. Administered in the standard way, the test therefore provided a built-in training programmed and indexes the ability to learn from experience or learning potential. The cyclical format also provided on opportunity to assess the consistency of a person's intellectual activity across five successive lines of thinking. The test length was just sufficiently long to assess a person's maximum capacity for coherent perception and orderly judgment without being too exhausting or unwieldy.

### **1.2 The Colored Progressive Matrices (CPM)**

CPM (52) (53), from which Sets C, D and E of the Standard series had been omitted, but into which an additional set of 12 problems (Sets Ab) had been interpolated between Sets A and B, was designed to assess with greater precision the intellectual processes of young children to under 11 years old, mentally retarded persons and the elderly. Success in Set A depended on a person's ability to complete continuous patterns which, toward the end of the set, change first in one, and the as then in two, directions at the same time. Success in Set Ab depended on a person's ability to see discrete figures as spatially related whole, and the choose figures which completed the design. Set B contained just sufficient problem involving analogies to show whether a person was capable of thinking in this way. The last few problems in Set B were of the same order of difficulty as the early problem in Sets C, D and E of SPM.

### **1.3 The Advanced Progressive Matrices (APM)**

APM (51) (54) provided a mean of (i) examining high -level eductive ability, (ii) spreading the distribution of score in the top 25% of the population, and

(iii) assessing more accurately a person's speed of intellectual work. This test had two components. Set I comprised a short set of 12 items covering all the intellectual processes sampled on the full test. It could serve several purposes :

a) As a set of practice item, to familiarize people with the test and allay anxiety. If it was thought desirable, people who were to be tested on Set II could be given Set I to take home and practice on to minimize the effects of prior practice, coaching, the and familiarity.

b) As a very short test, sorting adults into the "dullest" 10%, the "average" 80%, and the "brightest" 10%.

c) To decide whether the Standard or Advanced Matrices should be used next in situations of uncertainty as to the intellectual level of those taking the test. This would apply particularly to those occupations falling awkwardly on the boundary between a requirement for tests of general-level and high-level.

Set II consisted of 36 problems, arranged in ascending order of difficulty. As a result, it was not necessary for everyone to attempt every problem before stopping. By imposing a time limit that taking in 40 minutes, which Set II could use to assess intellectual effectively.

## 2. Scoring

Three form of Raven's progressive Matrices that score one point for each correct answer. If the person taking the test had given more than one answer to a give question, mark it incorrect. The most satisfactory method of interpreting the significance of person's score was to consider it in terms of the percentage frequency with which a similar score occurred amongst people of the same age. This was possible to classify a person according to the score obtained. (53)

Grade I "Intellectually superior," if a score lay at or above the 95<sup>th</sup> percentile for people of that age group.

Grade II "Definitely above the average in intellectual capacity," if a score lay at or above the 75<sup>th</sup> percentile.

II+, if a score lay at or above the 90<sup>th</sup> percentile.

Grade III "Intellectually average," if a score lay between the 25<sup>th</sup> and 75<sup>th</sup> percentile

III+, if a score was greater than the median or 50<sup>th</sup> percentile.

III-, if a score was less than the median.

Grade IV “Definitely below average in intellectual capacity,” if a score lay at or below the 25<sup>th</sup> percentile.

IV-, if a score lay at or below the 10<sup>th</sup> percentile.

Grade V “Intellectually impaired,” if a score lay at or below the 5<sup>th</sup> percentile for that age group.

### **3. Quality of Test**

#### **3.1 Quality of the Colored Progressive Matrices**

##### **3.1.1 Split-half Reliability (53)**

The study investigated the response of 1,662 young children covering three ethnic groups (Anglo, Black and Hispanic). A split-half reliability estimate value of .90. A subsequent study has analyzed the data from 783 of the respondents to find no overall split-half estimate of .85, with respondent age 6, 7 and 8 yielding values of .65, .86 and .85 respectively. These study found the low value for young children was contrast with the report of study in children age 6 to 7 years old to find overall split-half estimate of .90. Moreover, the study in children 737 of Queensland, 693 was White and 44 Aborigines that age 5 ½ - 11 ½ years old. At the youngest age reported a Cronbach alpha of .80 and .93 at age 11 ½.

##### **3.1.2 Test-retest Reliability (53)**

The report of the study in Chinese children from Shanghai found a reliability of .95 when the retest interval was short (10 days). That contrast, the study in Indian when the retest after 2-3 weeks reported a value of .86. This study was consistent with the study at 27 Canadian children in which a retest found a value of .87. Those results like a study in Slovakia reported that, a retest reliability of .85 over one month for 100 children aged 5 ½ to 12, while in Germany reported coefficients ranging from .68 to .90 after one month. In Lithuania (55), the Raven Colored

Progressive Matrices was administered to a sample of 259 children and re-administered 2 years later. The test-retest reliability was .499.

### **3.1.3 Internal Consistency Reliability**

Sucheera Phattharayuttawat et al. (40) had studied in Thai populations reported a reliability of .91 by KR-20 technique.

The most of the study reported reliability over .80 that the Colored Progressive Matrices is highly reliability (56).

### **3.1.4 Validity**

In the USA and Germany (53) had led the three types of item that abstract reasoning by analogy, pattern completion through identity and closure, and simple pattern completion to analyze those. In Germany using principle components analysis, found these factors accounted for 36% of the total variance, among a sample of 783 children of similar age from California confirmed the Germany finding. Using principle components analysis the same three factors accounted for 28%. In Thailand, Sucheera Phattharayuttawat et al (40) had analyzed the factor, which they suggested the Colored Progressive Matrices to assess one factor that could estimate to general factor of Spearman.

### **3.1.5 Item Difficulty Analysis and Item Discrimination Analysis**

From the study in Thai population by Sucheera Phattharayuttawat et al. (40) reported an item difficulty ranging from .43 to .99 and average of item-difficulty estimated value of .77. Moreover, they reported an item discrimination from .10 to .36, which 16 items had value lower than .20 and 20 items had value ranging .20 to .80. This result showed an easiness of item difficulty but a high discriminating power (57).

## **3.2 Quality of the Advanced Progressive Matrices**

### **3.2.1 Split-half Reliability**

The APM sections of Manual had reported that the APM set II had split-half reliability coefficients varying between .83 and .87 (54).

### **3.2.2 Test-retest Reliability**

Data on the re-test reliability of the APM were originally collected for the 48 items version of the test that was in use from 1947 to 1962 (54) 109 children aged 10.5 years, 92 children aged 11.5 years and 243 adult students took the test (with a 40 minute time limit) and were re-tested after six to eight weeks. The re-test reliabilities showed that the test was highly reliable for adult ( $r = .91$ ), reliable for 11.5 years old ( $r = .86$ ), but only reasonably reliable for 10.5 years old ( $r = .76$ ). These data suggested that the APM was unsuitable for the young children.

### **3.2.3 Internal Consistency Reliability**

Sucheera Phattharayuttawat et al. (44) had studied in 491 Thai students who were studying in the university, which they reported a reliability of .90. That report was similarity with the study of Wattana Prohmpetch (46) the in high achievement high school students to calculate by KR-20 yielded a reliability of .80.

Data in all study showed highly reliability that it was appropriate to assess intellectual in a person who aged over 11 years.

### **3.2.4 Validity**

Sucheera Phattharayuttawat et al. (44) had analyzed the factor, which they suggested the Advanced Progressive Matrices to assess one factor that could estimate to general factor of Spearman as same as Wattana Prohmpetch's report (46).

### **3.2.5 Item-Difficulty Analysis and Item-Discrimination Analysis**

From the study in Thai Students by Sucheera Phattharayuttawat et al. (44) reported an item-difficulty ranging from .12 to .99 and mean of item difficulty estimated value of .60. The test arranged item from easy to difficult was similar with

the study of Raven (52). Moreover, they reported item discrimination from .10. to .59. (44). Similarly, Wattana Prohmpetch's (46) report that found item difficulty ranging from .39-.99 and mean of item-difficulty estimated value of .76 while he reported item discrimination .32, which ranged from .03-.71. These results showed moderately difficulty and high discriminating power.

#### 4. Norms of Tests

Norms are the score obtained from a large number of subjects during the process of standardizing a test that using for diagnosis or predict interpretation of scores to let subject knows that what was his/her position when comparing with others in the same age. There were the norm studies of CPM in many countries including Australia (1980), West Germany (1982), United States of America (1986), and Netherlands (1994), which percentile norms were applied for children aged 5 ½ to 9 ½ years, 5 to 10 years, 5 ½ to 11 ½ , and elderly people, respectively (53). For Thailand, norm of CPM was created for children aged 5 to 11 years in North region, the Central region by Sudaporn Palas (37), and Sudanee Wuttiphrom (39), respectively. In addition, Sucheera Phattharayuttawat et al. (44) had studied norm of CPM in Thai population aged less than 5 to 10 years by comparing with full IQ on WISC.

For the APM, in the past had created norm of APM for many subjects including the United Kingdom adolescents and adults (1979 and 1992), United States adolescent (1986), the people's republic of China (1984 and 1992), which percentile norms were applied for age 12 to 70 years, age 12 to 16 years and 10 to 79 (54). For Thailand, norm of the APM was created for Thai Universities students (44), undergraduate students (45), and high achievement high school students (46).

## CHAPTER III

### MATERIALS AND METHOD

In order to examine the characteristic of CPM and APM in students who studied in the second semester of year 2004 in the Western region of Thailand, ages ranged from 6 to 18 years, a descriptive research approach had been conducted. The procedures were as follow:

#### Population and Sample

Total population consisted of 374,509 students, ranging from 6 to 18 years, in the Western region of Thailand comprising of Kanchanaburi, Ratchaburi, Phetchaburi, Prachaub Khiri Khan and Tak provinces (58). Among them, 179,919 and 195,310 students were studying in primary and secondary school, respectively (59).

Sample size was calculated using the following equation (48) with confidence interval of statistic at 95 % ( $\alpha = .05$ ) and values of sampling error (E) = .69 and (E) = .44 were applied respectively for CPM and APM.

$$n_{\mu} = \frac{(NZ^2)\sigma_x^2}{NE^2 + Z^2\sigma_x^2}$$

Where

- $n_{\mu}$  = sample size
- $N$  = total number of target population
- $Z$  = value of normal curve at area under the normal curve range  $\alpha/2$ . This search determine = 0.05;  
 $Z = 1.96$
- $\sigma_x^2$  = variance of population calculated based upon observed data of previous researches (34) (40) (44) (45)

$E$  = value of error, this research calculated by formula

$$E = \sqrt{\frac{S_p^2}{n}} \times Z$$

The calculated sample sizes were 450 and 619 students for the test of CPM and APM, respectively.

In order to justify the sampling group, multistage random sampling technique was applied. The sampling processes could be described as follow.

1. In order to select the representative province of the western region, cluster random sampling was conducted with respect to the identities of region such as physical geography, economics, and social condition, in particular. Criteria of sampling could be summarized as follow.

1.1 Provincial areas ranging from the largest to the smallest are Kanchanaburi, Tak, Prachaub Khiri Khan, Phetchaburi, and Ratchaburi, respectively.

1.2 Regarding to population density had the average of 58.51 per square kilometers for the whole region (60). The highest and lowest population densities of 161.12 and 31.49 per square kilometers were found for Ratchaburi and Tak. For the rest, 72.42, 77.83, and 42.37 per square kilometers were found for Phetchaburi, Prachaub Khiri Khan and Kanchanaburi, respectively.

1.3 Total students ranging from the highest to the lowest were Kanchanaburi, then Ratchaburi, Tak, Prachaub Khiri Khan and Phetchaburi, respectively (59).

1.4 In 2004, Ratchaburi showed the highest (61) ranging from the highest gross regional product (GRP) followed by Kanchanaburi, Prachaub Khiri Khan, Phetchaburi and Tak, respectively.

1.5 Considering annual income, Ratchaburi showed the highest of 85,057 baths per year followed by Prachaub Khiri Khan (68,498 baths per year), Kanchanaburi (65,434 baths per year), Phetchaburi (56,829 baths per year), and Tak (44,559 baths per year) respectively. While annual income of whole region was 64,074.6 baths per year.

According to mention criteria, Kanchanaburi was showed as representation of Western region because the fact that it covers the widest provincial area (36.29 percent of area in Western region), gross provincial product was the secondary of region, and 825,655 populations (60) that were 26.32 percent of whole population. Moreover, Kanchanaburi had 105,930 students who were the target of this research that was 28.28 percent of student who studied in the primary and secondary school of the Western region.

2. Representative schools were selected using stratified random sampling method. Three-school sizes form that of four (small, medium, large and extra large) were selected based on the criteria of Department of Elementary Education. Actually, for large and extra large school size, in each of existing, the latter was selected in priority. For Kanchanaburi, total numbers of school in each school size were as follow:

The small school size (1-499 students) consisted of 393 primary schools and 10 secondary schools.

The medium school size (500-1,499 students) consisted of 33 primary schools and 16 secondary schools.

The large and the extra large school size (1,500 students and above) consisted of 4 primary schools and 5 secondary schools.

In general, represented school of each type and size was selected by simple random sampling. However, for extra large junior secondary school, since there were only 3 male students in Kanchana Nukroh school and 33 female students in Visuttarangi. Therefore, in order to optimize the simple random sampling, both schools were selected. As a whole, represented schools were shown in the following table.

Table 2 The represented school from Kanchanaburi

School size	The primary school	The secondary school
Small	Banvangsarapee School	Nong Khao Kowit Pittayakom School
Medium	Anuban Watchaichumpon- chanasongkram School	Ladya Pittayakom School
Large	Anubankanchanaburi School	Kanchana Nukroh School Visuttarangsi School

3. In order to select one class from educational level of each school used simple random sampling for data collection.

### Tools

In this study, the Colored Progressive Matrices and the Advanced Progressive Matrices were used for the students of ages 6 to 11 and 12 to 18 years, respectively. Characteristic of both test were as follow:

1. Colored Progressive Matrices consists 3 subsets, A, Ab and B. Each subset comprises 12 problems, and 15-30 minutes of test are allowed.
2. Advanced Progressive Matrices consists two set. Set I consisted of only 12 problem, used to establish a field of thought for respondents and provide them with training in the method of working, there is a time limit of 10 minutes. Set II consisted of 36 problems; there was a time limit of 40 minutes. This research used only set II.

### Data Collecting

1. The researcher introduced herself to subject and clarify for objective and advantages of this study so that the subject could understand importance of test and gave cooperation as much as they could.

2. The test was done in-group of the class for subject conveniently and to maintain the standard of test. In the young child were administered in small group and

monitor closely because they did not acquaint on the test method by making a symbol in the answer sheet.

3. The researcher distributed test, pencil and answer sheet to subject that to write their name, surname, sex, grade, and school name on the answer sheet and warned subject did not perform before permit.

4. The researcher read an explanation of test to subject and made sample in first item until the subject understand in the method of working.

### Data Analysis

The data of this study was analyzed as follow (62):

#### 1. Statistical analysis for characteristics of test

- Item analysis was determined identity by statistic technique as follow:

Item difficulty: Calculate difficulties done by using the number of subjects who given the correct answer of that item by total number of subject who answer that item.

Item discriminating: The point biserial correlations between item score and total score were positive, and range from .13 to .64 that were mean each item had good discriminating power and concurrent valid to discriminate the student.

- Reliability analysis: Carry out internal consistency with Kuder-Richardson Formula 20 (KR-20).

- Construct validity: Performed the factor analysis by using the principal component analysis with varimax method.

#### 2. Descriptive statistic of score

- Mean, Median, Mode

- Standard Deviation, Standard Error of Measurement, Skew ness, Minimum and Maximum

#### 3. Inferential statistics

- Compare the difference of means classified by sex; age, education level by t-test and ANOVA.

#### 4. Norms

- Convert raw score to percentile and IQ score.



## CHAPTER IV

### RESULTS AND DISCUSSION

#### Results

The purpose of this research was to study the characteristics of CPM and APM in primary and secondary school students in the Western region of Thailand in the second semester of academic year 2004 represented by students from Kanchanaburi province. The subject consisted of 1,393 students and divided into 2 groups comprising 498 students aged 6 to 11 years and 895 students aged 12 to 18 years. The results used to construct IQ score norms. The study were presented as follows.

#### **I. The Colored Progressive Matrices**

Before determining of CPM characteristics and constructing the norm, various descriptive statistics obtained from the test in students age ranged from 6 to 11 years had been examined. It was found that among 498 students participated in this test, the minimum and maximum score were 4 and 36, respectively. Furthermore, mean, standard deviation, median, mode, and skewed were 26.38, 7.52, 28, 34 and -.77 were observed, respectively. Thereafter, characteristics of CPM had been analyzes based on the raw score of test and constructed norm. The results were as follows:

### Part 1 Characteristics of the CPM

The characteristics of test including discriminating power, item difficulty, reliability, and validity were determined. Within 36 items of CPM, range of discriminating power was .16 to .71 (mean=.52) and discriminating power of 35 items were more than .20. Range of difficulty was .29 to .99 (mean=.73). Reliability based on KR-20 was .92 and standard error of measurement was 2.13. All these results allow concluding that, based on low item difficulty, CPM should be classified as an easy test. However, it showed a high discriminating power, high reliability, and low standard error of measurement. Therefore, the CPM was a high quality and appropriate test to construct norm.

In this research, in order to examine the construct validity of test, factor analysis using principal component analysis for factor extraction was applied. The first step was an unrotated principal axes analysis, the first seven had eigenvalue of 1.00 and more. These factors accounted for 56.09% of the total variance, and were shown as Table 3. Among them, the factor I accounted variance of 28.92% and consisted of 35 items, factor loadings of more than .3 and positive were found (Table 4). These results showed that each item of the CPM could be used effectively to assess the common factor of intelligent structure and uniqueness.

Table 3 Unrotated principal axes analysis of the CPM

Factor	Eigenvalue > 1	Percent of Variance	Commulative Percent
1	10.41	28.92	28.92
2	3.43	9.52	38.44
3	1.77	4.90	43.35
4	1.28	3.56	46.91
5	1.23	3.42	50.34
6	1.06	2.94	53.27
7	1.01	2.82	56.09

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .92

Bartlett's Test of Sphericity = 7312.42; P < .000 / df = 630

Table 4 Factor loading of the CPM before varimax rotation

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
A1		0.4	0.38		-0.41		
A2	0.34	0.49	0.33			-0.34	
A3	0.42	0.47				-0.44	
A4	0.42	0.59					
A5	0.43	0.47					
A6	0.48	0.34					
A7	0.64						
A8	0.38				0.54		-0.3
A9	0.56				0.33		
A10	0.61						
A11	0.55						
A12	0.37				0.35		
A <sub>B</sub> 1	0.48	0.65					
A <sub>B</sub> 2	0.5	0.51					
A <sub>B</sub> 3	0.39	0.52				0.42	
A <sub>B</sub> 4	0.62						
A <sub>B</sub> 5	0.59						
A <sub>B</sub> 6	0.71						
A <sub>B</sub> 7	0.67						
A <sub>B</sub> 8	0.66						
A <sub>B</sub> 9	0.63						-0.38
A <sub>B</sub> 10	0.47						
A <sub>B</sub> 11	0.47						
A <sub>B</sub> 12	0.5		0.34				
B1	0.41	0.36	-0.37	0.53			
B2	0.52	0.32	-0.36	0.37			
B3	0.63		-0.33				
B4	0.63		-0.34				
B5	0.66						
B6	0.56						-0.43
B7	0.52						
B8	0.58						
B9	0.6			0.34			
B10	0.64	-0.32					
B11	0.62	-0.35	0.33				
B12	0.46	-0.33	0.31				

Table 5 Factor loading the CPM after varimax rotation

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
A1			0.37	0.59			
A2			0.76				
A3			0.69		0.32		
A4			0.72				
A5			0.4	0.38			0.44
A6			0.32	0.37			0.48
A7	0.38					0.48	
A8							0.72
A9	0.35					0.37	
A10	0.48						
A11		0.35				0.49	
A12						0.53	
A <sub>B1</sub>			0.32	0.61	0.43		
A <sub>B2</sub>				0.6	0.35		
A <sub>B3</sub>				0.73			
A <sub>B4</sub>	0.63						
A <sub>B5</sub>	0.5					0.49	
A <sub>B6</sub>	0.64					0.32	
A <sub>B7</sub>	0.66						
A <sub>B80</sub>	0.61						
A <sub>B9</sub>	0.67						
A <sub>B10</sub>	0.45	0.32					
A <sub>B11</sub>						0.52	
A <sub>B12</sub>		0.58					
B1					0.82		
B2					0.71		
B3	0.5				0.44		
B4	0.42				0.44	0.4	
B5	0.62						
B6	0.57						
B7	0.57						
B8		0.67					
B9		0.74					
B10	0.32	0.71					
B11		0.75					
B12		0.68					

In order to clarify the relationship among items of each factor, the orthogonal rotation was analyzed using varimax method. This analysis yielded factor loading of .30 or more of each factor and positive were shown in Table 5.

Item of all factors were summarized in Table 6. Factor I comprised 12 items (A10, A<sub>B</sub>4, A<sub>B</sub>5, A<sub>B</sub>6, A<sub>B</sub>7, A<sub>B</sub>8, A<sub>B</sub>9, A<sub>B</sub>10, B3, B5, B6 and B7) that measured the perception of similarity/difference, symmetry/asymmetry of appearance and orientation of miss part (Balance). Factor II comprised 6 items (A<sub>B</sub>12, B8, B9, B10, B11, and B12) that measured the perception of figure modification (Creation). Factor III comprised 3 items (A2, A3 and A4) that measured the perception of identical pattern (Distinguish). Factor IV comprised 4 items (A1, A<sub>B</sub>1, A<sub>B</sub>2 and A<sub>B</sub>3) that measured the perception of continuous discrete pattern (Continuity). Factor V comprised 3 items (B1, B2 and B4) that measured the perception of similarity (Category). Factor VI comprised 5 items (A7, A9, A11, A12 and A<sub>b</sub>11) that measured the perception of identity and continuous pattern (Connection). Finally, Factor VII comprised 3 items (A5, A6 and A8) that measured the perception of similarity and different pattern completion (Assembly).

Table 6 Varimax rotation of seven factors accounting for 56.09 percent of variance

Component	Item	Name
1	A10,A <sub>B</sub> 4,A <sub>B</sub> 5,A <sub>B</sub> 6,A <sub>B</sub> 7,A <sub>B</sub> 8,A <sub>B</sub> 9,A <sub>B</sub> 10, B3,B5,B6,B7	Balance
2	A <sub>b</sub> 12,B8,B9,B10,B11,B12	Creation
3	A2,A3,A4	Distinguish
4	A1,A <sub>B</sub> 1,A <sub>B</sub> 2,A <sub>B</sub> 3	Continuity
5	B1,B2,B4	Category
6	A7,A9,A11,A12,A <sub>b</sub> 11	Connection
7	A5,A6,A8	Assembly

### Part 2 Norm of the CPM

In this part, after comparison of mean scores of each variable (sex, age, and educational level), norms of CPM were created.

Table 7 The comparison of mean difference of the CPM between sex, age, and educational level

Group		Number		Standard deviation (SD)	t/F	Sig
		of student (n)	Mean			
Sex	Boy	246	26.53	7.57	.45	.654
	Girl	252	26.23	7.47		
Age (years)	6	24	18.83	6.20	60.90	.000
	7	120	20.08	6.97		
	8	91	25.49	6.78		
	9	80	28.25	5.88		
	10	104	30.35	5.35		
	11	79	32.14	3.33		
Educational level	Prathomsuksa 1	111	18.46	6.28	77.05	.000
	Prathomsuksa 2	93	24.33	6.78		
	Prathomsuksa 3	93	27.41	6.12		
	Prathomsuksa 4	93	30.39	4.86		
	Prathomsuksa 5	91	31.68	4.09		
	Prathomsuksa 6	17	33.35	2.09		
Total		498	26.38	7.52		

F-test or t-test was used to compare the mean difference of CPM in different groups of sex, age, and educational levels were presented in Table 7. Within different groups of age and educational level, mean scores were significantly different

and all of them increased with respect to increasing of age and educational level. In contrast, between different sexes, mean scores were non-significantly different.

When ANOVA technique using Scheffe's method was applied to analyze the differences of mean score between age groups as summarized in Table 8, four pairs of mean of each age that showed non-significantly different could be grouped; 6 and 7 years, 8 and 9 years, 9 and 10 years and 10 and 11 years. Thereafter, norm of CPM for 5 groups of age (6 and 7 years, 8 years, 9 years, 10 years and 11 years) were created as shown in Table 9. IQ score norm was converted from raw scores that were created based on mean of 100 and standard deviation of 15 for each group (the detail of the raw score converted to percentile was shown in appendix).

In the same manner, differences of mean score of different educational levels were analyzed as summarized in Table 10. It was found mean scores of students studied in Prathomsuksa 4, Prathomsuksa 5 and Prathomsuksa 6 were non-significantly different. In contrast, mean scores of all rest groups were significantly different and differed from those of the first group. Therefore, norm of CPM for 4 groups of educational level (Prathomsuksa 1, 2, 3 and Prathomsuksa 4 to 6) were created as shown in Table 11.

Table 8 The mean difference comparative by age group

Age (years)	6	7	8	9	10	11
6	-	1.25	6.66*	9.42*	11.51*	13.31*
7		-	5.41*	8.17*	10.26*	12.06*
8			-	2.76	4.85*	6.64*
9				-	2.10	3.89*
10					-	1.79
11						-

\* P<.05

Table 9 Converted raw score of the CPM to IQs classified by age

Raw Score	Age				
	6-7 years	8 years	9 years	10 years	11 years
36	135	123	119	114	116
35	133	121	116	112	112
34	131	118	114	109	108
33	128	116	112	107	104
32	126	114	109	104	100
31	124	112	107	102	96
30	122	110	105	100	91
29	120	108	102	97	87
28	118	106	100	95	83
27	116	104	98	92	79
26	114	101	95	90	75
25	111	99	93	87	71
24	109	97	91	85	67
23	107	95	88	82	-
22	105	93	86	80	-
21	103	91	83	78	-
20	101	89	81	75	-
19	99	87	79	73	-
18	96	84	76	70	-
17	94	82	74	68	-
16	92	80	72	65	-
15	90	78	69	-	-
14	88	76	67	-	-
13	86	74	65	-	-
12	84	72	-	-	-
11	81	70	-	-	-
10	79	67	-	-	-
9	77	65	-	-	-
8	75	65	-	-	-
7	73	-	-	-	-
6	71	-	-	-	-
5	69	-	-	-	-
4	66	-	-	-	-
3	-	-	-	-	-
2	-	-	-	-	-
1	-	-	-	-	-

Table 10 The mean difference comparative by educational level

Education level	Prathom 1	Prathom 2	Prathom 3	Prathom 4	Prathom 5	Prathom 6
Prathom1	-	5.87*	8.95*	11.93*	13.22*	14.89*
Prathom 2		-	3.08*	6.05*	7.35*	9.02*
Prathom 3			-	2.98*	4.27*	5.94*
Prathom 4				-	1.29	2.97
Prathom 5					-	1.67
Prathom6						-

\* P<.05

Table 11 Converted raw score of the CPM to IQs classified by educational level

Raw Score	Educational level			
	Prathomsuksa 1	Prathomsuksa 2	Prathomsuksa 3	Prathomsuksa 4-6
36	141	125	121	115
35	139	123	118	112
34	137	121	116	109
33	134	119	113	106
32	132	117	111	103
31	130	115	109	100
30	127	113	106	97
29	125	110	104	94
28	123	108	102	91
27	120	106	99	88
26	118	104	97	85
25	116	102	95	82
24	113	100	92	79
23	111	98	90	76
22	109	95	88	73
21	106	93	85	70
20	104	91	83	67
19	102	89	81	-
18	99	87	78	-
17	97	85	76	-
16	95	83	74	-
15	92	81	71	-
14	90	78	69	-
13	88	76	67	-
12	85	74	-	-
11	83	72	-	-
10	81	70	-	-
9	78	68	-	-
8	76	66	-	-
7	74	-	-	-
6	71	-	-	-
5	69	-	-	-
4	67	-	-	-
3	-	-	-	-
2	-	-	-	-
1	-	-	-	-

As a representative of the Western region, the present study had been investigated in parallel with similar studies in other six regions of Thailand including; the Central region represented by Nakornsawan (63), the Southern region represented by Nakornsrihammaraj (64), Bangkok (65), the Northern region represented by Lampang (66), the Eastern region represented by Chanthaburi (67), the Northeastern represented by Udon Tani (68). Profiles of mean scores and standard deviations of CPM for different age groups of students in the Western region and other regions were summarized in Table 12.

Table 12 Mean and Standard deviation of the CPM in seven provinces classified by age

Age (years)		Province							Total
		Nakorn Sawan	Nakorn sriham maraj	Bangkok	Kanchana buri	Lam pang	Chantha buri	Udon Tani	
6	$\bar{X}$	17.26	21.75	24.79	18.83	17.98	15.41	18.00	18.71
	S.D.	6.12	8.89	6.53	6.20	6.01	5.98	4.58	6.92
7	$\bar{X}$	22.48	22.88	24.75	20.08	21.59	21.76	19.78	21.85
	S.D.	6.39	7.26	7.13	6.97	6.35	6.38	6.42	6.85
8	$\bar{X}$	24.73	23.71	27.50	25.49	25.33	25.84	25.29	25.56
	S.D.	6.30	7.54	5.70	6.77	6.15	6.72	6.69	6.55
9	$\bar{X}$	27.62	27.02	30.39	28.25	27.94	28.60	27.41	28.30
	S.D.	5.78	5.40	4.59	5.88	5.81	4.95	5.76	5.52
10	$\bar{X}$	30.86	30.96	31.32	30.35	30.81	30.73	29.50	30.66
	S.D.	4.02	4.36	4.67	5.35	4.91	4.47	5.51	4.79
11	$\bar{X}$	31.71	31.46	33.16	32.14	32.11	31.23	31.48	31.93
	S.D.	5.32	4.74	3.50	3.33	3.72	4.76	4.58	4.36

Total mean scores of student age 6-11 years were 18.71, 21.85, 25.56, 28.30, 30.66, and 31.93 with standard deviation of 6.92, 6.85, 6.55, 5.52, 4.79, and 4.36, respectively. In case of students from Kanchanaburi, mean scores of age 6 and 8 to 11 years were 18.83, 25.49, 28.25, 30.35, and 32.14, respectively that closed to total

means scores of each age group whereas mean score of students of 7 years (20.08) was lower than total mean score. This finding allowed underlining that mean scores of the CPM in students aged 6-11 years from Kanchanaburi province were in average range.

## II. The Advanced Progressive Matrices

In case of APM, 895 students with age of 12 to 18 years had participated in this study. Among this group, minimum and maximum scores of 1 and 36 were observed with mean, standard deviation, median, mode, and skewed of 17.87, 6.75, 18, 18 and -0.23, respectively.

Thereafter, in order to determine characteristics of APM based on the raw score of test and to create its norm, various analyses had been conducted. All results could be presented as follows:

### Part 1 Characteristics of the APM

As same as CPM, characteristics of APM could be determined from discriminating power, item difficulty, reliability, and validity. Within its 36 items, range of discriminating power was .15 to .60 (mean=.42) and discriminating power of 2 items were less than .20. Range of difficulty was .09 to .98 (mean=.50). Reliability based on KR-20 was .87 and standard error of measurement was 2.43. All these results showed that APM is a high quality test that could effectively distinguish person with the highest ability from the lowest.

In order to examine the constructed validity of test, factor analysis using principal component analysis for factor extraction was applied. Before rotated principal axes analysis, it was found that 9 factors had eigenvalue of 1.00 and more. Among them, the first factor accounted variance of 20.00 % whereas the total cumulative variance of all factors accounted 46.00 % (Table 13). For factor I that consisted of 25 items, factor loadings of more than .3 and positive were found (Table

14). These results showed that each item of the APM could be used effectively to assess the common factor of intelligent structure and uniqueness.

Table 13 Unrotated principal axes analysis of the APM

Factor	Eigenvalue > 1	Percent of Variance	Commulative Percent
1	7.20	20.00	20.00
2	1.67	4.65	24.64
3	1.18	3.27	27.92
4	1.15	3.19	31.11
5	1.14	3.16	34.27
6	1.12	3.10	37.37
7	1.06	2.95	40.32
8	1.04	2.90	43.22
9	1.00	2.79	46.00

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .93

Bartlett's Test of Sphericity = 5592.52;  $P < .000$  /  $df = 630$

In order to clarify the relationship among items of each factor, the orthogonal rotation using varimax method was conducted. This analysis yielded factor loading of simple structure and the coefficient of the principal axis positive manifold. The factor loading of each factor with value of .30 or more were shown in Table 15.

Table 14 Factor Loading the APM before varimax rotation

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
1				0.5	-0.39	0.4		0.3	
2	0.6								
3	0.59	-0.33							
4	0.57								
5	0.56								
6	0.49								
7	0.51								
8	0.53								
9	0.55				0.32				
10	0.62								
11	0.64								
12	0.57								
13	0.33								
14	0.62								
15	0.55								
16	0.5								
17	0.5								
18	0.48								
19	0.46								
20	0.5								
21	0.5								
22	0.47	0.34							
23	0.42	0.3		-0.35	0.32				
24	0.36								
25	0.47								
26							-0.32		0.59
27		0.32					-0.51		
28			-0.45				0.31		
29				0.37		-0.3			
30						-0.44	0.39		
31		0.38							0.3
32			0.54						
33	0.37							0.34	
34			0.49						
35		0.3		0.34		-0.35			-0.33
36		0.38				0.47			

Table 15 Factor loading of the APM after varimax rotation

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
1									0.85
2	0.49								0.32
3	0.64								
4	0.64								
5	0.58								
6	0.58								
7	0.37								
8	0.56								
9	0.67								
10	0.57								
11	0.62								
12	0.46								
13			0.79						
14	0.56								
15	0.35		0.39						
16		0.4							
17	0.52								
18	0.41								
19	0.36	0.42							
20	0.36								
21		0.41	0.4						
22		0.62							
23		0.73							
24					0.32	0.32			
25					0.42				
26					0.71				
27							0.76		
28				-0.31		0.49			
29							0.32	0.61	
30								0.58	
31					0.39				
32				0.63					
33				0.49					
34				0.55					
35		0.32		0.3		0.42		-0.36	
36						0.69			

As summarized in Table 16, factor I comprised 15 items (2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 17, 18, and 20) that measured the perception of mergence and split of figure, step movement, and grouping (Organization). Factor II comprised 5 items (16, 19, 21, 22, and 23) that measured the perception of mergence of pattern (Combination). Factor III comprised 2 items (13 and 15) that measured the perception of grouping and pattern addition (Increase). Factor IV comprised 3 items (32, 33 and 34) that measured the perception of correlate of similarity (Relation). Factor V comprised 3 items (25, 26 and 31) that measured the perception of systematic movement (Continuity). Factor VI comprised 4 items (24, 28, 35 and 36) that measured the perception of modification with consistence of some identities (Remainder). Factor VII comprised item 27 that measured the perception of similar grouping and modified pattern (Creation). Factor VIII comprised 2 items (29 and 30) that measured the perception of identity change (Transformation). The last, factor IX held only item 1 that measured the perception of similar grouping, number and orientation (Category).

Table 16 Varimax rotation of nine factors accounting for 46.00 percent of variance

Component	Item	Name
1	2,3,4,5,6,7,8,9,10,11,12,14,17,18,20	Organization
2	16,19,21,22,23	Combination
3	13,15	Increase
4	32,33,34	Relation
5	25,26,31	Continuity
6	24,28,35,36	Remainder
7	27	Creation
8	29,30	Transformation
9	1	Category

### Part 2 Norm of the APM

In this part, after comparison of mean scores of each variable (sex, age, and educational level), norms of APM were created.

Table 17 The comparison of mean difference of APM between sex, age, and educational level

Group		Number		Standard deviation (SD)	t/F	Sig
		of student (n)	Mean			
Sex	Male	372	17.88	6.92	.36	.97
	Female	523	17.87	6.63		
Age (years)	12	128	13.72	6.56	16.07	.000
	13	143	16.91	6.69		
	14	166	17.34	6.64		
	15	156	18.65	5.74		
	16	129	20.14	5.66		
	17	107	19.14	6.89		
	18	66	21.06	7.20		
Educational level	Prathomsuksa 6	72	11.33	5.85	31.33	.000
	Mathayomsuksa 1	164	14.58	6.35		
	Mathayomsuksa 2	168	18.58	5.78		
	Mathayomsuksa 3	154	18.40	6.08		
	Mathayomsuksa 4	127	20.31	5.37		
	Mathayomsuksa 5	114	19.46	6.85		
	Mathayomsuksa 6	96	21.24	6.82		
	Total	895	17.87	6.75		

Mean scores of the APM in different groups of sex, age, and educational levels were illustrated in Table 17. It was found, mean scores within each group of different age and educational level were significantly different whereas mean scores of males and females groups were non-significantly different. In different groups of age, almost mean scores increased with respect to increasing of age, except, for a group of 17 years that was lower than mean score of 16 years. In the same way, almost mean scores increased with respect to educational level, except, that of Mathayomsuksa 5 that was lower than Mathayomsuksa 4.

As summarized in Table 18, when ANOVA technique with Scheffe's method was applied to analyze the differences of mean among different ages, 6 groups could be classified based upon significantly different of mean score; 12 years, 13 and 14 years, 15 years, 16 years, 17 years, and 18 years. Almost correlations between mean scores and ages showed positive values, except, between ages of 16 and 17 years which give negative value due to the fact that mean score of 16 years was higher than 17 years. Thereafter, norms of APM for these 6 groups were created and presented in Table 19. IQ score was converted from raw scores that were created based on mean of 100 and standard deviation of 15 for each group (the detail of the raw score converted to percentile was shown in appendix).

Table 18 The mean difference comparative by age group.

Age (years)	12	13	14	15	16	17	18
12	-	3.19*	3.62*	4.93*	6.42*	5.42*	7.34*
13		-	.43	1.74	3.23*	2.23	4.15*
14			-	1.30	2.80*	1.80	3.72*
15				-	1.49	.49	2.41
16					-	-1.00	.92
17						-	1.92
18							-

\* P<.05

Table 19 Converted raw score of the APM to IQ<sub>s</sub> classified by age

Raw Score	Age					
	12 years	13-14 years	15 years	16 years	17 years	18 years
36	150	142	145	141	136	131
35	148	140	142	139	134	129
34	146	138	140	136	132	127
33	143	135	137	133	130	125
32	141	133	135	131	128	123
31	139	131	132	128	126	121
30	137	129	130	126	123	119
29	135	127	127	123	121	117
28	132	124	125	121	119	115
27	130	122	122	118	117	113
26	128	120	119	115	115	111
25	126	118	117	113	113	109
24	123	116	114	110	111	107
23	121	113	112	108	109	104
22	119	111	109	105	107	102
21	117	109	107	103	104	100
20	114	107	104	100	102	98
19	112	105	102	98	100	96
18	110	102	99	95	98	94
17	108	100	96	92	96	92
16	106	98	94	90	94	90
15	103	96	91	87	92	88
14	101	94	89	85	90	86
13	99	91	86	82	88	84
12	97	89	84	80	85	82
11	94	87	81	77	83	80
10	92	85	79	74	81	78
9	90	83	76	72	79	76
8	88	80	73	69	77	74
7	85	78	71	67	75	72
6	83	76	68	-	73	70
5	81	74	66	-	71	68
4	79	72	-	-	69	66
3	77	69	-	-	66	-
2	74	67	-	-	-	-
1	72	65	-	-	-	-

In the same way, as summarized in Table 20, differences of mean scores of different educational levels were analyzed. It was found that mean scores of students studied in Mathayomsuksa 2, Mathayomsuksa 3, Mathayomsuksa 4, Mathayomsuksa 5 and Mathayomsuksa 6 were non-significantly different whereas mean scores of the rest (Prathomsuksa 6 and Mathayomsuksa 1) were significantly different among them and to that of the first group. Therefore, norm of APM for 3 groups of educational level (Prathomsuksa 6, Mathayomsuksa 1, and Mathayomsuksa 2 to Mathayomsuksa 6) were created as shown in Table 21.

Table 20 The mean difference comparative by educational level.

Educational level	Prathom 6	Mathayom 1	Mathayom 2	Mathayom 3	Mathayom 4	Mathayom 5	Mathayom 6
Prathom 6	-	3.25*	7.24*	7.07*	8.97*	8.12*	9.91*
Mathayom 1		-	4.00*	3.82*	5.73*	4.88*	6.66*
Mathayom 2			-	-0.17	1.73	0.88	2.66
Mathayom 3				-	1.9	1.05	2.84
Mathayom 4					-	-0.85	0.93
Mathayom 5						-	1.78
Mathayom 6							-

\* P<.05

Table 21 Converted raw score of the APM to IQ<sub>s</sub> classified by educational level

Raw Score	Educational level		
	Prathomsuksa 6	Mathayomsuksa 1	Mathayomsuksa 2-6
36	162	150	140
35	159	148	137
34	157	146	135
33	154	143	133
32	152	141	130
31	149	139	128
30	147	136	126
29	144	134	123
28	142	132	121
27	139	129	119
26	137	127	116
25	134	125	114
24	132	122	111
23	129	120	109
22	127	118	107
21	124	116	104
20	122	113	102
19	119	111	100
18	117	109	97
17	114	106	95
16	112	104	93
15	110	102	90
14	107	99	88
13	105	97	85
12	102	95	83
11	100	92	81
10	97	90	78
9	95	88	76
8	92	85	74
7	90	83	71
6	87	81	69
5	85	78	66
4	82	76	-
3	80	74	-
2	77	71	-
1	75	69	-

The same as CPM, this present study of APM had been conducted in parallel with comparable studies in other six regions of Thailand (63) (64) (65) (66) (67) (68). Profile of mean scores and standard deviations of APM for different age groups of students in Kanchanaburi and those from other regions were summarized in Table 22.

Table 22 Mean and Standard deviation of the APM in seven provinces classified by age

Age (years)	Province							Total	
	Nakorn sawan	Nakorn sitham maraj	Bangkok	Kanchanaburi	Lampang	Chantha buri	Udon Thani		
12	$\bar{X}$	13.60	14.31	17.57	13.72	13.76	15.14	12.01	14.44
	S.D.	7.06	6.07	6.51	6.56	6.61	6.21	5.70	6.59
13	$\bar{X}$	13.85	18.47	16.98	16.91	14.65	16.43	11.36	15.49
	S.D.	6.72	6.08	6.16	6.69	6.54	5.90	6.04	6.66
14	$\bar{X}$	15.58	18.91	16.16	17.34	16.14	18.77	13.82	16.78
	S.D.	7.45	6.48	6.35	6.64	6.55	7.17	6.48	6.95
15	$\bar{X}$	16.99	20.17	17.45	18.65	17.98	18.45	16.79	18.19
	S.D.	8.11	6.27	6.32	5.74	6.40	6.62	7.14	6.68
16	$\bar{X}$	18.95	21.15	17.58	20.14	21.96	20.29	18.07	19.83
	S.D.	7.42	7.03	5.61	5.66	5.82	5.84	7.09	6.44
17	$\bar{X}$	19.31	22.84	17.39	19.14	20.29	21.28	18.56	20.16
	S.D.	8.32	5.93	6.62	6.89	6.71	5.7	6.92	6.86
18	$\bar{X}$	20.98	21.15	16.33	21.06	20.99	21.41	17.02	20.24
	S.D.	7.71	6.47	5.56	7.20	5.17	6.16	6.36	6.65

Total mean scores of student age ranged from 12 to 18 years increased with respect to increasing of age with values of 14.44, 15.49, 16.78, 18.19, 19.83, 20.16, and 20.24 and with standard deviation of 6.59, 6.66, 6.95, 6.68, 6.44, 6.86, and 6.65, respectively. Regarding mean scores of students from Kanchanaburi, those of 13 years (16.91), 14 years (17.34), 15 years (18.65), 16 years (20.14) and 18 years (21.06) were slightly higher than total cumulative mean score of each age whereas those of 12 and

17 years (13.72 and 19.14) were slightly lower than total cumulative mean of each age. This finding allowed concluding that APM score of students aged 12 to 18 years in Kanchanaburi province were in average range.

## Discussion

In summary, both tests showed a high discriminating power and should be recommended for evaluation of intelligence ability of student age 6 to 18 years in the Western region. Discriminating power of CPM analyzed by point biserial correlation method gave a range of .16 to .77 and had positive direction. Only one item showed item discrimination value lower than .20. The result in this research implied that CPM could use to distinguish the high ability in Western region from the lower. This finding showed more good range of item discrimination than the report of Sucheera Phattharayuttawat et al. (40), which discriminating power ranging from .10 to .30 and sixteen items showed the value of item discrimination lower than .20. For APM, the discriminating power of test was consistent to the study in Thai University students (44). However, the results showed more good discriminating power than the study in high achievement high school students (46).

Results observed in presented work showed a good item difficulty for APM and appropriated to use for evaluation of intelligence ability of student age 12-18 years in the Western region. However, CPM could be used for evaluation of intelligence ability of student age 7 to 9 years in the Western region but might not appropriate to administrate to student of higher than 9 years. Item difficulty for CPM of .73 and a range of .29 to .99 were observed. Moreover, in this study, 14 items showed item difficulties higher than .80. This result was consistent with the study in Thai population (40), Regarding to APM, it had item difficulty of .50 with a range of .09 to .98. Seventeen showed a good item that had an items difficulty of .20-.80 that closed to the study in Thai University student (44) and high achievement high school students (46).

In this study reported that, the CPM and APM had a good reliability. These results indicated that both tests were highly efficient to evaluate the intelligence in Thai student age 6 to 18 years in the Western region. Internal consistency of CPM based on KR-20 had value of .92 (56). This result was high consistent to the results in Thai population, in three ethnic groups (Anglo, Black, and Hispanic) and in Chinese children from Shanghai that reported a reliability of .91 (40), .90 (53), and .95 (53) which obtained from KR-20, split-half and test-retest within short retest interval of 10 days, respectively. For APM, internal consistency of test was similar to the various works observed in Thai Universities students, high achievement high school students, and adults with reliability values of .90 (44), .80 (46) and .91 (54). Among them, values of the first two groups were obtained from KR-20 and the latter was obtained from test-retest.

The tests had a constructed validity and could used to measure an analogical reasoning of intellectual ability. In test, Raven created test based on one general factor, therefore the test structure should be measured one factor. In this research, the CPM and APM were found seven and nine factors respectively that were consistent with Raven's constructional concept. There were 5 approaches such as complete a pattern, complete an analogy, systematically alter a pattern, introduce systematic permutations, and systematically resolve figures into parts. Seven factors of CPM solution were found to yield the most interpretable structure. These seven factors showed parallel to the five approaches. Factor I (Balance) was based on a systematic permutation. Factor II (Creation) was based on the systematical alteration. Factor III (Distinguish) and factor V (Category) were based on completion of analogy. Factor IV (Continuity) and factor VI (Connection) were based on the systematical resolve. Factor VII (Assembly) was based on completion of pattern.

The same as CPM, nine factors of the APM showed consistent with the five approaches. Factor I (Organization) and factor V (Continuity) was based on the systematic permutation. Factor II (Combination) and factor VIII (Transformation) were based on the systematical alteration. Factor III (Increase), Factor IV (Relation) and Factor IX (Category) was based on completion of analogy. Factor V was based on

the systematic permutation. Factor VI (Remainder) was based on the systematically resolve figure into part. Factor VII (Creation) was based on complete a pattern.

The results implied that both CPM and APM were fair quality tests and could be used effectively to measure the common factor of intelligence structure and uniqueness. In CPM, even factor III and V could measure the same aspect, however, each of which was unique, factor III measured the perception of identical pattern while factor V measured the perception of similar. The same manner was found for factor IV and VI, factor IV measured the perception of continuous discrete pattern while factor VI measured the perception of identity and continuous pattern. Like that of the CPM, three pairs of factor of the APM that could measure the same aspect with uniqueness of each were factor I and factor V, factor II and VIII, and factor IV and IX.

In this research interested to construct norm that classified by sex, age and educational level but the result revealed no statistically significant variation by sex, therefore, age norm and grade norm were constructed. In subgroup, among age group, with educational group that was non-significantly different of mean score, they were set in the same group. These norms were constructed the same as other intelligence test such as the Wechsler Scale. The results revealed that age was influence to IQ and age related with educational level, therefore should be used norm that classified by age and educational level

Norm in this study had 2 type were percentile and IQ score. Percentile norm was used to classify the intelligence if user was not familiar with the interpretation of IQ level because it was a score, which divided the sample population into 100 parts. Moreover, the present study had been investigated in parallel with similar studies in other six regions of Thailand. Mean score of student in Western region represented by Kanchanaburi were slightly difference from total mean score in each of age group. This result revealed that, the different residence might be influence to mean score on the tests that was similar to the study of Choudhary R. et al. (28) and Pirot Kampiman (29).

## CHAPTER V

### CONCLUSION AND RECOMMENDATION

#### Conclusion

The objective of this research was to study the characteristics of the CPM and the APM in Thai student age 6 to 18 years and to construct norm. Samples consisted of 1,393 students that divided into 2 groups. There were 498 students (246 males, 252 females) age 6 to 11 years for the CPM and 895 students (372 males, 523 females) age 12 to 18 years for the APM. This study could conclude the finding as follow.

#### I The Colored Progressive Matrices

##### Part 1 Characteristic of the CPM

The study showed a high quality in the CPM that was examined as follow:

1.1 Range of item discrimination was .16 to .71 ( $\bar{r}=.77$ ). One item had a value of item discrimination lower than .20.

1.2 Range of item difficulty was .29 to .99 ( $\bar{p}=.73$ ). Fourteen items had a value of item discrimination higher than .80.

1.3 A reliability based on KR-20 was .92 and standard error of measurement was 2.13.

1.4 This research examined construct validity by factor analysis that found seven factors, which total factors had percent of variance 56.09%. All factors were as follow:

Factor I measured the perception of; similarity/difference, symmetry/asymmetry, and orientation of miss part (Balance factor).

Factor II measured the perception of figure modification (Creation factor).

Factor III measured the perception of identical pattern (Distinguish factor).

Factor IV measured the perception of discrete and continuous pattern (Continuity factor).

Factor V measured the perception of similarity (Category factor).

Factor VI measured the perception of identity and continuous pattern (Connection factor).

Factor VII measured the perception of similarity and difference pattern completion (Assembly).

### **Part 2 Norm of the CPM**

IQ score norms of CPM classified by age and educational level were created after comparison mean difference. The comparison mean difference based on raw score of the CPM in sex, age, and educational level of student aged 6 to 11 years found the results as follow:

2.1 Sex difference did not have difference of mean score at .05 level.

2.2 Age difference had a significant difference of mean score at .05, where mean score increased with age, which the constructional norm of CPM for student age 6 - 11 years could classify into 5 groups as 6-7, 8, 9, 10 and 11 years.

2.3 The difference of educational level had a significant difference of mean score at .05, where mean score increased with level of education, which the constructional norm of CPM for students age 6 through 11 years old could classify into 4 groups as Prathomsuksa 1, 2, 3 and 4-6.

## II The Advanced Progressive Matrices

### Part 1 Characteristics of the APM

The study showed a high quality in the APM that was examined as follow:

1.1 Range of item discrimination was .15 to .60 ( $\bar{r}=.42$ ). Two items had a value of item discrimination lower than .20.

1.2 Range of item difficulty was .09 to .98 ( $\bar{p}=.50$ ). Four items had a value of item-discrimination higher than .80 and five items had a value of item discrimination lower than .20.

1.3 A reliability based on KR-20 was .87 and standard error of measurement was 2.43.

1.4 This research examined construct validity by factor analysis that found nine factors, which total factors had percent of variance 40.00 %. All factors were as follow:

Factor I measured the perception of mergence and split of figure, step movement, and grouping (Organization factor).

Factor II measured the perception of mergence of pattern (Combination factor).

Factor III measured the perception of grouping and pattern addition (Increase factor).

Factor IV measured the perception of correlate of similarity (Relation factor).

Factor V measured the perception of systematic movement (Continuity factor).

Factor VI measured the perception of modified with consistence of some identities (Remainder factor).

Factor VII measured the perception of similar grouping and modified pattern (Creation factor).

Factor VIII measured the perception of identity change (Transformation factor).

Factor IX measured the perception of similar grouping, number, and orientation (Category factor).

### **Part 2 Norm of the APM**

IQ score norms of APM classified by age and educational level were created after comparison mean difference. The comparison mean score based on raw score of the APM in sex, age, and educational level of student aged 12-18 years found the results as follow:

2.1 Sex difference did not have difference of mean score at .05 level.

2.2 Age difference had a significant difference of mean score at .05, whereas mean score increase with age except age 17 years that had mean score lower than age 16 years. So the constructional norm of APM for student age 12 through 18 years old could classify into 6 groups as 12, 13-14, 15, 16, 17 and 18 years.

2.3 The difference of educational level had a significant difference of mean score at .05, whereas mean score increase with level of education except Mathayomsuksa 5 that had mean score lower than Mathayomsuksa 4. So the constructional norm APM for students age 12-18 years could classify into 3 groups as Prathomsuksa 6, Mathayomsuksa 1 and 2-6.

### **Recommendations**

1. The CPM measured g-factor of intelligent ability in the children age 6 to 11 years appropriately. However, this test could not measure the highest of intelligent ability in the children age more than 9 years and the children who were studying in the higher class than Prathomsuksa 3. To suggest that should select the SPM for these groups.

2. The results in this study found a significant effect of age and educational level on mean score. When using norms of this study, the background of examinee should be taken to consideration. If they studied in the formal education can use norms

that classified by age or educational level. In contrast, the non-formal education or no education is more appropriate use norms that classified by age.

3. When using the standard test must to carry out administration of test strictly and to consider the physical and mental readiness of respondent such as intention, motivation to gain the exact competence of the respondents.

4. Administration in the places without the interference that impact to concentration and attention of examinee. Because they should have a score lower than their capacity.

5. To be careful when testing in students were lower than Prathomsuksa 3, because the students do not acquaint on the test method by making a symbol in the answer sheet. This cause is an impact to receive lower score than the real capacity.

6. To further study in sex, age and educational difference combine with other factor such as family income or child rearing practice that cover the capacity of intelligence.

7. Norms of this research provides more advantage in clinical application than that of educational field. However in order to extent educational advantage, grade equivalent should be developed.

8. This research was only studied intra test validity, the inter test validity should be studied for further research.

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## APPENDIX A

Table 23 Mean, Standard Deviation, Difficulty, Discrimination of CPM

Item	Mean	S.D.	P	r	Item	Mean	S.D.	P	r
1	.99	.06	.99	0.16	19	.78	.42	.78	0.67
2	.98	.14	.98	0.29	20	.68	.47	.68	0.67
3	.96	.20	.96	0.37	21	.64	.48	.64	0.64
4	.95	.21	.95	0.36	22	.66	.48	.66	0.50
5	.93	.25	.93	0.39	23	.55	.50	.55	0.50
6	.91	.29	.91	0.45	24	.45	.50	.45	0.54
7	.75	.43	.75	0.63	25	.96	.19	.96	0.36
8	.80	.40	.80	0.40	26	.92	.27	.92	0.47
9	.80	.40	.80	0.56	27	.87	.34	.87	0.60
10	.72	.45	.72	0.61	28	.84	.37	.84	0.60
11	.50	.50	.50	0.58	29	.71	.45	.71	0.66
12	.38	.49	.38	0.41	30	.63	.48	.63	0.57
13	.96	.19	.96	0.40	31	.54	.50	.54	0.55
14	.96	.19	.96	0.44	32	.44	.50	.44	0.61
15	.96	.20	.96	0.33	33	.51	.50	.51	0.63
16	.81	.39	.81	0.60	34	.59	.49	.59	0.67
17	.77	.42	.77	0.57	35	.47	.50	.47	0.65
18	.71	.45	.71	0.71	36	.29	.45	.29	0.50

Table 24 Mean, Standard Deviation, Difficulty, Discrimination of APM

Item	Mean	S.D.	P	r	Item	Mean	S.D.	P	r
1	.98	.13	.98	0.15	19	.64	.48	.64	0.46
2	.80	.40	.80	0.57	20	.67	.47	.67	0.49
3	.83	.37	.83	0.55	21	.40	.49	.40	0.50
4	.75	.43	.75	0.54	22	.35	.48	.35	0.49
5	.79	.40	.79	0.53	23	.38	.48	.38	0.44
6	.83	.36	.83	0.46	24	.26	.44	.26	0.39
7	.66	.47	.66	0.50	25	.39	.49	.39	0.48
8	.68	.46	.68	0.51	26	.33	.47	.33	0.27
9	.82	.38	.82	0.52	27	.18	.39	.18	0.28
10	.70	.46	.70	0.59	28	.21	.41	.21	0.20
11	.73	.44	.73	0.60	29	.13	.34	.13	0.15
12	.65	.48	.65	0.56	30	.26	.44	.26	0.30
13	.46	.50	.46	0.36	31	.20	.40	.20	0.27
14	.70	.46	.70	0.59	32	.17	.38	.17	0.24
15	.50	.50	.50	0.54	33	.30	.49	.30	0.39
16	.53	.50	.53	0.51	34	.15	.35	.15	0.29
17	.58	.49	.58	0.49	35	.24	.43	.24	0.32
18	.50	.50	.50	0.48	36	.09	.28	.09	0.23

**APPENDIX B**

Table 25 IQ norm of CPM in students ages 6-11 years (N=498) from Western region.

Raw score	Frequency	Percentile	IQ
36	17	98.29	118
35	33	93.27	117
34	45	85.44	115
33	31	77.81	113
32	35	71.18	111
31	36	64.06	109
30	34	57.03	107
29	15	52.11	105
28	26	47.99	103
27	18	43.57	102
26	21	39.66	100
25	11	36.45	98
24	16	33.73	96
23	18	30.32	94
22	14	27.11	92
21	13	24.4	90
20	12	21.89	88
19	10	19.68	87
18	13	17.37	85
17	9	15.16	83
16	12	13.05	81
15	16	10.24	79
14	8	7.83	77
13	10	6.02	75
12	5	4.52	73
11	3	3.71	72
10	6	2.81	70
9	2	2.01	68
8	2	1.61	66
7	4	1	-
6	1	0.5	-
5	-	-	-
4	2	0.2	-

Table 26 IQ norm of APM in students ages 12-18 years (N=895) from Western region.

Raw score	Frequency	Percentile	IQ
36	1	99.94	140
35	1	99.83	138
33	4	99.72	133
32	4	99.44	131
31	10	98.66	129
30	4	97.88	127
29	15	96.82	125
28	25	94.58	122
27	26	91.73	120
26	22	89.05	118
25	42	85.47	116
24	44	80.67	114
23	45	75.7	112
22	48	70.5	109
21	60	64.47	107
20	43	58.72	105
19	48	53.63	103
18	64	47.37	101
17	50	41.01	99
16	38	36.09	96
15	39	31.79	94
14	28	28.04	92
13	32	24.69	90
12	27	21.4	88
11	30	18.21	86
10	26	15.08	83
9	12	12.96	81
8	29	10.67	79
7	26	7.6	77
6	16	5.25	75
5	17	3.41	73
4	14	1.68	70
3	7	0.5	68
2	-	-	66
1	1	0.06	64

## BIOGRAPHY

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