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Learning The Strategy of Reasoning Through Marzano Dimensional Mastery Learning Model Among Form Four Students for The Topic Of Differentiation

Mohamad Nizam Arshad, Noor Azean Atan, Abdul Halim Abdullah, Mahani Mokhtar, Mohd Salleh Abu*

Faculty of Education, University of Technology Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

*Corresponding author: salleh@utm.my

Abstract

Reasoning skills are very important in encouraging students to think more critically and logically, as depicted in the Malaysian Education Development Plan (2013-2025). Therefore, this study looked into improving the Differentiation Reasoning Level (DRL) of reasoning skills among students for a topic in the Additional Mathematics subject, known as Differentiation, through reasoning learning strategy. The study participants consisted of a total of 31 students from a secondary boarding school in Johor, selected through a purposive sampling method. A pre-test was carried out for the participants, from the advanced level, followed by a number of repetition tests, before the post-test assessment was conducted. The data collection for this study employed a set of Reasoning Test on Differentiation (RTD) and 10 sets of learning activities on Differentiation based on modified Marzano Rubric for Specific Task of Situations (1992). This dimension involved four types of reasoning skills, namely, comparison, classification, inductive, and deductive. The survey data, through paired samples t-test, revealed a significant difference between the mean scores in pre-test and post-test ($p < 0.05$). In addition, the paired sample t-test showed a significant difference on the level of reasoning among students from each construct in the reasoning skills before and after using this module. In conclusion, the Marzano Model of Dimensional Learning (1992) is a thinking skill model that can help improve students' reasoning skills. The model covers analysis aspects of what has been learned by implementing the process of identifying reasons, which will help students to add and expand their knowledge. The findings also implied that, the processes of teaching and learning play an important role in ensuring students' capability to emphasize on the implementation process of reasoning skills.

Keywords: Reasoning skills; dimensional model of mastery learning; topic differentiation

1.0 INTRODUCTION

The Malaysian Education Development Plan (2013-2025) has stipulated reasoning skills as one of the major components in Higher Order Thinking Skills (HOTS) to be mastered by students. The main focus of the curriculum is to foster Higher Order Thinking Skills (HOTS) in order to produce students who could demonstrate their own abilities through reasoning skills [1]. Findings of previous studies have shown that, Malaysian students, whether at school or university levels, are less proficient in reasoning skills [2, 3]. As such, all parties should join their efforts and expertise to help raise the levels of students' reasoning skills, so that, they become more competitive towards the 21st century. The need for students to master Mathematical reasonings is seen as important when they learn Mathematics, particularly for analytical mathematical topics, such as Differentiation, failure of which, in the early stages of learning, will affect further learning of Mathematics at higher levels.

Realizing the importance of the Differentiation topic in a broader context and its relation to students' achievement at higher levels in critical courses, [4] found that most UTM engineering students were weak in Fundamental Calculus due to their very limited pre-knowledge about the subject. Meanwhile, results of a study conducted by Julaihi *et al.* (2008) [5] found a correlation between academic achievement of engineering students at Universiti Teknologi Mara (UiTM) at the diploma level and their prior achievement in SPM level for Mathematics, especially on the topics of Differentiation and Integration, and Physics.

A preliminary study to identify the level of students' reasoning through Reasoning Test of Differentiation Questions or *Ujian Penaakulan Soalan Pembezaan* (UPSP), conducted by Mohamad Nizam *et al.*, (2016) [6] proved that, the requirement for students to master mathematical reasoning was at a sufficient level, but it widens to a larger context when they learn mathematical concepts that are analytic in nature, such as Calculus (differentiation, integration etc.). All of the above findings showed the importance of mastering Calculus among students when undertaking critical courses in the university, the basis of which, must essentially be gained while in secondary school education.

Once the required skills can be successfully mastered, they become useful tools for the students to understand and master any mathematical concept. Researchers have used Marzano's Extending and Refining Knowledge Dimension [7] to improve the quality of students' thinking skills, particularly, reasoning skills. This dimension describes very complex thinking skills in the learning process and it has the ability to increase HOTS-based reasoning of students [8]. Based on the dimension, reasoning skills can be divided into two stages, namely, low level (the ability to classify and make comparisons) and high level (inductive reasoning and deductive reasoning).

Thus, students need to acquire the skills at both levels so that, they can carry out the stages of reasoning effectively, thus enabling them to expand and improve their knowledge.

2.0 PROBLEM STATEMENT

Information, evidence and critical arguments stated in most of the studies by Mohamad Nizam *et.al.*, 2016, Yee Mei Heong *et al.*, 2015 and Yudariah & Roselainy (1997) ([6], [9] and [4]) suggested that, there exists empirical evidence to indicate that Malaysian students acquired the procedural understanding and Low Order Mathematics Thinking Skills (LOMTS) but had less mastery of conceptual understanding and High Order Mathematics Thinking Skills (HOMTS), especially reasoning skills. Reasoning skills are one of the main components in HOMTS to be mastered by students as set forth in the Blueprint 2012-2025. Weakness in the mastery of mathematical reasoning skills among students at the primary level is expected to have significant impacts on the success or failure of Mathematics learning at the higher level.

This reasoning weakness is commonly associated with Mathematical learning difficulties experienced by students. Empirical evidences are aplenty which showed that, many Malaysian students have problems in mastering both aspects of Mathematical learning, namely, conceptual understanding and HOMTS. The requirement for students to master mathematical reasoning was at a sufficient level, but it widens to a larger context when they learn mathematical concepts that are analytic in nature, such as Calculus (Differentiation, Integration, etc.). A systematic and rigorous study must be conducted in order to develop effective learning strategies and methods in helping students master the reasoning skills in Mathematics learning, especially for such analytical Mathematics topics as Differentiation.

3.0 METHODOLOGY

A pre-test was carried out for the participants, from the advanced level, followed by a number of repetition tests, before the post-test assessment was conducted. The study was held for six week and involved 31 from four secondary school in Johor taking Additional Mathematics, selected by purposive sampling. All respondents in the group had learned the concept of Differentiation traditionally prior to being exposed to SPPP.

This study design is a Learning Strategy for Differential Reasoning or *Strategi Pembelajaran Penaakulan Pembezaan* (SPPP) which is expected to support students' learning in the Differentiation topic, covering all the skills contained within it. Data analysis was conducted according to the following perspectives:

a. Collection of Differentiation Reasoning Level (DRL) Data through Reasoning Test on Differentiation (RTD), comprising Pre- and Post- tests.

b. Reasoning Level Data for each student was obtained from four components, namely, comparison, classification, inductive and deductive through Pre- and Post-tests.

The data were collected using RTD based on Marzano's Rubric for Specific Task of Situations (1992) to determine the students' level of reasoning on their achievement in Differentiation, which is a topic in Additional Mathematics subject. The RTD a two-stage nonroutine problem solving instrument that consists of four components namely, comparison, classification, inductive and deductive contained in SPPP. These skills are the important elements to generally define the students' reasoning ability in the context of Marzano's Learning Dimension. The first stage is to solve nonroutine problem for the topic of Differentiation, followed by discovering and investigating the answers that should be given using reasoning to develop an understanding of a mathematical concept. Students have to solve the problem given in the first stage, and then reason in the second stage to allow them to obtain the highest score of 4 for each item. The RTD scoring scheme consists of four items that cover all the topics of Differentiation according to the Additional Mathematics Syllabus Description outlined by the Curriculum Development Division.

4.0 DATA ANALYSIS

Descriptive statistics such as mean and standard deviation was used to describe the data distribution. Inference test analysis was also used to study the impact of SPPP developed, as shown in Table 1 to help students improve their DRL through RTD, and to improve their Reasoning Level through the four reasoning components, namely, comparison, classification, inductive and deductive.

Table 1 Study design and data analysis method

No.	Research Type	Analysis Method
1	Descriptive	Mean score and standard deviation
2	Inference	Paired Sample t-test

The findings were translated into scores and mean scores of the students' Reasoning Level, based on each of the reasoning components as described in Table 3 below:

Table 2 Score interpretation for reasoning components

Score	Reasoning Level
1	Low
2	Moderate
3	Good
4	Excellent

(Source: Adopted from Marzano, 1992) [10]

Table 3 Mean score range interpretation for reasoning components

Mean Score	Reasoning Level
1.00 – 2.00	Low
2.01 – 3.00	Moderate
3.01 – 4.00	High

(Source: Adapted from Wiersma, 2000) [11]

■5.0 FINDING

Based on the findings of the study, Paired Sample T-Test was conducted to confirm if there was a significant difference in pre- and post-SPPP intervention results. Results of the analysis in Table 4 shows that, there was a significant difference in DRL mean scores before and after learning, using SPPP ($t = -27.47$; $p < 0.05$).

Table 4 Paired sample t-test for drl before and after learning using SPPP

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
DRL	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pra ~ Post	-53.68	10.88	1.95	-57.67	-49.69	-27.47	30	.000

A measurement was subsequently made to see the impacts caused to students' achievement by the difference between pre- and post-test scores, as summarized in Table 5 below:

Table 5 DRL statistics before and after learning using SPPP

Pairs	Mean	Standard Deviation	Sig. (2-tailed)	Cohen d
Pre-Test	11.45	3.38	0.000	0.961
Post-Test	32.39	2.31		
Pre-Test ~ Post-Test				

Referring to the value of d = 0.961 (Cohen, 1988) obtained above, the difference in DRL mean scores of the students' pre-test and post-test has a significant impact on students' DRP on the Differentiation topic. This shows that, the results of the findings suggest that learning using SPPP can increase the percentage of DRL scores of the students who participated in this study.

Table 6 Increased percentage in DRL achievement test scores before and after learning using SPPP

	DRL Score Percentage		
	Pre	Post	Improved Score
	% Score	% Score	
Minimum	18.0	66.7	48.7
Maximum	48.7	87.2	38.5
Mean	29.4	83.0	53.6
Range	30.8	20.5	10.3

Table 6 shows the increased score percentage of the lowest marks, with the improved score of 48.7 per cent, to the highest, with an improved score of 38.5. Similarly, it was found that, the minimum and maximum values of DRL score percentage before learning using SPPP were 18 and 48.7, respectively, and the values increased after learning using SPPP with the minimum and maximum percentage score percentages of 66.7 and 87.2, respectively. In addition, the range of DRL score percentage dropped to 20.5 from 30.8 previously. These findings show that, the individual gap among the respondents' DRL became smaller after learning using SPPP.

In conclusion, each student showed an improved DRL mean score, evident from the minimum score percentage in Post-Test being higher than the maximum score in Pre-Test. Figure 1 shows the score percentage distribution obtained before and after learning using SPPP. Overall, it was noted that, the DRL score percentage after the SPPP intervention.

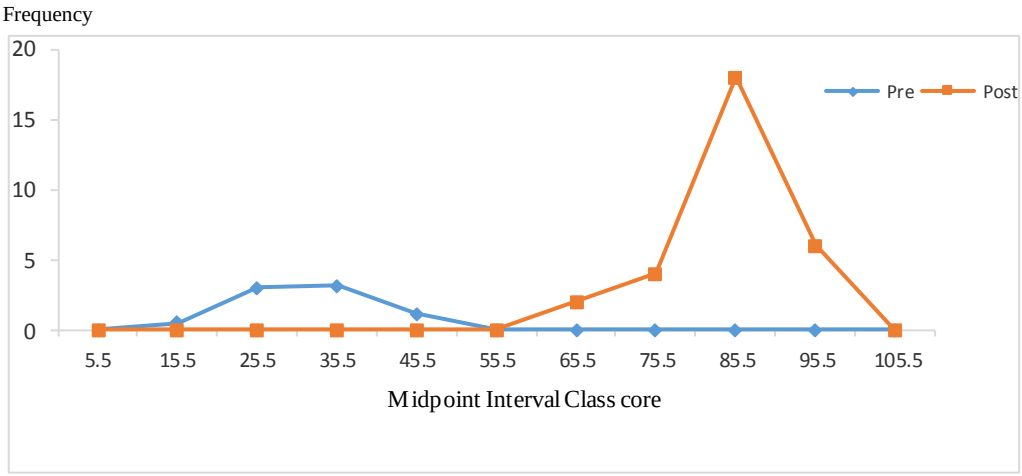

Figure 1 DRL score percentage distribution before and after learning using SPPP

Results of Mean Score Data Analysis For Each Students' Reasoning Component Before and After Learning Using SPPP Skills

Table 7 below shows a description of the number of students with score difference after learning using SPPP.

Table 7 Changes experienced by the students in the four reasoning components after using SPPP (Figures in parentheses indicate percentages)

Change categories pre- and post- test after using SPPP	**Number of Respondents**			
	Comparison	**Classification**	**Inductive**	**Deductive**
High improvement	18 (58.1 %)	12 (38.7 %)	21 (67.7 %)	12 (38.7 %)
Moderate improvement	10 (32.3 %)	18 (58.1 %)	9 (29.1 %)	19 (61.3 %)
Low improvement	3 (9.6 %)	1 (3.2 %)	1(3.2%)	0
Overall	31	31	31	31

* Note: Change categories
High improvement= spurt (3 scores)
Moderate improvement = spurt (2 scores)
Low improvement = spurt (1 score)

Table 7 shows that, there was a change of scores for each component, divided into three categories, namely, high improvement, moderate improvement and low improvement, based on the given scores of 1, 2, 3 and 4, with spurts of scores of 1, 2 and 3. This improvement was concluded by the researchers as a high improvement, with a total of 18 students for the comparison component, 12 students for the classification component, 21 students for the inductive component and 12 students for the deductive component. Similarly, the moderate improvement and the low improvement went the way same way, with a 1 score. The information obtained also served as indicators of the effectiveness of SPPP.

Figure 2 shows the mean score difference for each of the reasoning components before and after using SPPP. It shows that, learning using SPPP proved itself to successfully improve the mean scores of all the reasoning components with the highest difference being obtained from the deductive reasoning component, with mean percentage of Pre-Test score =26.2 improving to 92.5 percent in the Post-Test, a score improved percentage of 66.3. In addition, all the reasoning components also showed improvements with very good mean percentages, namely 58% (comparing), 58% (classifying), 66.3% (inductive) and 59.8% (deductive).

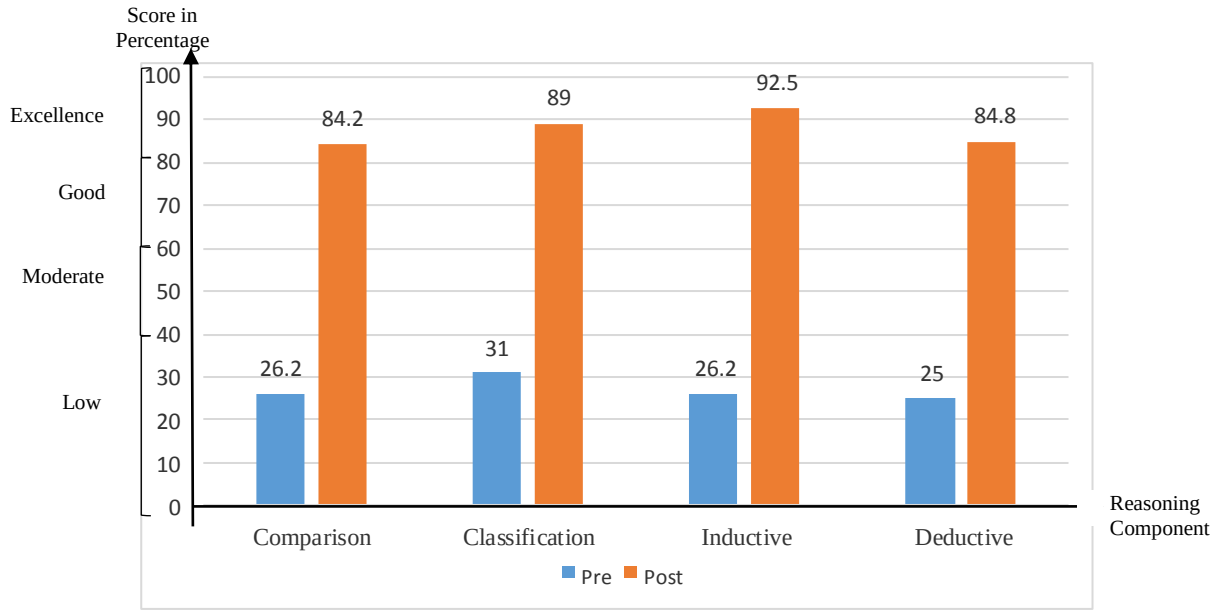

Figure 2 Differences in score mean percentage for each reasoning component in pre- and post-tests.

When compared with the score range of reasoning level for each component in Table 3, the students seemed to have a good level of reasoning on each component after learning using SPPP. Referring to Table 8, it was found that, the minimum and the maximum scores were 1 and 2, respectively, before learning using SPPP, and these scores improved to 2 and 4, respectively, for the comparison component.

Similarly with the other components, there was a slight improvement experienced by the students in the Post-Test. Overall, the level of reasoning for each component after learning using SPPP was good and excellent with average minimum scores in Pre-Test and Post-Test being 1 and 3, respectively, and average maximum scores 2 and 4, respectively.

Table 8 Improved scores of reasoning components before and after learning using SPPP

Reasoning Components		Mean	Range	Minimum	Maximum
Comparison	Pre Score	1.05	1	1	2
	Post Score	3.37	4	3	4
	Improved Score	2.32	3	2	2
Classification	Pre Score	1.24	1	1	2
	Post Score	3.56	4	3	4
	Improved Score	2.65	3	2	2
Inductive	Pre Score	1.05	1	1	2
	Post Score	3.70	4	3	4
	Improved Score	2.65	3	2	2
Deductive	Pre Score	1.00	1	1	1
	Post Score	3.39	4	3	4
	Improved Score	2.39	3	2	3

The results of t-test showed that, learning using SPPP had a significant difference in the levels of the four reasoning components. The components were, comparison [(31) = - 22.097, p <0.05, eta^2 = 0.942], classification [(31) = - 32.416, p <0.05, eta^2 = 0.972], inductive [(31) = - 38.325, p <0.05, eta^2 = 0.979] and deductive [(31) = - 26.843, p <0.05, eta^2 = 0.960]. This difference could clearly be seen from the mean scores before and after learning using SPPP. The mean of the comparison component (M = 1.05), classification component (M = 1.24), inductive component (M = 1.05) and deductive component (M = 1.00) improved to an excellent level after learning using SPPP, namely, M = 3.37 (comparison), M = 3.56 (classification), M = 3.70 (inductive) and M = 3.39 (deductive). All of the mean differences were measured at the 0.05 significance level.

Table 9 Results of paired samples t-test for reasoning components before and after learning using SPPP

Component	SPPPP	N	Min	S.P	t	Sig. (2-tailed)	Cohen d
Comparison	Pre	31	1.05	0.150	-22.097	.000	0.942
	Post	31	3.37	0.577			
Classification	Pre	31	1.24	0.285	-32.416	.000	0.972
	Post	31	3.56	0.359			
Inductive	Pre	31	1.05	0.213	-38.325	.000	0.979
	Post	31	3.70	0.303			
Deductive	Pre	31	1.00	0.000	-26.843	.000	0.960
	Post	31	3.39	0.495			

■6.0 DISCUSSION

The findings thus obtained from the study showed that, overall, the students' reasoning scores in the four reasoning components of comparison, classification, inductive and deductive were at an excellent level. Similarly, their achievement in the Differentiation topic improved by heaps and bounds. The reasoning level obtained by the researchers in this study was the same with that proposed by Yee Mei Heong (2010) [12] who realized the potentials of the four components to generate Higher Order Thinking Skills (HOTS) among students.

Based on the components of Reasoning Skills modified from Rubric for *Specific Task of Situations* developed by Marzano (1992)[10], the researchers found that, the levels of the students' reasoning in all the four components of comparison, classification, inductive and deductive were excellent after learning using SPPP. This was because, the 10 activities developed in SPPP were so meticulously arranged according to the learning objectives and systematic rating of learning levels tailored to the students' needs to improve their reasoning in terms of comparison, classification, inductive and deductive components.

Views given by experts in Mathematics education were also taken into account in establishing the SPPP, to ensure that it could help improve students' reasoning skills. In contrast, findings by Yee Mei Heong *et. al*, (2010) [12] found that, the HOTS level for students who majored in technical education in UTHM, was moderate for comparison, inductive and deductive components, and low for the classification component. These apparently less than convincing results might have been caused by such factors as reasoning skills assessed not being practised, but merely tested through the instruments provided. Whereas, in this study, the SPPP module was systematically established by ourselves, which proved capable of improving the four components of reasoning among students.

■7.0 CONCLUSION

In conclusion, the Marzano Model of Dimensional Learning [7], based on the Dimension of Expanding and Enhancing Knowledge, is a thinking skill model that indeed had improved reasoning skills among students. The model covers analysis aspects of what has been learned by implementing the process of identifying reasons that will help students to add and expand knowledge. [10] found that the four processes of reasoning were capable of improving the students' reasoning skills. This notion supports the benchmark specified by the Ministry of Education, which is to put Malaysia in the upper third of the international assessments, as measured by TIMSS and PISA, in the next 15 years [13]. This aim can be achieved through the efforts to enhance the quality of Malaysian education system. The findings also implied that the processes of teaching and learning play an important role in ensuring students' capability to emphasize on the implementation process of reasoning skills.

Obviously, mathematical reasoning skills are one of the key elements in Higher Order Thinking Skills which are given a major emphasis in the teaching of Additional Mathematics in Malaysia so that the students will be able to solve problems well, innovatively and with arguments based on evidence in decision making [13]. In addition, Learning Dimensions introduced by Marzano (1999) [10], via the third dimension, namely developing and expanding specialized knowledge on reasoning skills could also help increase the level of reasoning based on HOTS [8].

References

Switala, M. S. (2013). Enacting Reasoning-and-Proving in Secondary Mathematics Classrooms through Tasks (Doctoral dissertation), University of Pittsburgh.

Amalina Ibrahim, Nor'ain Binti Mohd. Tajudin dan Norashiqin Mohd. Idrus. (2012). Hubungan Antara Tahap Kemahiran Penaakulan Saintifik Dan Stail Pengajaran Pensyarah Dalam Kalangan Pelajar Matematik Di Universiti Pendidikan Sultan Idris. *Prosiding Kolokium Kebangsaan Pasca Siswazah Sains dan Matematik*, 8–19.

Maidinsah, H. (2004). Kesan Kaedah Pengajaran Metakognisi-Inkuiri Terhadap Prestasi Dalam Matematik Dan Penaakulan Saintifik Di Kalangan Pelajar Diploma (Doctoral dissertation), Universiti Sains Malaysia.

Yudariah M. Y., & Roselainy A. R. (1997). An Assessment of the Modular Approach in Teaching and Learning First Year Calculus at UTM. *Conference on Science and Technology Education, Kuala Lumpur*, 15– 6 December 1997.

Julaihi, N. H. B., Teknlogi, U., Eng, T. H., & Li, V. L. (2008). Lecturers'and Students'perceptions on the Teaching and Learning Of Calculus: Case Study Of UiTM Sarawak. *UiTM Sarawak Research Conference 2008*.

Mohamad Nizam, A., Noor Azean,A., Mohd Salleh, A., Abdul Halim, A., dan Mahani, M. (2016). Improving the Reasoning Skills of Students to Overcome Learning Difficulties in Additional Mathematics.(2016). *International Conference on Education and High Order Thinking Skills 2016 in conjunction with the 2nd International Seminar on Science and Mathematics Education.*

Marzano, Robert J., Debra Pickering, and Jay McTighe. (1993). Assessing Student Outcomes: Performance Assessment Using the Dimensions of Learning Model. 1250 N. Pitt St., Alexandria: Association for Supervision and Curriculum Development.

Yee, M. H., Md Yunos, J., Hassan, R., Mohamad, M. M., Othman, W., & Tee, T. K. (2013). Penilaian Kualiti Manual Pembelajaran Kendiri Pengintegrasian Gaya Pembelajaran Kolb dan Kemahiran Berfikir Aras Tinggi Marzano. *Proceeding of the International Conference on Social Science Research*.

Yee, M. H. (2015). *Kesan Manual Pengintegrasian Strategi Pembelajaran Dan Kemahiran Berfikir Aras Tinggi Terhadap Penjanaan Idea Dalam Kalangan Pelajar Teknikal* (Doctoral dissertation), Universiti Tun Hussein Onn Malaysia.

Marzano, Robert J. (1992). *A Different Kind of Classroom: Teaching with Dimensions of Learning*. 1250 North Pitt Street, Alexandria: Association for Supervision and Curriculum Development.

Wiersma, W. (2000). Research Methods In Education: An Introduction (7th Ed). Boston: Allyn & Bacon.

Yee, M. H., Jailani, M. Y., Suzanna, I., Othman, W., & Tee, T. K. (2010). Pola Kemahiran Berfikir Aras Tinggi Marzano Berdasarkan Dimensi Menggunakan Pengetahuan Bermakna. *World Congress on Teacher Education on TVET in Conjuction with World Teachers Day Celebration*, 5-6 October 2010, Universiti Tun Hussein Onn, Malaysia.

Malaysia, Ministry of Education. (2012). Malaysian Education Development Plan 2013-2025. Putrajaya: Ministry of Education Malaysia.