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The Effects of Identifying Errors Teaching Technique and SPM Performance on Higher Order Thinking Skills (HOTS)

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Abstract

Students' higher-order thinking skills (HOTS) such as analysing, evaluating and creating thinking skills were examined in this study using the Identifying Errors Teaching (IET) technique. Pre-diploma commerce students from Universiti Teknologi MARA Cawangan Melaka were divided into two groups as part of the experimental research design. To measure the HOTS elements, six sets of tests comprising of mathematics problems with incorrect solutions were used. The study found that there were statistically significant interaction effects between the control group and the previously high-performing Sijil Pelajaran Malaysia (SPM) modern mathematics group's performance in the creation and level of thinking skills. Students from the experimental group differ significantly from previously high-performing SPM modern mathematics students where the former scored higher in then creation of thinking skills compared to the control group, therefore indicating that the IET technique does influence the creation of thinking skills among previously high-performing SPM modern mathematics students. Students from the experimental group who took additional mathematics during SPM also had significantly higher level of analysing and thinking skills than their peers from the control group. It was found that creating thinking skills was the highest contributor to HOTS for MAT037 GPA compared to analysing thinking skills. These findings show that the IET approach may have improved the levels of creating and analysing thinking skills among pre-diploma commerce students.

Keywords: Identifying Errors Teaching (IET) Technique, Higher-Order Thinking Skills, Analyzing Thinking Skills, Evaluating Thinking Skills, Creating Thinking Skills.

Introduction

Higher-order thinking skills (HOTS) include the mental processes of analysis, synthesis, and assessment. Problem-solving, reasoning, thinking, assessing, and concluding are the most common activities used in HOTS (Engelhart et al., 1956). There are six levels of thinking in the earlier version of Bloom's Taxonomy (1956): knowledge, understanding, application, analysis, synthesis, and evaluation. However, (Anderson et al., n.d.) revised the previous taxonomy by changing the terminology, structure and emphasis where knowledge has been changed to remembering, comprehension has been changed to understanding, application has been changed to applying, analysis has been changed to analysing, synthesis has been changed to evaluating, and evaluation has been changed to creating in this revised version of Bloom's Taxonomy. The first three levels are known as lower-order thinking skills (LOTS) while the other three levels are known as higher-order thinking skills (HOTS). Higher-order thinking skills are an important tool for students to compete in the global job market. Chen (2016) revealed that providing students with high cognitive abilities by asking higher-order questions would encourage students to think proactively and independently, a method which may minimise the traditional learning style of rote learning. Higher-order thinking is also emphasised on in mathematical education.

For students to develop or improve their HOTS abilities, they must be trained with HOTS using several learning models such as project-based learning, cooperative learning, inquiry learning and problem-based learning. The current study focuses on a teaching strategy that uses the IET technique to improve HOTS. The HOTS levels of the students in this study were measured using identifying errors technique tests. The HOTS components that were measured were analysing, evaluating, and creating thinking skills.

Figure 1: The Identifying Errors Teaching Technique Flow

The researchers created a test instrument to evaluate the three HOTS components in students by adapting (Anderson et al., n.d.), (Edwards & Briers, 2000) and (Vijayaratnam, 2012) showed that organising, showing, and distinguishing parts are indicators of analysis skills. Indicators of evaluation skills consist of skills of assessing, concluding, contrasting, criticising, interpreting, and deciding, and indicators of creating skills include the skills of planning, designing, formulating, and proposing hypotheses. The current study is important because it is necessary to explore the levels of higher-order thinking skills among pre-diploma commerce students in terms of their mathematical abilities so that they may compete with their peers when pursuing their studies at the diploma and bachelor degree levels. (Jama et al., 2020) revealed that the identifying errors teaching (IET) approach has a positive effect on students' understanding and learning of mathematics. Zainudin et al (n.d) discovered and highlighted fifteen types of mathematical errors in basic mathematics in a study on a sample of pre-diploma commerce students conducted in September 2015. Students' mathematical thinking skills can be stimulated through the identification of mathematical errors. Consequently, using the IET technique when learning mathematics is one way to measure students' higher-order thinking skills.

Research Questions

From the research, the authors hope to answer the following two research questions.

1. What are the effects of the identifying errors teaching technique and each respondents' previous Sijil Pelajaran Malaysia (SPM) performance (Number of As scored in SPM, SPM Modern Mathematics' performance and SPM Additional Mathematics' performance) on combined HOTS elements?
2. What contributions do the analysing, evaluating, and creating thinking skills using the identifying errors teaching technique have on the prediction of mathematics' (MAT037) grade point average (GPA)?

Research Objectives

The research objectives were formulated from the two research questions posed.

1. To explore whether the identifying errors teaching technique and each respondents' previous Sijil Pelajaran Malaysia (SPM) performance (Number of As scored in SPM, SPM Modern Mathematics' performance and SPM Additional Mathematics' performance) significantly affect combined HOTS elements?
2. To investigate the contribution of analysing, evaluating and creating thinking skills done using the identifying errors teaching technique to the prediction of mathematics' (MAT037) grade point average (GPA).

Literature Review

A high level of HOTS in mathematics learning is one of the determinants of a student's success. Retnawati et al (2018) concluded in their study that the complexity of materials and problems in mathematics requires both students and teachers to have HOTS. According to the findings of the study, not all teachers grasp HOTS well, and teachers are still unable to differentiate HOTS from ability, skills, learning techniques, learning models, or learning activities. Teachers and students must be prepared and trained in HOTS so that HOTS can be attained at the optimal level in order to meet national or global challenges. Teachers must apply learning models that can increase the level of HOTS amongst students in class.

(Tanujaya et al., 2017) revealed that there is a strong and positive correlation between grade point average and students' higher-order thinking skills. Binti et al (n.d) also revealed that HOTS significantly influence students' academic achievement and their ability to solve science or mathematical problems.

(Mohamed & Lebar, 2017) conducted a literature study on previous research that focused on authentic assessment. They highlighted that various cognitive skills in a realistic situation can be measured by authentic assessments which indirectly involve performance-based tasks. Students were able to demonstrate the knowledge and skills achieved through this method of authentic assessment. According to (Mohamed & Lebar, 2017), assessment practices include forms of assessment, items used, questioning techniques, and scoring rubrics. They also suggested that the forms of assessment practiced and the items used play an important role in improving students' ability in HOTS. Furthermore, the appropriate assessment methods should be practiced to increase HOTS. A study by (Yin Peen & Yusof Arshad, 2014) highlighted that problem-based learning promotes high order questioning and stimulates students' thinking, thus playing an important role in preparing students to face real-world challenges. They further concluded that active learning, student thinking, and questioning in Malaysian science classrooms can be promoted via a problem-based learning environment provided that the students and teachers' questions should be enhanced to be at the higher order level.

(Apino & Retnawati, 2017) showed that the instructional design developed is effective in improving students' HOTS in learning mathematics. The three main components used in the instructional design developed include students' involvement in non-routine problem-solving activities; facilitation of students in developing the ability to analyse, evaluate, and create; and encouragement towards students to construct their own knowledge. Research by (Vijayaratnam, 2012) on group problem solving found the method to be effective in developing students' higher order thinking, problem solving, and team skills. Research by (Vijayaratnam, 2012) also proved that adopting real world tasks for students to work in small groups energises language classes and helps students to relate theory with practice.

In fostering higher order thinking skills, teachers must be competent in inculcating these higher order thinking skills amongst students using creative and innovative teaching techniques in the classroom. According to (Abu et al., 2017), teaching will become interesting if teachers use innovative teaching methods. When using creative and innovative teaching methods, teachers can inculcate higher order thinking skills in students. Findings by (Miri et al., 2007) suggest that if teachers purposely and persistently practise higher order thinking strategies, there is a good chance for the consequent development of critical thinking capabilities. Some examples of purposely and persistently practices of higher order thinking strategies are dealing with real-world problems in class, encouraging open-ended class discussions, and fostering inquiry-oriented experiments. Findings by (Chuensirimongkol, 2015) in their meta-analytic structural equation modeling (MASEM) helped them conclude that classroom climate and teaching and learning methods significantly affect the HOTS of students.

Methodology

Participants

The study involved 107 students among 263 pre-diploma commerce students enrolled in the Intensive Mathematics (MAT037) course during the academic term of September 2019 to January 2020.

Sampling Technique

Students in the Intensive Mathematics classes were separated into 10 groups, with only two groups using the identifying error teaching (IET) technique to study MAT037 and the other eight groups using the traditional teaching method. Using cluster sampling, the two groups of students were randomly picked from the initial ten groups. The experimental groups were designated as the two groups of students using the IET approach, whereas the control groups were two groups chosen at random. There were 50 students in the experimental groups that were exposed to the IET technique for enhancing HOTS. The other two groups (n=57) served as control and were taught in the traditional manner.

Data Collection

Data were obtained in phases. An online survey was used to collect data on respondents' SPM Modern Mathematics and Additional Mathematics' performance. HOTS instrument tests were used to obtain data for actual HOTS levels. The respondents' MAT037 performance was gathered at the end of the academic session from their final examination grade point average (GPA) MAT037 results. The degree of HOTS elements was rated from 1 to 5 using the level of HOTS derived from (Mohamed & Lebar, 2017), as shown in Table 1. The HOTS tests were based on the content of syllabus for MAT03 which consists of six tests of identifying errors in six chapters learned in MAT037. Mathematical problems with incorrect solutions were provided to the students, and they were asked to detect the errors. The HOTS elements were used to grade the students' work. After completing each chapter, students were asked to answer the HOTS test. Students' work was graded based on the chosen HOTS elements (analysing, evaluating and creating).

Table 1
Level of HOTS and Mean Score

Level of HOTS	**Mean Score**
Low	1.00 – 2.50
Moderate	2.51 – 3.75
High	3.76 – 5.00

Data Analysis
The Statistical Package for Social Sciences (SPSS) Version 26.0 was used to analyse the data. Table 2 lists the statistical tests for each research question.

Table 2
Statistical Tests for Research Questions

Research Question (RQ)	**Statistical Test**
RQ1: What are the effects of the identifying errors teaching technique and each respondents' previous Sijil Pelajaran Malaysia (SPM) performance (Number of As scored in SPM, SPM Modern Mathematics performance and SPM Additional Mathematics performance) on the combined HOTS elements?	Two-way multivariate analysis of variance (Two-way MANOVA)
RQ2: What contributions do the analysing, evaluating, and creating thinking skills using the identifying errors teaching technique have on the prediction of mathematics' (MAT037) grade point average (GPA)?	Multiple regression analysis

Results and Discussion
Demographic Characteristics
The research involved 107 students aged between 18 and 21, with the majority (94.4%) of them being 18 years old. Table 3 shows the demographics of the participants.

Table 3
Statistics of Demographic Variables

Demographic Variable	Categories of Variable	Frequency	Percent
Group	1 – Control group 2–Experimental group	57 50	53.3 46.7
Number of As scored in SPM	1 – No As 2 – At least 1 A	51 56	47.7 52.3
SPM Modern Mathematics performance	1 – Low 2 – Moderate 3 – High	53 24 30	49.5 22.4 28.0
SPM Additional Mathematics performance	1 – Did not take additional mathematics 2 – Took additional mathematics	82 25	76.6 23.4

Effects of the Identifying Errors Teaching (IET) Technique and SPM Performance on the Combined HOTS Elements

A two-way between-groups multivariate analysis of variance (two-way MANOVA) was conducted to examine the effect of number of As scored in SPM (1 – no As; 2 – at least 1 A) and group (1 – control; 2 – experimental) on the combined levels of analysing, evaluating and creating thinking skills. There were statistically significant main effects for the number of As scored ($F(3,101) = 10.265$, $p < 0.01$; Wilks' Lambda = 0.766, partial eta squared = 0.234) and group ($F(3,101) = 51.171$, $p < 0.01$; Wilks' Lambda = 0.397 ; partial eta squared = 0.603) as displayed in Table 4. Students from the experimental group who scored at least 1 A in SPM (Mean = 3.60, SD = 0.585) have significantly higher level of analysing thinking skills than their counterparts from the control group (Mean = 3.14, SD = 0.631). Students with no As in SPM (Mean = 3.07, SD = 0.523) from the experimental group also showed significantly higher analysing thinking skills than their peers from the control group (Mean = 2.82, SD = 0.433). In contrast, students from the control group showed significantly higher levels of evaluating thinking skills compared to students from the experimental group. The results also revealed that both groups showed approximately equal high creating thinking skill levels. Across the number of As scored, results showed that students who scored at least 1 A in SPM had significantly higher analysing, evaluating, and creating thinking skill levels compared to students with no As.

A two-way between-groups multivariate analysis of variance (two-way MANOVA) was also conducted to examine the effect of SPM Modern Mathematics performance (1 – low; 2 – moderate; 3 – high) and group (1 – control; 2 – experimental) on the combined levels of analysing, evaluating and creating thinking skills. There was a statistically significant interaction effect between the group and SPM Modern Mathematics performance on the combined levels of analysing, evaluating and creating thinking skills ($F(6,198) = 2.445$, $p < 0.05$; Wilks' Lambda = 0.867 ; partial eta squared = 0.070) as presented in Table 4.

Table 4
Multivariate Tests for Sijil Pelajaran Malaysia (SPM) Performance

Variable of SPM Performance	Source	Wilks' Lambda	F	Sig.	Partial Eta Squared
Group and number of As scored	Group	0.397	F(3,101) = 51.171	0.000**	0.603
	Number of As scored	0.766	F(3,101) = 10.265	0.000**	0.234
	Group*Number of As scored	0.961	F(3,101) = 1.373	0.255	0.039
Group and SPM Modern Mathematics performance	Group	0.394	F(3,99) = 50.746	0.000*	0.606
	SPM Modern Mathematics performance	0.570	F(6,198) = 10.693	0.000*	0.216
	Group* SPM Modern Mathematics performance	0.867	F(6,198) = 2.445	0.027*	0.070
Group and SPM Additional Mathematics performance	Group	0.426	F(3,101) = 45.319	0.000**	0.574
	SPM Additional Mathematics performance	0.808	F(3,101) = 8.016	0.000**	0.179
	Group* SPM Additional Mathematics performance	0.957	F(3,101) = 1.511	0.216	0.039

*Significant at 0.05 level **Significant at 0.01 level

Upon further examination of the interaction effect, it was found that there is a statistically significant interaction between the effects of group and SPM Modern Mathematics performance on creating thinking skills level. Simple main effects analysis showed that the experimental group had significantly higher creating thinking skills than the control group when the SPM Modern Mathematics performance was high ($t = -2.425$, $p < 0.05$), but there were no differences between the groups when the SPM Modern Mathematics performance was low ($t = -0.998$, $p > 0.05$) or moderate ($t = 1.826$, $p > 0.05$). Figure 2 depicts the interaction effect between groups and the SPM Modern Mathematics performance.

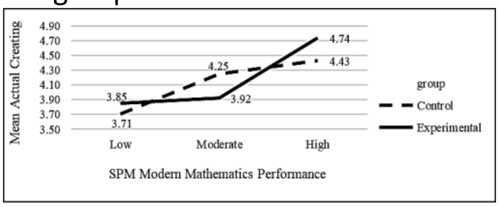

Figure 2: Interaction Effect of Group*SPM Modern Mathematics Performance

There were also statistically significant main effects for SPM Modern Mathematics performance ($F(6,198) = 10.693$, $p < 0.01$; Wilks' Lambda = 0.570, partial eta squared = 0.216) and group ($F(3,99) = 50.746$, $p < 0.01$; Wilks' Lambda = 0.394 ; partial eta squared = 0.606) as presented in Table 4. Students with low (Mean = 3.01, SD = 0.531), moderate (Mean = 3.39. SD = 0.443) and high (Mean = 3.96, SD = 0314) SPM Modern Mathematics performances from the experimental group have significantly higher levels of analysing thinking skills than their peers from the control group. Students with low (Mean = 3.85, SD = 0.488) and high (Mean = 4.74, SD = 0.370) levels from the experimental group also showed significantly higher creating thinking skill levels than their peers from the control group.

A two-way between-groups multivariate analysis of variance (two-way MANOVA) was again conducted to explore the effect of SPM Additional Mathematics performance (1 – did not take Additional Mathematics; 2 – took Additional Mathematics) and group (1 – control; 2 – experimental) on the combined levels of analysing, evaluating and creating thinking skills. There was a statistically significant main effect for SPM Additional Mathematics performance ($F(3,101) = 8.016$, $p < 0.01$; Wilks' Lambda = 0.808, partial eta squared = 0.179) and group ($F(3,101) = 45.319$, $p < 0.01$; Wilks' Lambda = 0.426 ; partial eta squared = 0.574) on the combined levels of analysing, evaluating and creating thinking skills (Table 4). Further analysis showed that students who did not take Additional Mathematics during SPM (Mean = 3.22, SD = 0.589), and who took Additional Mathematics (Mean = 3.87, SD = 0.409) from the experimental group have significantly higher levels of analysing thinking skills than their peers from the control group. Students who took Additional Mathematics (Mean = 4.72, SD = 0.418) from the experimental group also showed significantly higher creating thinking skills level than their peers from the control group (Mean = 4.35, SD = 0.428). A study by Fuzi et al (2020) supported this finding. Fuzi et al (2020) reported that the factor of students who took Additional Mathematics during SPM moderated the relationship between SPM Modern Mathematics scores and mathematical error occurrences.

These results help the researchers conclude that after intervention using the IET technique, students with low and high SPM Modern Mathematics performance from the experimental group enhanced their levels of analysing thinking skills while creating thinking skill levels were only enhanced among high-performing students. This means that the IET technique is effective among low- and high-performing SPM Modern Mathematics students in enhancing their analysing thinking skills, but it is only effective in enhancing the creating thinking skill levels among high-performing SPM Modern Mathematics students. The results also revealed that the analysing and creating thinking skill levels among students from the experimental group who took Additional Mathematics during SPM were higher than students who took Additional Mathematics from the control group. The results indicate that the IET technique is effective in enhancing the analysing and creating thinking skills of students who took Additional Mathematics during SPM. However, the IET technique was found to be ineffective in the enhancement of evaluating thinking skills among students. Also, after the intervention using the IET technique, the results concluded that students from the experimental group who scored either at least 1 A in their SPM or no As in their SPM have significantly higher levels of analysing thinking skills than their peers from the control group.

Contribution of the Analysing, Evaluating and Creating Thinking Skills to the Prediction of Mathematics (MAT037) Grade Point Average (GPA)

To answer Research Question 2, a multiple regression analysis was conducted to explore the contribution of the analysing, evaluating and creating thinking skills to the prediction of mathematics (MAT037) GPA. The dependent variable is mathematics (MAT037) GPA final performance while the predictors are the three levels of analysing, evaluating and creating thinking skills. The normal plot for the regression standardized residuals for MAT037 grade point average indicated a relatively normal distribution for both the control and experimental groups as shown in Figure 3. Thus, it can be said to not violate the normality assumption of multiple regression analysis. From the scatterplot of residuals against predicted values shown in Figure 4, there is no clear relationship found between the residuals and the predicted value, thus not violating the linearity assumption of multiple regression analysis. Outliers can be detected from the scatterplots. According to (Barbara G Tabachnick & Linda S Fidell, 2007), outliers are detected when the values of standardised residuals are more than 3.3 or less than -3.3 from the scatterplot. As evident in the scatterplot of the control group, no outliers were detected as the standardised residuals (SR) are within the range of -3.3 < SR < 3.3. However, for the experimental group, there is an outlier of -3.511 detected from the casewise diagnostic shown in Table 5.

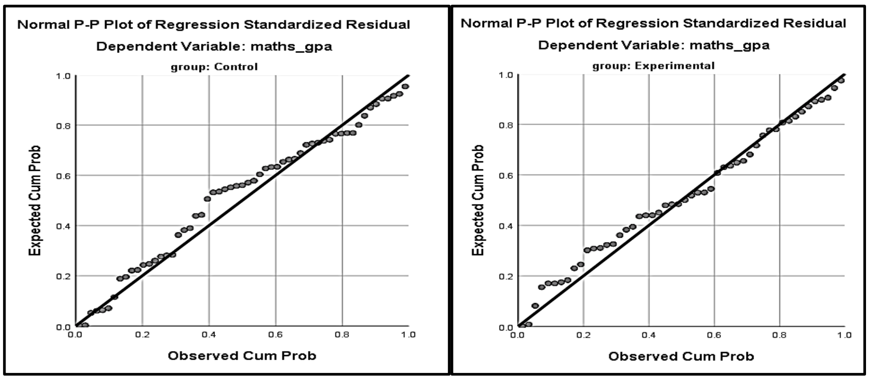

Figure 3: Normal P-P Plot of Regression Standardized Residual of MAT037 Grade Point Average for Control and Experimental Groups

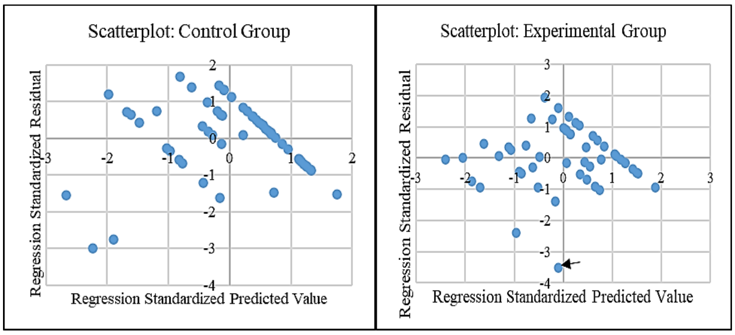

Figure 4: Scatterplot of Residuals Against Predicted Value for Control and Experimental Groups

Table 5
Casewise Diagnostics

Case Number	Std. Residual	MAT037 GPA	Predicted Value	Residual
81	-3.511	0.67	2.9642	-2.29421

In this study, the existence of an outlier does not violate the assumption of multiple regression analysis as further examination on the Cook's Distance maximum value is 0.206 (Table 6) which is not greater than 1. According to (Barbara G Tabachnick & Linda S Fidell, 2007), this outlier is not a potential problem.

The three independent variables (analysing, evaluating and creating) together explain 71.7% of the variance (R Square) for the control group and 63.6% of the variance for the experimental group in terms of mathematics (MAT037) grade point average. These values are highly statistically significant $F(3,53) = 44.712$; $p < 0.01$ and $F(3,46) = 26.849$; $p < 0.01$ respectively as presented in Tables 7 and 8.

Table 6
Residuals Statistics for Experimental Group

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.0331	4.6221	3.0470	0.83767	50
Std. Predicted Value	-2.404	1.880	0.000	1.000	50
Standard Error of Predicted Value	0.095	0.339	0.177	0.055	50
Adjusted Predicted Value	1.0386	4.8248	3.0481	0.84608	50
Residual	-2.29421	1.26804	0.00000	0.63303	50
Std. Residual	-3.511	1.941	0.000	0.969	50
Stud. Residual	-3.620	1.978	-0.001	1.005	50
Deleted Residual	-2.43829	1.31689	-0.00105	.68138	50
Stud. Deleted Residual	-4.234	2.045	-0.014	1.064	50
Mahal. Distance	0.058	12.243	2.940	2.657	50
Cook's Distance	0.000	0.206	0.019	0.036	50
Centered Leverage Value	0.001	0.250	0.060	0.054	50

Table 7
Model Summary for Control and Experimental Groups

Model	**Control Group**				**Experimental Group**			
	R	R Square	Adjusted R Square	Std. Error of the Estimate	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.847	0.717	0.701	0.437	0.798	0.636	0.613	0.653

Table 8
Analysis of Variance for Control and Experimental Groups

Control Group							Experimental Group				
Model		Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25.613	3	8.538	44.712	0.000**	34.383	3	11.461	26.849	0.000**
	Residual	10.120	53	0.191			19.636	46	0.427		
	Total	35.734	56				54.019	49			

**Significant at 0.01 level

Table 9 shows that the multicollinearity assumption is not violated for both the control and experimental groups. The proofs are shown by the values of tolerance that are greater than 0.1 and the variance inflation factor (VIF) of less than 10 (Pallant, 2011) as summarized in Table 9. Examining the t-values in Table 9, the results indicate that for the control group, only creating thinking skills ($t = 6.905$; $p < 0.01$) contribute to the prediction of MAT037 grade point average (GPA). On the other hand, for the experimental group, analysing ($t = 2.889$; $p < 0.01$) and creating ($t = 3.219$; $p < 0.01$) thinking skills levels contribute to the prediction of MAT037 grade point average. Further examination on beta standardized coefficients show that creating thinking skills (Beta = 0.435; $t = 3.219$; $p < 0.01$) was the most contributing thinking skills to MAT037 GPA compared to the analysing thinking skills level (Beta = 0.410; $t = 2.889$; $p < 0.01$). The current study is coherent to the study conducted by (Retnawati et al., 2018) which found a linear, positive and strong relationship between HOTS (the critical thinking skill and creative thinking skill) and the mathematics GPA of students. These results help conclude that the IET technique is effective in developing and enhancing analysing and creating thinking skill levels among pre-diploma commerce students.

Table 9
Contribution of Analysing, Evaluating and Creating Thinking Skills to the Prediction of Mathematics (MAT037) Grade Point Average (GPA) for the Control and Experimental Groups

Control Group								
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-1.583	0.445		-3.553	0.001**		
	Analyzing	0.027	0.164	0.019	0.166	0.869	0.415	2.411
	Evaluating	0.014	0.095	0.014	0.146	0.884	0.594	1.684
	Creating	1.229	0.178	0.824	6.905	0.000**	0.376	2.662
Experimental Group								
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance (> 0.1)	VIF (< 10)
1	(Constant)	-2.418	0.637		-3.798	0.000**		
	Analyzing	0.700	0.242	0.410	2.889	0.006**	0.392	2.550
	Evaluating	0.026	0.178	0.015	0.147	0.884	0.781	1.280
	Creating	0.733	0.228	0.435	3.219	0.002**	0.433	2.310

**Significant at 0.01 level

Conclusion
From the findings, it can be concluded that there is a significant interaction between the effects of group and SPM Modern Mathematics performance on students' creating thinking skill levels. After intervention using the IET technique, students who previously had low and high SPM Modern Mathematics performance from the experimental group enhanced their levels of analysing thinking skills, while creating thinking skill levels were only enhanced among previously high-performing students. Students who scored at least one A in SPM from the experimental group had higher levels of analysing thinking skills and equally higher levels of creating thinking skills than their peers from the control group. The results also revealed that the analysing and creating thinking skill levels among students from the experimental group who took Additional Mathematics during SPM are higher than students from the control group. These results help the researchers conclude that the IET technique can influence previously low- and high-performers in SPM Modern Mathematics in enhancing their analysing thinking skills, but it only enhances the creating thinking skills of high-performing SPM Modern Mathematics students. The IET technique also enhanced the analysing and creating thinking skills of students who previously took Additional Mathematics during SPM. It was found that after intervention using the IET technique, the students' analysing and creating thinking skills have influenced their mathematics (MAT037) final grade point average (GPA), where the creating thinking skills was the biggest contributing factor to the students MAT037 final GPA. According to our findings, there is a good chance that pre-diploma commerce students' analysing and creating thinking skills in mathematics will be improved if instructors practise teaching strategies utilising the IET technique. Future

research could benefit from a larger sample size and from adopting the IET technique in other mathematics courses, specifically calculus and algebra courses at the diploma and undergraduate levels. Additionally, future studies could be beneficial by improving the test instrument of the IET technique for assessing higher-order thinking skills, especially analysing, evaluating, and creating thinking skills among students in calculus and algebra classes.

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