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Attributes Affecting Students' Ability in Thinking Skills

(Atribut yang Mempengaruhi Kebolehan Pelajar dalam Kemahiran Berfikir)

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ABSTRACT

The Ministry of Education has reemphasized the implementation of higher order thinking skills (HOTS) in science and mathematics curriculum in 2014. In relation to this, a research was carried out to analyse students' ability in thinking skills (ATS), and to construct a model that estimates their ATS. The study involved 300 students of engineering and science foundation programme from a university. A Scientific Reasoning Test was used as instrument. Binary logistic regression is used to categorize the students' level of thinking skills. Results show that 51.7% of students are categorized as having higher order thinking skills (HOTS) and 48.3% having lower order thinking skill (LOTS). More male students at HOTS level (57.1%) compared to LOTS (42.9%), while more female students at LOTS level (52.7%) compared to HOTS (47.3%). Higher percentage of boarding school students (55.4%) at HOTS level compared to daily school students. There is a significant correlation between ATS with students' performance in mathematics course in foundation programme (MAT093) and performance in mathematics subject in SPM (MAT). A binary logistic model was constructed to estimate students' ATS. The findings implicate that teaching method through inquiry and mind-mapping in i-Think process which has been implemented in schools since 2015 seems to give an impact in enhancing and developing students' thinking skills.

Keywords: Higher order thinking skill (HOTS); scientific thinking skills; scientific reasoning test; binary logistic regression model; mathematics achievement

ABSTRAK

Kementerian Pendidikan Malaysia telah memberi penekanan semula terhadap penerapan kemahiran berfikir aras tinggi (KBAT) di dalam kurikulum sains dan matematik pada tahun 2014. Sehubungan itu, satu kajian dijalankan untuk menganalisis keupayaan kemahiran berfikir (KKB) pelajar dan membina model untuk telahan kemahiran berfikir mereka. Kajian ini melibatkan 300 pelajar Asasi program kejuruteraan dan sains dari sebuah universiti. Ujian Penaakulan Saintifik digunakan sebagai instrumen. (MAT) dan Matematik Tambahan (ADMAT) dalam SPM. Regresi Logistik Binari digunakan untuk menentukan kategori tahap kemahiran berfikir pelajar. Hasil kajian mendapati 51.7% pelajar berada pada kemahiran berfikir aras tinggi (KBAT) dan 48.3% berada pada kemahiran berfikir aras rendah (KBAR). Lebih banyak pelajar lelaki berada pada aras KBAT (57.1%) daripada aras KBAR (42.9%), manakala lebih banyak pelajar perempuan berada pada aras KBAR (52.7%) berbanding aras KBAT (47.3%). Lebih pelajar berasrama penuh berada pada aras KBAT (55.4%) berbanding pelajar sekolah harian. Terdapat korelasi yang signifikan antara KKB dengan pencapaian dalam kursus matematik matrikulasi (MAT093) dan pencapaian Matematik SPM (MAT). Sebuah model logistik binari telah dibina untuk telahan KKB pelajar. Dapatan mengimplikasikan bahawa kaedah pengajaran yang berbentuk inkuiri dan peta minda dalam proses i-Think yang telah diperkenalkan di sekolah pada tahun 2015 adalah berpotensi dan berkemampuan untuk mengembangkan aras kemahiran pemikiran pelajar.

Kata Kunci: Kemahiran berfikir aras tinggi (KBAT); kemahiran berfikiran saintifik; ujian penaakulan saintifik; model regresi logistik binary; pencapaian matematik

Introduction

The Malaysian Ministry of Education (MOE 2013) has introduced the implementation of critical and creative thinking skills (CCTS) into Malaysian Education curriculum in the 90s. Poor performance of Malaysian students in two international assessments, such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) were recorded since 2007 to 2012 (Star, 2013). Hence, MOE has begun to reemphasize and implement higher order thinking skills (HOTS) in 2014. HOTS has been implemented in our curriculum and examination where school-based assessment was emphasized to improve students' performance and reduce examination orientation fever among parents, students and teachers. PISA is conducted every three years and its analysis is based on reading, mathematics and science test scores of 15 years-old students since 2006. Its focus is on students' ability to think critically in order to solve real world problems. The

TIMSS provides reliable and timely data on Grade 4 and Grade 8 students' achievement in mathematics and science, every four years since 1995.

Table 1 and 2 show the results of PISA by Organisation for Economic Co-operation and Development (OECD) and TIMSS for Malaysian (MAS) students respectively. Even though there are improvements in Malaysian students' mathematics scores for PISA from year 2009 to 2015, the scores are much lower than the average scores. For TIMSS, Malaysian students' scores for year 2007-2015 are less than 500 and below international average as compared to year 1999 and 2003.

TABLE 1. Results of PISA (2009-2015)

	2009		2012		2015	
	MAS Score	OECD average	MAS Score	OECD average	MAS Score	OECD average
Mathematics	404	494	421	511	446	490
Reading	414	496	398	508	431	493
Science	422	501	420	528	443	493

TABLE 2. Results of TIMSS (1999-2015)

	1999	2003	2007	2011	2015
Mathematics	519	508	474	440	465
Science	492	510	471	426	471

One of the objectives of the Malaysian Education Blueprint (MEB) 2013-2025 is to be above the global average and top tier in international assessment. According to the MEB, in order to compete with the best in the world, our education system must develop young Malaysians who are knowledgeable, critical and creative thinkers, have leadership skills and are able to communicate with the rest of the world. One of the objectives of MEB is to understand the current performance and challenges of the Malaysian education system, with a focus on improving access to education, raising standards (quality), closing achievement gaps (equity), fostering unity amongst students and maximising system efficiency within these years.

The Malaysian education system has emphasised the development of strong content knowledge in subjects such as Science, Mathematics and Languages. However, the increasing global recognition need has caused it to be no longer enough for a student to leave school with the 3R skills (Reading, wRiting & aRithmetic). Another 'R' which is Reasoning is being emphasized in education. The first time that the MOE introduced HOTS in teaching and learning was in Form 3 examination, *Pentaksiran Tingkatan* 3 (PT3), which replaced *Penilaian Menengah Rendah* (PMR) in 2014. Consequently, the new format of questions of Form 5 public examination, *Sijil Pelajaran Malaysia* (SPM) in 2016 consists of certain percentage HOTS format. Students need to think more critically and creatively in solving problems. Result of SPM 2017 showed an improvement from SPM 2016 (NST 2018). The SPM 2017 candidates achieved better results with a National Average Grade (GPN) of 4.90 compared to 2016 which is 5.05. There is a healthy increment in the results. Overall, 66% of SPM candidates have mastered HOTS. Based on the candidates' quality of answers, 27% have mastered HOTS at a high level, 39% at a moderate level, and 34% at a low level. Even though the candidates mastered the application skills at the highest level, their analysis, evaluating and creating skills, are still at a moderate level.

The students who succeed in applying HOTS will be more inclined to ask many questions and can make suggestions based on existing knowledge (Bakry & Md. Nor 2015; Omardin 1999). HOTS is not just a school programme, but a process of the students' development and thinking skill. The use of learning materials such as high-level questions can encourage students to think deeper, conclude and reflect, and then apply that knowledge in real situations (Marzita 2015; Siti et al. 2016; Owi et al. 2017). An active and group learning can allow students to interact and collaborate amongst each other easily (Azieyana & Christina 2018).

The purposes of this study are: i) to evaluate students' ability in thinking skills according to gender, type of schools and performance in mathematics, and ii) construct a Binary Logistic Regression model that categorized students' level of thinking skills as LOTS or HOTS.

Higher Order Thinking Skills (HOTS) Concept

According to King et al. (1998), individuals with HOTS can deal with unfamiliar problems, uncertainty questions or dilemmas. They have critical, logical, reflective, metacognitive and creative thinking skills and ability to apply knowledge, skills and values in reasoning, reflection, problem solving, decision making, innovating and creating something new. Lawson (1995) has refined Piaget's theory of cognitive thinking in terms of scientific reasoning skills (SRS) such that Empirical-Inductive (EI) is equivalent to concrete thinking and Hypothetical-Deductive (HD) as formal thinking. In the revised Bloom's Taxonomy (Huitt 2001) concrete thinking skills is categorized as lower order thinking skills (LOTS) and formal thinking as HOTS. The development towards formal or HD is an important factor in a students' achievement in science and mathematics studies (Mitchell & Lawson 1988).

Based on cognitive theory, Piaget regarded achievement at a formal level as something universal, this level however is still beyond the reach of many students and adults (Inhelder & Piaget 1958; Khoo 1985; Macnab & Cummine 1986). Six thinking patterns related to scientific thinking are relational, proportional, combinatorial, control of variable, probability and conservation. Scientific thinking is the skills involved in inquiry, experimentation, evidence evaluation and inference. The first step is to determine and state a particular problem leading to the process of making generalizations and conclusions using scientific methods. It is linked to several other skills such as the science process skills, manipulative skills, reflective thinking skills and creative and critical thinking skills (Lawson 1995; Corrine 2007).

ABILITY OF SCIENTIFIC THINKING SKILLS

Studies pertaining to scientific thinking ability had been carried out for more than 15 years (Syed Anwar & Merza, 2000; Hamidah & Merza 2001; Hamidah & Merza 2002; Hamidah 2004; Zuraidah 2006). Hamidah & Merza (2001) conducted a study on science students at UiTM Shah Alam and found that less than 25% of the students have achieved HD level or high thinking level. Majority of the students are within the transitional level, which is between EI and HD. The result shows that many students are functioning well below their actual cognitive capability. Comparison between genders also demonstrates that there are meaningful differences in mean score of male students compared to female students (Hamidah & Merza 2002). Male students are said to be more matured in scientific reasoning compared to female students. Although female students have been frequently regarded as a better group in terms of academic achievement compared to male students, male students show higher scientific reasoning level compare to female students.

Zuraidah (2006) studied on form five students from Sekolah Menengah Sains Kuala Selangor found that 61% of the students are at HD level, 37% at transitional level and another 2% at EI level. Most students not only excel academically but also capable in scientific reasoning. This study also revealed that more male students are at the HD level (33.3%) compared to female students (27.5%). The study found that there are no significance differences between genders in all reasoning thinking patterns. In Malaysia, female students often perform better in academic achievement. More female students are selected to higher learning institutions based on their excellent SPM performance compared to male students (MOE 2018).

Hamidah et al. (2004) carried out a comparative study between secondary full boarding schools (BS) and daily schools (DS) in terms of scientific thinking ability. They found that BS students achieved higher grades in SPM for science and mathematics subjects but no meaningful differences in scientific thinking abilities. For BS, 23.8% are in HD level compared to 16.3% for DS, 22.7% of BS are in EI level compared to 25.3% for DS. The rest of BS students (53.5%) are in transitional compared to 58.4% of DS. Although more BS students have achieved the HD level, few are still at the concrete level or EI.

RELATIONSHIP BETWEEN ABILITY IN THINKING SKILLS (ATS) AND ACADEMIC PERFORMANCE

Based on studies on relationship between ATS and mathematics achievement among Malaysian students, preliminary findings have shown that 94% of the students achieved concrete level of SRS, 5.7% achieved transitional and only 0.3% of them achieved formal level (Nor'ain & Mohan 2016). The coefficient of correlation (r = 0.593) indicating that there was a moderate positive relationship between the SRS and mathematics achievement. This study suggests that if a student has a high score in scientific thinking skill, the student is expected to achieve high score in mathematics. The study also performed T-test analysis to compare the mean scores of the overall level of SRS. The mean mathematics score between high-achievement group (mean = 81.02) is better than the low-achievement group (mean = 46.86). Specifically, the high-achievement group had better SRS and mathematics scores compared to low-achievement group. The results of T-test analysis showed that there were no significant differences in the overall level of SRS scores and mathematics scores between males and females. These findings indicate that students have similar level of SRS and mathematics achievement based on gender. This result is consistent with Hamidah (2004) and Zuraidah (2006) who found that higher performance of female students academically does not mean that their thinking skills are higher than males.

According to Tanujaya et al. (2017), there is strong positive relationship (r = 0.84) between HOTS and grade points average (GPA). Subjects for this research are 41 students of mathematics education from University of Papua, Indonesia. This study estimated regression model to predict their GPA result and it indicated that there is very strong evidence of both coefficients for HOTS and GPA. Students with high level of HOTS are expected to succeed in their study programme. A study conducted by Salyungu (2015) used four explanatory factors which are absenteeism, conduct, type of school and gender to estimate mathematics performance using binary logistic regression. This study was conducted on student 250 form three student with 1:1 gender ratio. The students were selected from five selected secondary schools. The model fitted for the log-odds in favour of poor performance is given by Logit $[P(Performance = 0)] = -1.185 + 0.346 *$ absenteeism $+ 1.137 *$ misconduct.

TEACHERS' KNOWLEDGE, PRACTICE AND ASSESSMENT OF HOTS

Curriculum, pedagogy and assessment are important components in the implementation of HOTS (MOE 2013).

Hence the level of knowledge and practice among teachers in these three components are crucially needed. Abdul Halim et al. (2017) studied on 196 teachers from 37 schools in Terengganu on the level of their knowledge and practice on the implementation of HOTS. Their finding revealed that the teachers' level of knowledge and practice of HOTS are high and satisfactory in the aspect of curriculum and pedagogy. Exposure of HOTS courses among teachers give positive impact towards the understanding of HOTS concept and teaching method. Mazlini (2017) reported that 50 secondary mathematics teachers in Kuala Langat, Banting gave positive feedback on the implementation of HOTS in schools. There exists significant relationship between the knowledge of HOTS and the implementation of HOTS in teaching and learning. However, years of experienced is not a significant factor in determining teachers' knowledge and practices of HOTS.

One of the enhancement programmes that has been introduced by MOE in developing HOTS are eight process of cognitive thinking named as i-Think Map which was launched in 2012 (Marzita 2016). Siti Ruzila et al. (2016) described the process of implementation of i-Think Map in teaching the topic of polygon in geometry to promote higher-order thinking. Owi et al. (2017) applied i-Think thinking map approach in pre and post study among year five students in solving HOTS questions. They found a significant improvement in solving the questions and majority of the students (90%) agree that i-Think help them analysed during the process of solving problems. Abdul Rashid et al. (2017) studied on the effectiveness of i-Think method in learning Malay Literature (KOMSAS) subject among form four students. The finding shows a significant difference in the achievement in understanding KOMSAS. Hence, the use of i-Think facilitates and promotes HOTS process. However, in the aspect of assessment, the level is quite low since many teachers are unable to change from exam-oriented practice in designing assessment (Abdul Halim et al. 2017).

Methodology

Population and Sample

The research uses a descriptive quantitative survey design. The research population of the study is the first semester students of Science and Engineering Foundation programmes at a public university in Selangor. These students were among those who applied HOTS method during their upper secondary schools' curriculum from year 2014-2016. A total of six classes have been selected at random by using the cluster sampling technique with 300 students selected as samples for this study. These students had their foundation mathematics course MAT093 in the first semester.

Table 3 shows the students' information on gender and their previous secondary schools. From a total of 300 students, 133 students involved in this research were males while 167 were females. Most of the students are from National Secondary Schools (SMK) (45.5%) followed by Boarding Schools (BS) and MARA Junior Science Colleges (MRSM) (43.8%).

TABLE 3. Students' profile on gender and type of secondary schools

	Frequency (N)	Percentage (%)	Total
Gender			
Male	133	44.3	300
Female	167	55.7	
Type of Secondary School			
SMK	135	45.5	297*
SMKA	23	7.7	
BS/MRSM	130	43.8	
TVET	5	1.7	
Private	4	1.3	

*No data regarding the three students' type of school

Instrumentation

The instrument used in this study is the Scientific Reasoning Test (SRT) by Hamidah (2004) as attached in the appendix. The test contains 12 items with six reasoning patterns (five HD and one EI). The five HD patterns in the SRT are proportionate reasoning, control of variable, combinatorial, probability and relation. For the EI, the reasoning skill is the volume/shape conservation. Each component contains two questions with different degree of difficulty. As to reliability of the instruments, Cronbach alpha test was conducted and the results of the Reliability index of the SRT is 0.78. According to Cronbach (1951), and Churchill (1979), a Cronbach's alpha value above 0.7 generally signifies high reliability. Thus, the items involved have been tested successfully and found valid.

The SRT questions require logical reasoning skills and no specific mathematical or science formula are required to be memorized to solve the problems. The paper and pencil and test require students to provide reasons or explanations in support of the answers provided. No marks will be awarded if an answer or explanation is incorrect. Both answers and explanation must be correct to score a mark. This type of evaluation is aimed at avoiding students from guessing the answers. Besides reasoning, question 1, 2, 11 and 12 have multiple choices answers while other questions are in subjective form. For each thinking pattern, odd numbered questions are easier version than even numbered questions. Approximately one hour is allocated for the SRT. Students are categorized into HD or HOTS level (8 to 12 marks) and EI or LOTS level (0 to 7 marks) based on the total score.

DATA ANALYSIS

The data and information collected are coded and quantitative data are analysed using the SPSS (23.0) software. The Pearson Chi-square test are being used between variables (categorical data) and SRT Score to determine the strength of relationship. For non-categorical data, Kendall's tau-b test is being used to determine the strength of relationship. For Pearson Chi-Square test, the significance value must be less than 0.05 to being significant but for Kendall's tau-b test must be less than 0.01 (Agresti 2007).

Logistic regression is a method for analysing a dataset in which there are one or more independent variables that determine an outcome (Hosmer & Lemeshow 1989). The outcome is measured with a dichotomous variable, in which there are only two possible outcomes. Logistic regression model is more robust since the independent variables do not have to be normally distributed, or have equal variance in each group, it does not assume a linear relationship between the independent variable and dependent variable and this model may handle non-linear effects (King 2003). Logistic regression analysis extends the techniques of multiple regression which the outcome variable is categorical (Stieler 2002). The logistic regression was employed to study the relationship between SRT score of the students and gender, MAT093 result, grades for Mathematics (MAT) and Additional Mathematic (ADMAT) results in SPM (A+, A, … , F) and type of schools (SMK, SMKA, SBP & MRSM, technical & vocational (TVET) and private schools). The binary response variable, Y is coded as 0 for LOTS (0 to 7 marks) and coded as 1 for HOTS (8 to 12 marks).

FINDINGS AND DISCUSSION

STUDENTS' ABILITY IN THINKING SKILLS (ATS)

STUDENTS' ATS AND GENDER

From a total of 300 students, there are 155 students (51.7%) are categorized as HOTS level and 145 students (48.3%) at the LOTS level as shown in Table 4. In comparison to ATS, higher percentage of male students are at HOTS level (57.1%) compared to female students (47.3%). Among male students, more students are HOTS level (57.1%) than LOTS level (42.9%) while more female students are at LOTS (52.7%) than HOTS level (47.3%).

TABLE 4. Distribution of students according to gender and ATS

Gender	HOTS		LOTS	
	N	%	N	%
Male	76	57.1	57	42.9
Female	79	47.3	88	52.7
Total	155	51.7	145	48.3

STUDENTS' ATS AND TYPE OF SCHOOLS

Based on Table 5, for daily schools (SMK), the number of students who achieved HOTS (50.4%) is almost similar to LOTS (49.6%).

TABLE 5. Distribution of students according to type of school and ATS

School	HOTS		LOTS	
	N	%	N	%
SMK	68	50.4	67	49.6
SMKA	11	47.8	12	52.2
BS/MRSM	72	55.4	58	44.6
TVET	1	20.0	4	80.0
PRIVATE	2	50.0	2	50.0
Total	154	100.0	143	100.0

The same results are recorded for SMKA students, 47.8% for HOTS and 52.2% for LOTS. For both SMK and SMKA, the different of only one student between HOTS and LOTS levels. Among BS and MRSM, higher percentage of students are at HOTS (55.4%) compared to LOTS level (44.6%). Higher percentage of BS and MRSM students are at HOTS level compared to both daily school students SMK and SMKA. This result could be justified since BS and MRSM students were selected based on their high achievement in academic and co-curriculum during primary six. Out of five TVET students, 80% are at LOTS compared to HOTS (20%) while the number of private students who are at HOTS and LOTS are equal. Since the number of TVET and private students is very small, the result is not significantly to be discussed further.

STUDENTS' ATS AND PERFORMANCE IN MATHEMATICS

1. Ability in thinking skills and MAT

The foundation students performed very well in MAT subject during SPM examination (Table 6). About 99% of students scored A+ and A, and only 1% (4 students) scored A-. From the 193 students that scored A+, 58% of them are at HOTS level while 42% are at LOTS level. Among students with grade A, almost 40% are at HOTS level while 60% are at LOTS level. Most students (75%) who scored A- are at HOTS level compared to LOTS (25%). More students with grade A+ are at HOTS level (58%) while more students with grade A are at LOTS level (60.4%).

2. Ability in thinking skills and ADMAT

The students also performed well in ADMAT (Table 7). About 76% of the students are in the category of grade A (A+, A and A-) and another 24% are in category grade B (B+ and B). Majority of the students scored A- (38.9%) followed by A (31.5%). Higher percentage of category A students are at HOTS level while higher percentage of category B students are at LOTS level.

TABLE 6. Distribution of students according to ATS and MAT

MAT	HOTS		LOTS		TOTAL	
	N	%	N	%	N	%
A+	112	58.0	81	42.0	193	64.8
A	40	39.6	61	60.4	101	33.9
A-	3	75.0	1	25.0	4	1.3
Total	155	100.0	143	100.0	298*	100.0

* No data regarding the two students' MAT grades

TABLE 7. Distribution of students according to ATS and ADMAT

ADMAT	HOTS		LOTS		TOTAL	
	N	%	N	%	N	%
A+	12	75.0	4	25.0	16	5.4
A	54	57.4	40	42.6	94	31.5
A-	61	52.6	55	47.4	116	38.9
B+	18	40.0	10	60.0	45	15.1
B	10	37.0	17	63.0	27	9.1
Total	155	100.0	143	100.0	298*	100.0

* No data regarding the two students' ADMAT grades

3. Ability in thinking skills and MAT093

Table 8 shows the students' MAT093 grades in their first semester. Almost 50% of the students are in category A (A and A-) and almost 40% in category B (B+, B, B-). Another 8.4% scored C+ and C while one student failed the test. As many as 52.3% of category A students are at HOTS level while about 45% are at LOTS level. Majority of category B students are at LOTS level (43.4%) compared to 39.3% are at HOTS level. Less percentage of students in category C (C+, C, C-) are at HOTS level (8.4%) compared to LOTS level (10.3%).

TABLE 8. Distribution of students according to ATS and MAT093

MAT093	HOTS		LOTS		TOTAL	
	N	%	N	%	N	%
A	52	33.6	30	20.7	82	27.3
A-	29	18.7	37	25.6	66	22.0
B+	31	20.0	16	11.0	47	15.7
B	16	10.3	28	19.3	44	14.7
B-	14	9.0	19	13.1	33	11.0
C+	9	5.8	8	5.5	17	5.7
C	4	2.6	6	4.1	10	3.3
C-	0	0.0	1	0.7	1	0.3
Total	155	100.0	145	100.0	300	100.0

CORRELATION BETWEEN SCIENTIFIC REASONING TEST (SRT) AND SELECTED VARIABLES

Table 9 shows the result of the Pearson Chi-Square test used to determine if there are significant relationships between the SRT score and the categorical data such as gender, type of secondary school, MAT and ADMAT. For correlation between SRT and gender, χ^2 (1) = 2.869, p = 0.090. Since the p-value is greater than the chosen significance level α = 0.05, hence, it can be concluded that there is not enough evidence to suggest there is a relationship between SRT and gender.

There was no significant association between SRT and type of schools as well, since χ^2 (4) = 2.955, p = 0.565. The test between SRT and MAT result shows that χ^2 (2) = 9.878, p = 0.007. Hence, there is enough evidence to suggest a significant association between SRT and MAT. There is also an association between SRT and ADMAT since the result shows χ^2 (4) = 9.543, p = 0.049.

TABLE 9. Pearson Chi-Square between SRT and selected variables

Variables	Value	df	Assumption (2-sided)
Gender	2.869	1	0.090
Secondary school	2.955	4	0.565
MAT	9.878	2	0.007
ADMAT	9.543	4	0.049

Correlation between SRT and MAT093 is done by using cross tabulation Kendall's tau-b test. As shown in Table 10, the correlation coefficient between SRT and MAT093 score is 0.128 with p = 0.007. Since the p-value is less than significant level 0.01, then there is enough evidence to conclude that there is a significant correlation between SRT and MAT093 result. Thus, it can be concluded that Mathematics, Additional Mathematics and MAT093 have a relationship with SRT scores.

TABLE 10. Kendall's tau-b test based on MAT093 result

Variable	Value	Assymp. Std. Error	Approx. Sig.
MAT093	0.128	0.47	0.007

THE LOGISTIC REGRESSION MODEL

One of the objectives of the study is to model the students' ability in thinking skills and categorized them as HOTS or LOTS level. To evaluate factors that would contribute to the probability of the occurrence of HOTS or LOTS level, rate of estimation is calculated. With the indication of HOTS = 1 and LOTS = 0, the result of logistic regression is discussed as follows. The Omnibus test of model shows (Table 11) the overall indication of how well the model performs. This is referred to a 'goodness of fit' test. The p-value is

0.001 which is less than 0.05. It shows that the model is good. The chi-square value is reported with 15.566 with 3 degrees of freedom.

TABLE 11. Omnibus tests of model coefficients

	Chi-Square	df	Sig.
Model	15.566	3	0.001

Based on the Hosmer and Lemeshow test (Hosmer & Lemeshow 1989), the value of chi-square is 5.623 and the significant value is 0.689 (Table 12). The significant value is greater than 0.05. It indicates that the model is valid.

TABLE 12. Hosmer and Lemeshow Test

	Chi-Square	df	Sig.
Model	5.623	8	0.689

Since MAT093 and MAT results are significant factors to SRT score, the coefficient and estimation values of the fitted model is represented in Table 13. Based on the analysis of logistic regression, MAT093 is the only significant predictor with p-value less than 0.05 (Table 13). This indicates that 1unit change in MAT093 will increase the odds of students' HOTS by 3.5%.

TABLE 13. Logistic regression model (significant variable)

x	B	Sig.	Exp(B) (odds ratio)	Exp(B) - 1	% change in odds
MAT093	0.035	0.020	1.035	0.035	3.5

Therefore, the fitted model is given by:

$$\text{logit} = \ln\frac{p}{1-p} = -1.193 - 0.931*\text{ADMAT} - 1.569*\text{MAT} + 0.035*\text{MAT093}.$$

More than 15 years ago, only about 25% of SPM leavers in science programme in one of the public universities achieved HOTS level (Hamidah 2004). MOE (2013) has strongly emphasized and implemented HOTS in schools' curriculum since 2014. This study shows that there is a good achievement in the ability in thinking skills since almost 52% are at HOTS level. The implementation of i-Think and other alternative teaching methods (Azieyana & Christina, 2018; Siti Ruzila et al. 2016; Abdul Rashid et al. 2017: Owi et al. 2017; Hamidah 2004; Ibrahim 2003) that emphasize on inquiry or discovery learning give positive results in the development of thinking skills' ability.

These foundation programme students were generally an above average students in their form five SPM examination. This result seems to be consistent with Zuraidah (2006) who reported that more than 50% of boarding school students were at HOTS level. Male students show a better achievement in thinking skills compared to female students. This result is consistent with Zuraidah (2006). In addition, male students have higher percentage of HOTS compared to female students. More female students are at LOTS level compared to HOTS. Although female students are regularly regarded as high achievers in academic schools and public examination such as SPM, it does mean that they have better ability in thinking skills. Students with many 'As' does not necessary mean that they have high level of thinking as well (Ainon & Abdullah 1996; Hamidah 2004).

Conclusion

This study evaluates students' ability in thinking skills according to gender, type of schools and mathematics performance. A Binary Logistic Regression model is constructed, and students are categorized according to LOTS or HOTS level. This study also reveals that MAT, ADMAT and MAT093 has significant relationship with SRT score. However, only MAT093 can be used to estimate and categorize students' thinking skills in the construction of the binary regression model. Both MAT and ADMAT are not suitable for prediction of HOTS level. HOTS is basically a generic thinking skill. Meanwhile, flying colours results in MAT and ADMAT are probably content dependent and insufficient to influence HOTS ability. Generally, students from boarding school performed better in SPM examinations compared to daily school. However, the findings of this study show that it does not confirm that boarding school students are better in their ability in thinking skills than daily school students. Previously, before HOTS is being implement, examination questions have a certain format or pattern and can be remembered and predicted. In mathematics, students will try to remember the procedures and steps to work out the answers. Now, with different format of questions, it is not that easy to answer the exam questions which required HOTS ability. There are several suggestions to improve HOTS among students might be useful to teachers, schools and higher institutions. The learning environment is important for students to develop and acquire knowledge. Cooperative, problem-based learning, thinking map, metacognitive and inquiry learning are among learning methods that enhance the development of thinking skills. Teaching students to think 'how' and 'what' they are thinking can improve their generic thinking skills. The implementation of i-Think process in various subjects in schools could give great impact in the development of students' metacognitive thinking. Besides, through contextual and discovery learning, students can develop and sharpen their thinking skills from concrete to formal level as well as from LOTS to HOTS. Hence MOE's expectation to see improvements in the evaluation of HOTS among students in Malaysia after three years of HOTS being implemented through various strategies in terms of teaching method and exam questions can be considered as successful and very encouraging.

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APPENDIX

SCIENTIFIC THINKING TEST

UJIAN PEMIKIRAN SAINTIFIK

Soalan 1:

Katakan anda diberi dua biji bola A dan B yang dibuat daripada tanah liat. Kedua-dua bola mempunyai bentuk, saiz dan berat yang sama. Kemudian, bola A dileperkan seperti bentuk lempeng.

Pernyataan yang manakah yang benar?

a) Bola B lebih berat daripada bola A.

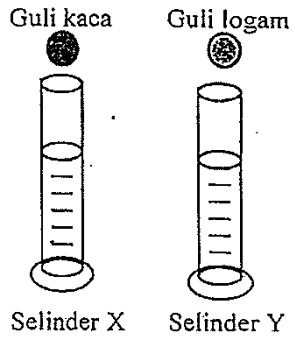
b) Kedua-dua bola sama beratnya.

c) Bola A lebih berat daripada bola B.

Sila terangkan pilihan jawapan anda.

Soalan 2:

Selinder X dan Y diisi dengan air hingga ke paras yang sama. Kedua-dua selinder mempunyai saiz dan bentuk yang sama. Terdapat dua biji guli. Sebiji dibuat daripada logam dan sebiji lagi dibuat daripada kaca. Kedua-dua guli mempunyai saiz yang sama tetapi guli logam lebih berat daripada guli kaca.



Apabila guli kaca dimasukkan ke dalam selinder X, ia tenggelam hingga ke dasar dan paras air meningkat hingga ke tanda yang ke-6.

Jika guli logam dimasukkan ke dalam selinder Y, maka paras air akan berubah

a) ke paras yang lebih rendah daripada tanda 6.

b) ke paras yang lebih tinggi daripada tanda 6.

c) ke paras yang sama seperti selinder X.

Sila jelaskan pilihan yang dibuat.

Soalan 3:

Terdapat enam keping duit syiling di dalam sebuah dompet. Kesemua syiling itu serupa dari segi bentuk dan saiz. Tiga keping syiling perak dan tiga lagi syiling emas. Jika anda memilih sekeping syiling tanpa melihat ke dalam dompet, apakah kebarangkaliannya jika syiling yang dipilih ialah syiling emas?

Jawapan: _____

Sila jelaskan dan tunjukkan bagaimana anda mendapat jawapan.

Soalan 4:

Raju memasukkan 21 biji bola yang telah dicat dengan warna ke dalam sebuah kotak. Bola-bola tersebut terdiri daripada:

3 bola pingpong merah

4 bola pingpong putih

5 bola pingpong jingga

4 bola tenis merah

2 bola tenis putih

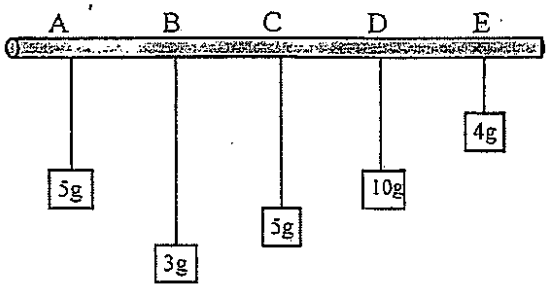
3 bola tenis jingga

Jika adik Raju memilih sebiji bola (tanpa melihat ke dalam kotak tersebut), apakah kebarangkalian bola yang dipilih berwarna merah?

Jawapan: _____

Sila jelaskan dan tunjukkan bagaimana anda mendapat jawapan.

Soalan 5:



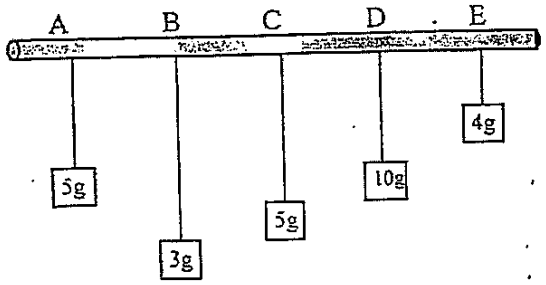
Katakan anda ingin membuat satu ujikaji untuk mengetahui samada panjang tali akan mempengaruhi masa ayunan lengkap suatu pendulum.
(1 ayunan lengkap = 1 perjalanan pergi dan balik).

Pendulum-pendulum yang manakah akan anda gunakan untuk ujikaji tersebut?

Jawapan: _____

Soalan 6:

(Sila rujuk soalan 5)



Jika anda ingin membuat ujikaji untuk mengetahui samada berat akan mempengaruhi masa ayunan lengkap, pendulum-pendulum yang manakah yang anda akan pilih?

Jawapan: _____

Soalan 7:

Sebuah restoran menyediakan menu sajian utama yang terdiri daripada tiga jenis minuman, tiga jenis nasi dan tiga jenis lauk:

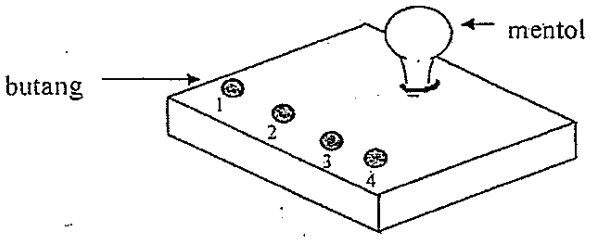
Minuman	Nasi	Lauk
Sirap (S)	Minyak (M)	Kambing (K)
Soya (Y)	Tomato (T)	Lembu (L)
Cincau (C)	Beryani (B)	Ayam (A)

Setiap hidangan mesti mengandungi sejenis minuman, nasi dan lauk sahaja. Berapa jenis hidangan yang boleh disediakan?

Senaraikan semua jenis hidangan yang boleh disediakan dalam ruang di bawah

Soalan 8:

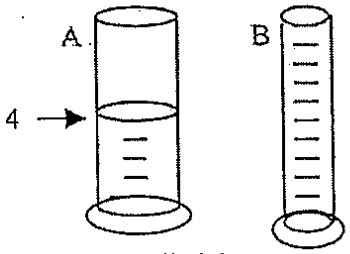
Gambarajah berikut menunjukkan sebuah mentol dan empat biji butang berlabel 1, 2, 3 dan 4. Mentol akan menyala jika butang atau gabungan butang-butang yang betul ditekan.



Senaraikan semua kemungkinan yang boleh dibentuk untuk menyalakan mentol tersebut.

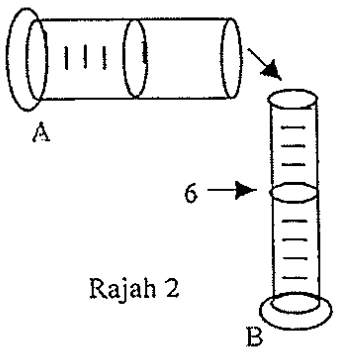
Soalan 9:

Perhatikan akan kedua-dua selinder yang diberi. Selinder A lebih luas bukaannya daripada selinder B. Kedua-dua selinder mempunyai selang tanda yang sama. Air dituangkan hingga sampai ke paras bertanda 4 (lihat Rajah 1).



Rajah 1

Apabila air daripada selinder A dituang ke dalam selinder B yang lebih sempit bukaannya, paras air akan naik hingga ke tanda 6 (lihat Rajah 2).



Rajah 2

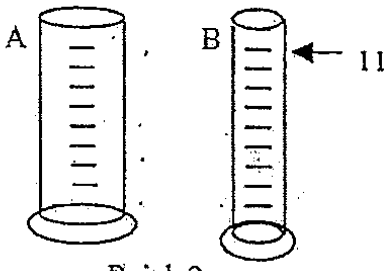
Jika air yang dituang ke dalam selinder A mencapai ke tanda 6, ke paras manakah air itu akan naik jika ianya dituangkan ke dalam selinder B yang kosong?

Jawapan: _____

Soalan 10:

(Sila rujuk soalan 9)

Jika air yang dituangkan ke dalam selinder B naik ke paras bertanda 11 (lihat Rajah 3), berapa tinggikah paras air apabila air itu dituangkan ke dalam selinder A yang kosong?



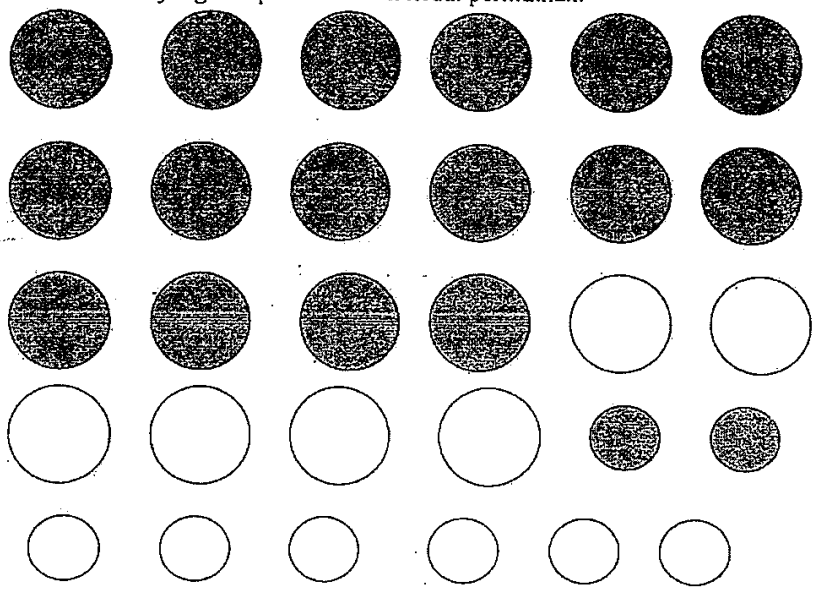
Rajah 3

Jawapan : _____

Sila tunjuk (atau jelaskan) bagaimana anda mendapat jawapan.

Soalan 11:

Berikut ialah bola-bola yang didapati di sebuah kedai permainan.



Adakah anda dapati bahawa kebanyakan bola besar berwarna kelabu dan kebanyakan bola kecil berwarna putih?

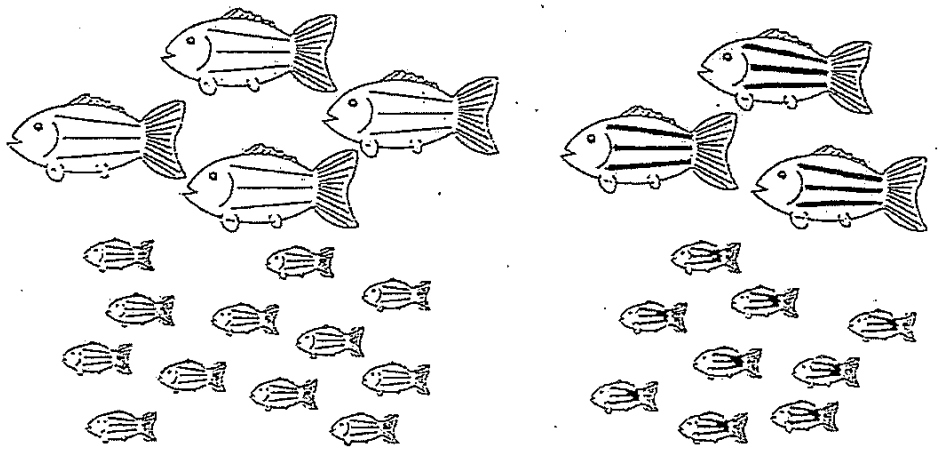
a) Ya

b) Tidak

Sila jelaskan mengapa anda menyatakan demikian.

Soalan 12:

Ikan-ikan dalam rajah berikut telah ditangkap oleh seorang nelayan. Nelayan tersebut sedar bahawa ikan-ikan yang ditangkap ada yang besar, ada yang kecil, ada yang berjalur besar dan ada yang berjalur kecil. Ini membuatkan nelayan itu tidak pasti sama ada terdapat hubungkait antara saiz ikan dengan jenis jalur ikan tadi.



TAMAT