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The Effects of an Inductive Reasoning Learning Strategy Assisted by the GeoGebra Software on Students' Motivation for the Functional Graph II Topic

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ABSTRACT Motivation is an aspect heavily emphasized in a mathematics class to produce a quality human capital. However, students' motivation towards mathematics is still low while students' performance in mathematics is declining. The students' lack of motivation toward mathematics could be attributed to ineffective learning strategies in mathematics classrooms. In addition, many previous studies have only focused on an inductive reasoning strategy and the separate use of GeoGebra. Therefore, this study aims to identify the effects of learning through an inductive reasoning strategy assisted by GeoGebra on students' motivation for the Functional Graph II topic. The research design was quasi-experimental which involved 94 Form 4 students from a secondary school in Johor. The research sample was divided into three groups: (1) Study Group 1 (an inductive reasoning strategy assisted by GeoGebra); (2) Study Group 2 (an inductive reasoning strategy without GeoGebra); and (3) Control Group (a conventional strategy). The research instruments consisted of a motivational questionnaire set and an inductive reasoning strategy assisted by GeoGebra and without GeoGebra. The inductive reasoning strategy was guided by the Marzano's Inductive Reasoning Model consisting of an observation process on specific examples and patterns that determined if a generalization was true. The MANOVA test results show that the overall motivation level for Study Group 1 is high in terms of attention and relevance. With regard to confidence, the results indicate that Control Group and Study Group 1 show the same motivation level. As for satisfaction, the motivation level for Control Group is the highest compared to other groups. In conclusion, learning through an inductive reasoning strategy assisted by GeoGebra can increase the students' motivation in mathematics specifically for the Functional Graph II topic.

INDEX TERMS Inductive reasoning strategy, GeoGebra, students' motivation.

I. INTRODUCTION

The [1] reveals that the students' interest in mathematics was still less satisfying even though the Primary School Integrated Curriculum (KBSR) and the Secondary School Integrated Curriculum (KBSM) had been implemented long before the new Primary School Standard Curriculum (KSSR) and the Secondary School Standard Curriculum (KSSM) were implemented in the country's education system. Reference [2] states that mathematics goes beyond the mastery of basic concepts and skills; it also involves thinking skills, problem-solving strategies, communication in mathematics,

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and mathematics appreciation. A quality human capital can be achieved by practicing suitable learning styles to motivate students and improve their achievements [3], [4]. As students differ in terms of their motivation level, various factors need to be considered so that students are able to focus consistently on a given activity [5].

Motivation is the driving force to achieve something or to be successful [6]. It is also the force that leads and controls someone when executing a task [7]. In the education context, motivation plays an important role because it serves as a catalyst that directs students toward learning goals with excellence [8]. It is generally known that students with high motivation are potentially more prone to achieve success than those with low motivation [5]. Reference [9] claims that highly motivated students show better academic achievements as compared to less motivated students. Reference [10] further asserts that, when highly motivated students decide to be involved in a learning activity, they are ready to dedicate their time and strive to achieve their goals. Therefore, motivation is one of the important factors in education that can affect students' performance in mathematics. In Malaysia, it has been found that teachers pay less attention to students' motivation during the learning process; they put more emphasis instead on academic achievements and acceptable grades [11]. Thus, it is critical for teachers to motivate their students and help them practice a suitable learning style in order to attain academic success.

A. STUDENTS' MOTIVATION IN MATHEMATICS

Motivation has been one of the widely discussed topics in the field of education psychology for the past few decades (e.g., [12]). Students' motivation has been highly emphasized because the students' achievement can be improved if they are motivated in a learning process [13]. In mathematics education, students' low motivation has been associated with the alarming decline in mathematics achievements. In the ARCS motivation model [14] used in the current study, four main aspects of motivation are emphasized, i.e., attention (A), relevance (R), confidence (C), and satisfaction (S). First, with regard to the attention aspect (A), students' interest and curiosity toward the subject are taken into account [15]. Some factors such as the implementation of monotonous learning strategies in mathematics classrooms may affect students' attention, particularly among those with a low motivation level [16].

Second, some students are less motivated in learning mathematics because they do not fulfill the relevance aspect (R). That is, they are unable to understand the importance and the use of mathematics in real life [12]. Research has shown that students are less motivated toward mathematics because they are unable to associate the use of mathematics in their life [17]. Therefore, it is important for teachers to place more emphasis on the importance of mathematics so that their students become more motivated and are more curious in mathematics. Third, it has been found that students are less motivated in mathematics because they lack the confidence aspect (C) when solving certain problems. Some students have a negative perception on mathematics, assuming that mathematics is too abstract and difficult to master. This negative perception makes students less motivated and less confident to study mathematics [18]. Finally, students do not fulfill the satisfaction aspect (S) especially when they do not enjoy attending mathematics classes and start to avoid doing mathematics homework. All of these scenarios show that the students' motivation in mathematics is low. An immediate action, especially in the learning strategy aspect, must be taken in order to increase the students' motivation level so that they become more enthusiastic to solve mathematical problems.

B. LEARNING THROUGH AN INDUCTIVE REASONING STRATEGY

The main focus of the Ministry of Education Malaysia (KPM) is to create a balanced human capital with critical, creative and innovative thinking abilities that are able to address current and future challenges [19]. Thus, it is important for educators to plan and choose a suitable learning strategy that allows students to follow the lessons more effectively. One of the learning strategies that can be applied to improve students' motivation is the inductive reasoning strategy. Inductive reasoning is one the reasoning processes that requires students to be involved in collecting information, interpreting and generalizing activities [20]–[22]. Reference [23] suggests that, through inductive reasoning, students are able to generalize and draw conclusions based on observations and analyses on specific examples. Therefore, it is necessary for students to draw conclusions based on as many observations as possible [24]. Through this method, students are able to reason inductively although the exact conclusion could not be determined. However, the conclusion made is more authentic, especially when it can be supported by specific examples [24]. With the inductive reasoning strategy, students are encouraged to find more information and make more observations in order to support their conclusions. By increasing the students' ability to establish relationships through observations and examples, students are able to expand and improve their knowledge.

This learning strategy can enhance students' comprehension in a given topic. Besides, inductive reasoning also encourages students to be fully involved in making observations and inspections before reaching a conclusion [25]. Although there are many benefits of the inductive reasoning strategy, it is rarely applied in mathematics classes. In many cases, students learn mathematics in a conventional way in which students depend on memorizing and practicing algorithm concepts with much less emphasis on critical thinking skills especially reasoning [26]. When students are not exposed to the inductive reasoning strategy, they are not given opportunities to build understanding, to stimulate cognitive skills, and to conduct their own exploration [27]. Therefore, to overcome this problem, teachers must diversify their teaching strategies so that the objective of the Malaysia Education Blueprint (PPPM 2013-2025) can be realized.

Learning mathematics in the 21st century requires technology-based education and dynamic geometry software such as GeoGebra. The learning strategy assisted by technology can help students to grasp lessons without fully depending on teachers. Through GeoGebra, students can learn actively, independently and flexibly through exploration, problem solving and reasoning [28]. Additionally, GeoGebra can make a mathematics concept more interesting and easier to understand because it provides colorful texts and graphics. GeoGebra is an innovative open source mathematics software that can be downloaded for free at any time at the designated website [29]. It offers learning tools with geometry and algebra characteristics [29]. It is suitable to be used in learning mathematics at secondary schools, colleges and other higher education institutions [30]. Learning mathematics via GeoGebra can improve students' understanding because it has many functions in the visualization process that gives an opportunity for students to make observations and present findings [30]–[32].

However, many previous studies focusing on learning mathematics only employed GeoGebra without clear learning strategies, such as [33]–[36]. These studies only used GeoGebra as a tool in learning mathematics without applying effective learning strategies that might increase students' motivation. In addition, there were studies on the implementation of an inductive reasoning strategy in mathematics classes without the assistance of any teaching aids [23], [37]. GeoGebra can be integrated in an inductive reasoning learning strategy in various areas of mathematics such as geometry and algebra [38], [39]. In Malaysia some students are less motivated in learning mathematics, which can be potentially due to a conventional learning style [40], [41]. For example, some students struggle to grasp the Functional Graph II topic using a conventional learning strategy. They are unable to apply the graph concept into a new situation and also are weak at making a connection between manipulative and responding variables [42]. They are also unable to visualize and draw the graph shape [43]. Also, the students' comprehension on the parameter effect against the functional graph is also poor; they mainly depend on a formula without knowing its true meaning in solving problems [44]. This situation makes the students weak at analyzing and giving justification for the analysis made. In the end, the students are less motivated to learn this topic.

Thus, an inductive reasoning learning strategy assisted by GeoGebra is needed to help overcome the problems mentioned above. Through this strategy, learning is centered on the students and is more fun. With GeoGebra, students can understand a concept more deeply and increase their understanding. GeoGebra provides a fun learning environment and has helpful functions in the visualization process that provides opportunities for students to make observations and present findings. It is hoped that the results of this study will be able to improve students' motivation and encourage them to learn mathematics through an inductive reasoning strategy and the use of GeoGebra.

As such, this research was conducted to answer the following research question: What is the students' motivation through an inductive reasoning learning strategy assisted by GeoGebra from the aspects of

i. overall motivation?
ii. attention?
iii. relevance?
iv. confidence?
v. satisfaction?

II. RESEARCH METHODOLOGY

A. RESEARCH DESIGN

In the present study, we aimed to examine the effects of an inductive reasoning strategy assisted by GeoGebra (the independent variable) on students' motivation (the dependent variable). The quasi-experimental design with post-tests was employed. This design is appropriate for the purpose of testing the effectiveness of a program when the groups studied cannot be distributed randomly. In this study, three groups of students were divided according to the school's class system: (1) Study Group 1 (an inductive reasoning strategy with GeoGebra); (2) Study Group 2 (an inductive reasoning strategy without GeoGebra); and (3) Control Group (conventional learning). Study Groups 1 and 2 were compared against each other in order to examine whether an inductive reasoning strategy with or without GeoGebra would yield positive effects on students' motivation. Control Group served as a benchmark so that the differences between the two study groups could be clearly seen. Table 1 shows the research design.

TABLE 1. Quasi-experimental pre-post test design for unbalanced groups.

Group	Research	Instrument
Study Group 1	X1	O1
Study Group 2	X2	O1
Control Group	X3	O1

X1 = An inductive reasoning strategy with GeoGebra, X2 = An inductive reasoning strategy without GeoGebra, X3 = Conventional learning, O1 = Motivation questionnaire

The lessons were conducted following the assigned strategy. For Study Groups 1 and 2, the students learned mathematics by using a worksheet that exposed them to an inductive reasoning strategy. For Control Group, the students learned mathematics conventionally by using a textbook as the main reference. After the lessons, all of the students were required to answer motivation questionnaires in order to examine their motivation level after following the lessons.

B. SAMPLING

The study was conducted in a school in Pasir Gudang, Johor, Malaysia. The school was chosen because of the large number

TABLE 2. Lesson results for every worksheet.

Worksheet	Lesson Results	Question Type
1	i. Drawing a graph for functions: • Linear $y = ax + b$ when a, b are constant. • Quadratic $y = ax^2 + bx + c$ when a, b and c are constant and $a \neq 0$. • Cubic $y = ax^3 + bx^2 + cx + d$ when a, b, c and d are constant and $a \neq 0$. • $y = \frac{a}{x}$ when a is constant and $a \neq 0$.	i. Stating graph characteristics based on observations on some examples. ii. Finding differences between graph characteristics
2	i. Identifying: • A graph shape when the function is given. • A function type when the graph is given.	i. Finding a graph shape difference when the constant value $a > 0$ and $a < 0$. ii. Generalizing factors that affect graph shape based on similarities and graph shape differences.
3	i. Drawing a linear graph from a given function. ii. Identifying the constant effects, a and b for $y = ax + b$ on the graph.	Finding the correlation between a and b constant effect on linear graph shape and position.
4	i. Drawing a quadratic graph from the given function. ii. Identifying a and c for $y = ax^2 + c$ constant effect on a graph.	Finding the correlation between a and c constant effect on quadratic graph shape and position.
5	i. Drawing a quadratic graph from the given function. ii. Identifying the constant effect b for $y = ax^2 + bx + c$ on the graph.	Finding the correlation between constant effect b on the width of quadratic graph opening.
6	i. Drawing a cubic graph from the given function. ii. Identifying the constant effect, a and d for $y = ax^3 + d$ on the graph.	Finding the correlation between constant effect a and d on cubic graph shape and position.
7	i. Drawing a reciprocal graph from the given function. ii. Identifying the constant effect, a for $y = \frac{a}{x}$ on the graph.	Finding the correlation between constant effect a on reciprocal graph shape and position.

of student population with a varying degree of achievements in mathematics. The school was also chosen because of an appropriate computer facility and a good internet connection that made learning activities smooth. The research sample consisted of 94 Form 4 students who were going to learn the Functional Graph II topic. Three Form 4 classes were chosen as samples for this study. Prior to the experiment, all of the research samples involved had acquired basic mathematical concepts. Based on their examination results, the samples shared a similar level of mathematics proficiency. Two classes were chosen as Study Groups 1 and 2 that consisted of 32 and 31 students, respectively. 31 students from another class were chosen as Control Group. It is sufficient for an experiment to use samples at around 30 people for each group because it would make it easier for researchers to control the experiment.

C. INSTRUMENTATION

The instruments used in this research were worksheets and questionnaires. The worksheets consisted of six sets that incorporated the inductive reasoning strategy with and without GeoGebra. Control Group followed the conventional lesson by using an existing Form 4 mathematics textbook. Study Group 1 (with GeoGebra) and Study Group 2 (without GeoGebra) used the worksheets following the inductive reasoning strategy for the Functional Graph II topic. The worksheets were used to expose the students to an inductive reasoning strategy and were developed according to the inductive reasoning methods suggested by [24]. Given the focus on the understanding of the graph concept, we developed 7 sets of worksheets that focused on the graph concept and the constant effect or parameter on 4 types of functional graphs, namely linear, quadratic, cubic and reciprocal graphs (see Table 2). We chose to teach these topics because, according to [45], students must first be exposed to concept making and making correlations between concepts in order to obtain a wider overview. Thus, the inductive reasoning question types prepared in the worksheets consisted of making generalizations based on the similarities or differences of graph characteristics and identifying the correlation between functional graph and constant.

The worksheets for Study Groups 1 and 2 were developed based on four inductive reasoning strategies by [24]. Therefore, we divided the worksheets to four main sections, i.e., introduction, activity, inductive reasoning and exercise. In the introduction section, the students were exposed to the objectives of the lessons. The students were also exposed to some graphics or information used as an induction set so that they were ready to receive the new lessons. Next, in the activity section, the students were exposed to some specific examples. This section required students to build or draw a graph for those functions by using the GeoGebra application or a graph paper. The content of the worksheet for Study Groups 1 and 2 was similar; the only difference was the aiding materials used by the students when building or drawing a graph. For Study Group 1, the students were required to conduct the activity with GeoGebra, while for Study Group 2, the students used a graph paper. Through the graphs built, the students made the observation and looked for patterns or correlations between those examples. Then, the students were exposed to the inductive reasoning section in which they answered some questions related to the given examples. The questions were asked in order to encourage the students to draw general conclusions based on their observations on specific examples [46]. Finally, the students were exposed to the exercise section that helped them check whether the conclusions were true or otherwise. If the conclusions were true, they could proceed to the next worksheet. If the conclusions were false, they were asked to reobserve and reconclude.

The questionnaire consisted of items that evaluated the students' motivation after following the lessons. Based on the ARCS motivation model, the questionnaire consisted of two sections: Section A and Section B. Section A contained the students' demographic information, i.e., gender, race and class. Section B consisted of 36 items related to motivation based on the ARCS motivation model, namely *Attention*, *Relevance*, *Confidence* dan *Satisfaction*. The items were modified in order to suit the *Instructional Materials Motivation Survey* (IMMS) built by [47]. We obtained permission from Prof Emeritus John M. Keller to use the questionnaire in the current study. The questionnaire was divided into four elements, as shown in Table 3.

TABLE 3. Questionnaire items.

Motivation Aspects	Items	Total	Cronbach alpha
Attention	2, 8, 11, 12, 15, 17, 20, 22, 24, 28, 29, 31	12	0.87
Relevance	6, 9, 10, 16, 18, 23, 26, 30, 33	9	0.91
Confidence	1, 3, 4, 7, 13, 19, 25, 34, 35	9	0.89
Satisfaction	5, 14, 21, 27, 32, 36	6	0.88

The students answered the motivation items in the questionnaire by using the likert scale. The likert scale was chosen because it is easy to administer, suitable to be applied in many situations and has high credibility compared to other scales [48], [49]. In the current study, we used a four-point likert scale, as shown in Table 4.

TABLE 4. Likert scale classification.

Score	Statement
1	Strongly Disagree (SD)
2	Disagree (D)
3	Agree (A)
4	Strongly Agree (SA)

After modifying the questionnaire items, the instrument was reviewed by three specialists: (1) a mathematics lecturer in the UTM Education Faculty; (2) a school counsellor; and (3) an excellent mathematics teacher. The questionnaire was improved through reviews and comments from the specialists [50]. To ensure the reliability of the modified questionnaire from the *Instructional Materials Motivation Survey* (IMMS), we ran the inner consistency method. The Cronbach alpha coefficient value for the questionnaire was 0.89. Hence, the questionnaire items were proven to be reliable and satisfactory.

TABLE 5. Students' motivation level for study Group 1.

Motivation Level	Study Group 1			
	Min	Standard Deviation	Minimum	Maximum
Overall	2.00	0.46	0.85	2.72
Attention	0.89	0.09	0.57	0.97
Relevance	0.62	0.17	0.18	0.86
Confidence	0.44	0.17	0.09	0.73
Satisfaction	0.06	0.41	0.01	0.16

III. DATA ANALYSIS

In the present study, we used ordinal data for the questionnaire. However, we changed the ordinal data obtained from the questionnaire to interval data using the Winsteps Version 3.72.3 software. According to [51], the Winsteps software can be used to generate ordinal scale conversion algorithm to interval that allows researchers to use parametric statistics. Furthermore, [48] asserts that the data obtained from the interval scale is more precise than the data obtained using the ordinal scale. Thus, ordinal data was changed to interval data so that the data could be analyzed more precisely. The current study applied the inference analysis using the *Multivariate Analysis of Variance Test* (MANOVA) via the *Statistical Package for Social Science* (SPSS) software version 16.0.

A. STUDENTS' MOTIVATION VARIABLE ANALYSIS

This section presents the descriptive results of the students' motivation based on the answers to the questionnaire given to the students after the lessons were conducted. It discusses the overall students' motivation level and for all ARCS aspects which are *Attention*, *Relevance*, *Confidence* dan *Satisfaction*. This section also provides descriptive results according to each group after the intervention was conducted.

B. MOTIVATION DESCRIPTIVE ANALYSIS FOR STUDY GROUP 1

This section presents the descriptive results of the students' motivation based on the answers to the questionnaire given to the students after the lessons were conducted. It discusses the overall students' motivation level and for all ARCS aspects which are *Attention*, *Relevance*, *Confidence* dan *Satisfaction*. This section also provides descriptive results according to each group after the intervention was conducted.

C. MOTIVATION DESCRIPTIVE ANALYSIS FOR STUDY GROUP 2

Table 6 shows the descriptive analysis for the students' motivation level following the inductive reasoning strategy without GeoGebra. The results show that the overall motivation min score for this group is low compared to Study Group 1 (min = 2.00), which is 1.62 with the standard deviation of 0.43. For the attention aspect, the min score is 0.81 with the standard deviation of 0.10. The min scores for the relevance, confidence and satisfaction aspects are 0.45, 0.33 and 0.03, respectively, with the standard deviations of 0.16, 0.15 and 0.27, respectively.

TABLE 6. Students' motivation level for study Group 2.

Motivation Level	Study Group 1			
	Min	Standard Deviation	Minimum	Maximum
Overall	1.62	0.43	0.87	2.61
Attention	0.81	0.10	0.57	0.96
Relevance	0.45	0.16	0.18	0.81
Confidence	0.33	0.15	0.11	0.71
Satisfaction	0.03	0.27	0.01	0.13

D. MOTIVATION DESCRIPTIVE ANALYSIS FOR STUDY GROUP 2

Table 7 shows the descriptive analysis for the students' motivation level following the conventional lesson. The results show that the overall motivation min score for this group is 1.75, which is lower than Study Group 1 (min = 2.00) but higher than Study Group 2 (min = 1.62) with the standard deviation of 0.43. For the attention aspect, the min score is 0.67 with the standard deviation of 0.15. The min scores for the relevance, confidence and satisfaction aspects are 0.50, 0.44 and 0.26, respectively, with the standard deviations of 0.15, 0.10 and 0.65, respectively.

TABLE 7. Students' motivation level for control group.

Motivation Level	Study Group 1			
	Min	Standard Deviation	Minimum	Maximum
Overall	1.75	0.28	1.02	2.09
Attention	0.67	0.15	0.35	0.92
Relevance	0.50	0.15	0.21	0.69
Confidence	0.44	0.10	0.11	0.64
Satisfaction	0.26	0.65	0.15	0.45

E. NORMALITY AND HOMOGENITY TEST

Before the inference analysis on data is conducted, a normality test has to be determined first. This is because the data collected from samples have to be of a normal distribution. This is one of the basic rules for inference statistics like MANOVA. The normality tests on the motivation questionnaire are −0.46 and −0.53. According to [52], the data is normally distributed if the Skewness and Kurtosis value is between −1.96 and +1.96. This shows that the motivation questionnaire data is normally distributed. Table 8 below shows the Skewness and Kurtosis value for the data of the current study.

TABLE 8. Normality test on the questionnaire.

Instrument	Skewness	Kurtosis
Motivation questionnaire	-0.46	-0.53

TABLE 9. Motivation descriptive statistics.

Aspects	Groups	Min	Standard deviation	N
ARCS	Study Group 1	2.0081	.45581	32
	Study Group 2	1.6213	.42923	31
	Control Group	1.7558	.27810	31
	Total	1.7973	.42406	94
Attention	Study Group 1	.8928	.08978	32
	Study Group 2	.8071	.09890	31
	Control Group	.5423	.14456	31
	Total	.7489	.18728	94
Relevance	Study Group 1	.6163	.16980	32
	Study Group 2	.4510	.16156	31
	Control Group	.5048	.15086	31
	Total	.5250	.17378	94
Confidence	Study Group 1	.4350	.16756	32
	Study Group 2	.3306	.14808	31
	Control Group	.4439	.10458	31
	Total	.4035	.15038	94
Satisfaction	Study Group 1	.0641	.04118	32
	Study Group 2	.0326	.02658	31
	Control Group	.2648	.06506	31
	Total	.1199	.11303	94

The Levene test was also conducted on the motivation data to determine its homogenity (*homogenity of variance*). The results show that the Levene test is not significant which is $p = 0.43$ for the motivation data. According to [53], if the significant value is $p > 0.05$, the data is homogen. This shows that the motivation data is homogen and fulfills the condition to conduct the MANOVA test.

F. MOTIVATION LEVEL DIFFERENCES BETWEEN GROUPS

To determine whether there are significant differences for the four motivation aspects between Study Group 1, Study Group 2 and Control Group, the MANOVA analysis was employed. The *Pillai's Trace* value was used as a reference. Then, the analysis was run separately (*Test of Between-Subjects Effect*) for each of the four motivation aspects, i.e., attention, relevance, confidence and satisfaction. To obtain a more accurate result, we used the Bonferroni alpha value (0.05/4) = 0.0125. The Bonferroni alpha value was obtained from the original significant value and divided with the number of dependent variables used in the current study. The use of the Bonferroni alpha value will control the *Type 1 Error* problem that often occurs in research [54], [55]. Table 9 shows the MANOVA results of the motivation aspects for all three groups.

Table 9 shows that the overall ARCS motivation min value is the highest for Study Group 1 (overall min: Study

TABLE 10. Multivariate test for motivation.

	Effects	Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.980	1102.584b	4.000	88.000	.000
	Wilks' Lambda	.020	1102.584b	4.000	88.000	.000
	Hotelling's Trace	50.117	1102.584b	4.000	88.000	.000
	Roy's Largest Root	50.117	1102.584b	4.000	88.000	.000
Group	Pillai's Trace	1.096	26.975	8.000	178.000	.000
	Wilks' Lambda	.073	59.664b	8.000	176.000	.000
	Hotelling's Trace	10.456	113.712	8.000	174.000	.000
	Roy's Largest Root	10.229	227.601c	4.000	89.000	.000

a. Design intercept + group, b. Exact statistic, c. the statistic is an upper bound on F that yields a lower bound on the significance level

Group 1 = 2.01, Study Group 2 = 1.62, Control Group = 1.76). Similarly, for the attention and relevance aspects, Study Group 1 also exhibits the highest min value compared to other groups (attention min: Study Group 1 = 0.89, Study Group 2 = 0.81, Control Group = 0.54; relevance min: Study Group 1 = 0.62, Control Group = 0.50, Study Group 2 = 0.45). As for the satisfaction aspect, Control Group shows the highest min value (satisfaction min: Control Group = 0.26, Study Group 1 = 0.06, Study Group 2 = 0.03). However, the min value for the confidence aspect for Study Group 1 and Control Group is similar (confidence min: Study Group 1 = 0.44, Control Group = 0.44, Study Group 2 = 0.33).

Table 11 below shows that there are main effects of independent variables [F(8,178) = 26.98, $p < 0.05$] on all four dependent variables as a whole.

TABLE 11. Levene's test of equality of error variances for motivation.

Aspects	F	df1	df2	Sig.
Attention	5.894	2	91	.004
Relevance	.005	2	91	.995
Confidence	4.714	2	91	.011
Satisfaction	5.606	2	91	.005

Tests the null hypothesis that the error variance of the dependent variable is equal across groups. a. Design: Intercept + Group

The *Levene's Test of Equality of Error Variances* in Table 11 tests if variances for dependent variables across every category in independent variables are the same. The results show that three dependent variables (attention, confidence and satisfaction) have significant results at $p < 0.05$ (this variance equivalence test is needed in the *Stepdown* procedure that analyzes all four dependent variables separately). For the relevance dependent variable, it shows a non-significant result because the value obtained is $p > 0.05$. Since the MANOVA test uses the *Enter* analysis procedure (analyzing all four dependent variables together), this analysis can continue.

Overall, there are group's main effects on all four dependent variables. The analysis on the dependent variable separately also found that all four ARCS motivation aspects have significant differences based on the Bonferroni alpha level (0.05/4 = 0.0125). The MANOVA results in Table 12 show that there are group's significant main effects on all four dependent variables. That is, group is the factor to all four ARCS motivation aspects which are attention [F(2,91) = 81.32, $p < 0.0125$], relevance [F(2,91) = 8.66, $p < 0.0125$], confidence [F(2,91) = 6.05, $p < 0.0125$] and satisfaction [F(2,91) = 223.80, $p < 0.0125$]. In other words, group is the factor to the attention, relevance, confidence and satisfaction aspects based on the Bonferroni alpha level. The R^2 values show that group contributes 0.64 or 64% changes in the attention dependent variable, 0.16 or 16% changes in the relevance variable, 0.12 or 12% changes in the confidence dependent variable, and 0.83 or 83% changes in the satisfaction dependent variable.

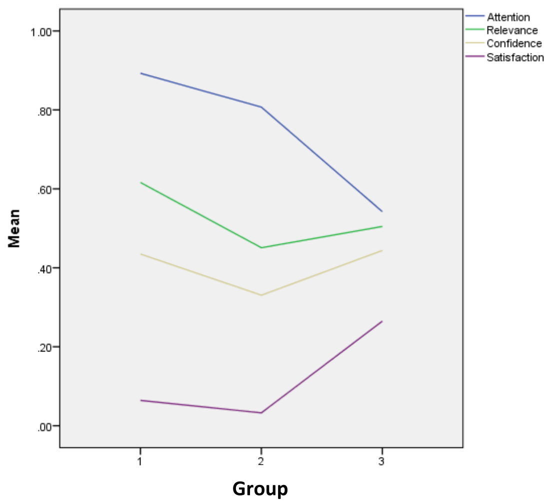

FIGURE 1. ARCS motivation line graph.

Figure 1 shows that the attention aspect has a steep linear shape to the right, with Study Group 1 paying more attention in lessons. For the relevance, confidence and satisfaction aspects, Study Group 2 shows the lowest level across the board. Overall, the *multivariate Pillai's Trace* results (Table 10) show that the group's effect is significantly present for all ARCS motivation aspects (attention, relevance, confidence and satisfaction) [F(8,178) = 26.98, $p < 0.05$]. The MANOVA analysis conducted on dependent variables separately shows that there are significant differences between the three groups in the ARCS motivation aspects for attention [F(2,91) = 81.32, $p < 0.0125$], relevance [F(2,91) = 8.66,

$p < 0.0125$], confidence [$F(2,91) = 6.05$, $p < 0.0125$] and satisfaction [$F(2,91) = 223.80$, $p < 0.0125$]. This result shows that the students affect all four ARCS motivation aspects. In other words, the learning strategy used by every group affects the level of all four ARCS motivation aspects. Referring to the mean value for every dependent variable across all groups in Table 13, it was found that Study Group 1 is most motivated from the attention aspect (mean score: Study Group 1 = 0.89; Study Group 2 = 0.81; Control Group = 0.54), and the relevance aspect (mean score: Study Group 1 = 0.62; Study Group 2 = 0.45; Control Group = 0.50). Also, it was found that Control Group is most motivated from the satisfaction aspect (mean score: Control Group = 0.26; Study Group 1 = 0.06; Study Group 2 = 0.03). The results also show that Study Group 1 and Control Group share a similar value from the confidence aspect (mean score: Study Group 1 = 0.44; Control Group = 0.44; Study Group 2 = 0.33). However, the group factor only contributes 64 % changes in the attention dependent variable, 16% changes in the relevance dependent variable, 12% changes in the confidence dependent variable, and 83% changes in the satisfaction dependent variable.

IV. DISCUSSIONS

A. THE EFFECTS OF AN INDUCTIVE REASONING STRATEGY ASSISTED BY GEOGEBRA ON STUDENTS' OVERALL MOTIVATION

The current study aimed to examine the effects of an inductive reasoning strategy assisted by GeoGebra on students' motivation. To achieve this aim, we measured motivation by referring to the ARCS motivation model pioneered by [14]. Motivation is one of the important factors that act as critical catalysts for students to continuously strive in their studies [13], [56]. Previous studies have shown that students' motivation in mathematics is still at a lower level. Therefore, we observed the students' motivation in four aspects: *Attention*, *Relevance*, *Confidence*, and *Satisfaction*. Based on the overall MANOVA results, it was found that the learning strategy used in the current study has significant effects on the students' motivation. The results from the questionnaire reveal that Study Group 1 exhibits the highest motivation level, showing that an inductive reasoning strategy assisted by GeoGebra is effective in increasing the students' motivation level. GeoGebra is known to be highly interactive, user friendly and helpful in increasing students' motivation [57], [58]. Besides, GeoGebra also supports the functional graph building activity and encourages students to investigate the graph built. This accords well with the claims from [30], [59], [60] who assert that GeoGebra supports the building activity and attracts students' attention in the classroom. However, the results indicate that the motivation level for Control Group is higher than Study Group 2, showing that students who study mathematics conventionally are more motivated than those who learn mathematics through an inductive reasoning strategy. It appears that most students are comfortable with the conventional learning style that is teacher-centred and uses a textbook. The students also seem to be more confident to complete their homework when they only have to use the formula prepared than drawing a conclusion based on the observation on specific examples.

Reference [61] claims that, although KPM has provided some exposure on various learning strategies in mathematics, most students still prefer conventional learning because most teachers use this strategy in their mathematics class. These teachers believe that a conventional learning strategy is more effective because it involves a two-way communication and focuses on exercises and formulas.

It also appears that the students in Study Group 2 are unable to adapt themselves to the inductive reasoning learning strategy. Although the time allocated for the students to learn the Functional Graph II topic was sufficient, the results show that the students' motivation level for Study Group 2 is still low compared to Control Group. According to [62], the time needed to develop an inductive reasoning skill depends on an individual. Thus, the students may need more time to adapt to the inductive reasoning strategy.

B. THE EFFECTS OF AN INDUCTIVE REASONING STRATEGY ASSISTED BY GEOGEBRA ON STUDENTS' MOTIVATION FROM THE ATTENTION ASPECT

Motivation is one of the factors that affect student's achievements. In the academic setting, motivation is the catalyst that sparks students' interest [4], [6]. In the ARCS motivation model proposed by [14], attention is an aspect that measures if the lesson is successful in arousing curiosity among students. Based on the MANOVA results, it was found that the learning strategy used in this study has a significant effect on the students' attention aspect. The results from the questionnaire show that the students in Study Group 1 score the highest in the attention aspect, proving that learning through an inductive reasoning strategy and assisted by GeoGebra works in increasing the students' motivation in the attention aspect. This could be due to the fact that an inductive reasoning strategy assisted by GeoGebra is able to attract the students' attention toward learning and understanding the Functional Graph II topic.

This particular finding shows that an inductive reasoning strategy is able to attract attention because the students are given the opportunity to get involved actively in lessons. Besides, the students can make full observations on specific examples given, find the patterns based on those examples and consequently draw general conclusions. This is in contrast to the conventional learning style in which the lessons are teacher-centred and focus on formulas and exercises without conducting investigations. Through this conventional learning, the students may be bored easily while curiosity is blocked because they only passively receive information. In the inductive reasoning strategy, the students are more active and the lessons are more student-centred in which they make observations before reaching any conclusions. These

TABLE 12. Tests between-subjects effects for motivation.

Sources	Dependent variables	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Attention	2.091a	2	1.046	81.319	.000
	Relevance	.449b	2	.224	8.657	.000
	Confidence	.247c	2	.123	6.050	.003
	Satisfaction	.987d	2	.494	223.797	.000
Intercept	Attention	52.496	1	52.496	4082.209	.000
	Relevance	25.806	1	25.806	995.241	.000
	Confidence	15.276	1	15.276	748.858	.000
	Satisfaction	1.364	1	1.364	618.542	.000
Group	Attention	2.091	2	1.046	81.319	.000
	Relevance	.449	2	.224	8.657	.000
	Confidence	.247	2	.123	6.050	.003
	Satisfaction	.987	2	.494	223.797	.000
Error	Attention	1.170	91	.013		
	Relevance	2.360	91	.026		
	Confidence	1.856	91	.020		
	Satisfaction	.201	91	.002		
Total	Attention	55.987	94			
	Relevance	28.717	94			
	Confidence	17.408	94			
	Satisfaction	2.539	94			
Corrected Total	Attention	3.262	93			
	Relevance	2.809	93			
	Confidence	2.103	93			
	Satisfaction	1.188	93			

a. R Squared = .641 (Adjusted R Squared = .633), b. R Squared = .160 (Adjusted R Squared = .141), c. R Squared = .117 (Adjusted R Squared = .098), d. R Squared = .831 (Adjusted R Squared = .827)

TABLE 13. Estimated marginal means (Group) for motivation.

Dependent Variables	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Attention	Study Group 1	.893	.020	.853	.933
	Study Group 2	.807	.020	.767	.848
	Control Group	.542	.020	.502	.583
Relevance	Study Group 1	.616	.028	.560	673
	Study Group 2	.451	.029	.394	.508
	Control Group	.505	.029	.447	.562
Confidence	Study Group 1	.435	.025	.385	.485
	Study Group 2	.331	.026	.280	.382
	Control Group	.444	.026	.048	.081
Satisfaction	Study Group 1	.064	.008	.048	.081
	Study Group 2	.033	.008	.016	.049
	Control Group	.265	.008	.248	.282

activities will spark the students' interest and arouse their curiosity [25], [63]–[65].

Furthermore, the findings also show that learning through an inductive reasoning strategy assisted by GeoGebra helps increase students' attention in the classroom. GeoGebra provides a learning environment that is more fun and encourages the students' curiosity. Geogebra contains graphics, texts and colors that can be modified and influence the students' emotion. The features provided via GeoGebra greatly help the students to observe and find results more deeply [30]–[32]. GeoGebra also provides new experiences for the students. With GeoGebra, the students can explore on their own until they feel more comfortable and more interested to continue their studies. GeoGebra provides a learning environment that allows the students to be active and flexible in receiving the information [28].

C. THE EFFECTS OF AN INDUCTIVE REASONING STRATEGY ASSISTED BY GEOGEBRA ON STUDENTS' MOTIVATION FROM THE RELEVANCE ASPECT

Besides the attention aspect, the ARCS motivation theory also includes relevance as one of the motivation aspects. Sometimes, students fail to correlate the knowledge learned with their daily life. When the students feel that a lesson is important, it is useful and can be used in the future [66]. Also, a lesson is relevant when it fulfills students' goals and provides positive effects on their attitude.

Based on the MANOVA results, it was found that the learning strategy used in the current study has a significant effect on the students' relevance aspect. The results from the questionnaire show that the students in Study Group 1 receive the highest score for the relevance aspect, showing that GeoGebra provides many advantages to this particular group. This finding proves that learning through an inductive reasoning strategy assisted by GeoGebra is effective in improving the students' motivation in the relevance aspect. Learning through an inductive reasoning strategy requires a clear instruction for every activity. With the help of GeoGebra, the students can better understand the instructions because GeoGebra provides clearer information and better images. GeoGebra can help the students identify the importance of functional graphs and correlate them with daily life situations. GeoGebra can demonstrate how Functional Graph II is relevant in life and explain how the Functional Graph concept works. This finding is also supported by the research conducted by [67] who claims that GeoGebra can help students to relate between existing knowledge and newly received knowledge. GeoGebra also helps students to conduct observations and explorations until they can feel their use and relevance in daily life [57].

However, the findings reveal that the motivation mean score for the relevance aspect for Control Group is higher than that for Study Group 2, showing that the students in Control Group can better understand the learning activity since they depend on their teacher. That is, when they have difficulties in understanding a concept, they can ask for explanation from their teacher. This helps students to better understand the lessons and relate them in life [68], [69]. In contrast, the students in Study Group 2 have to draw their own conclusions based on their understanding on the given examples. When the instruction given is not clear, they find it difficut to correlate the lesson in their daily life. This is also supported by [14], [70] and [71] who assert that the instruction used in an inductive reasoning strategy needs to be more precise in order to help students feel its importance in real life.

D. THE EFFECTS OF AN INDUCTIVE REASONING STRATEGY ASSISTED BY GEOGEBRA ON STUDENTS' MOTIVATION FROM THE CONFIDENCE ASPECT

Confidence is one of the important aspects in the ARCS motivation theory to ensure that students are encouraged to continue their studies. This confidence aspect allows students to build self-confidence by participating and enjoying the learning process. Most students have a negative perception on mathematics because of the lack of confidence in solving mathematical problems. The confidence aspect will help them build self-confidence and make them feel that they will be successful. So, it is crucial for teachers to consider students' confidence level when preparing the lessons.

Based on MANOVA results, it was found that the learning strategy used in the current study has a significant effect on the students' confidence aspect. The results from the questionnaire show that the mean score of the confidence aspect for Control Group is almost the same with Study Group 1 but higher than Study Group 2. This proves that the students' motivation for the confidence aspect is higher with an inductive reasoning strategy assisted by GeoGebra. The GeoGebra software provides an environment that helps students understand easily through visualization [30]–[32]. The visual aids provide the opportunity for students to observe easily and improve their confidence level. Using GeoGebra in the classroom can address the difficulty encountered by students when they are unable to picture and draw the graph correctly [72]. With the help of GeoGebra, students can visualize the effect of parameter change on a graph and this will improve their understanding. As a result, students can answer correctly and their confidence level will increase.

The results also reveal that the mean score of the confidence aspect for Control Group is almost similar to that for Study Group 1, showing that the students are comfortable in following the lessons that can help them answer examination questions. It is generally accepted that conventional learning puts more emphasis on memorizing, exercising and exposing students to past examination questions [73]. Students usually prefer to be exposed to lessons that are centered on teachers in which they are always given exercises and questions that can help them answer examination questions. When students keep practicing, their skill in drawing a graph can indirectly improve. Students are also given questions that can help them answer examination questions and this can increase their confidence.

The results show that the mean score for Study Group 2 is the lowest in the confidence aspect. The students in this group may be less skilled in using this strategy and spend more time making observations, finding patterns and drawing their own conclusions. Besides, they may not allocate time to practice drawing a graph correctly. Furthermore, they may be less exposed to the examples of other questions. Subsequently, they are unable to answer the questions given correctly, causing a negative perception on the lesson. Reference [18] claims that, when students always fail to carry out the task correctly, they will not enjoy learning and will avoid completing the task, causing the lack of confidence in learning.

Therefore, the current study proves that learning through an inductive reasoning strategy assisted by GeoGebra and conventional learning can provide positive effects on students' confidence aspect. The results are also in tandem with past studies [74], [75], confirming the fact that an inductive reasoning strategy assisted by GeoGebra in mathematics can boost students' motivation from the confidence aspect. Although conventional learning is always downgraded, this learning style actually makes the students more confident in the current study.

E. THE EFFECTS OF AN INDUCTIVE REASONING STRATEGY ASSISTED BY GEOGEBRA ON STUDENTS' MOTIVATION FROM THE SATISFACTION ASPECT

The last motivation aspect in the ARCS motivation theory is satisfaction. Satisfaction refers to students' intrinsic motivation and their attitude on extrinsic benefits [66]. Intrinsic strengthening offerings such as oral compliments and extrinsic strengthening offerings such as monetary benefits are part of the measurement of students' satisfaction. It is important to ensure that students obtain satisfaction in learning so that they will feel content after successfully completing their studies. Based on the MANOVA results, it was found that the learning strategy used in the current study has a significant effect on the students' satisfaction aspect. The results from the questionnaire show that the mean score of the satisfaction aspect for Control Group is the highest among all groups, proving that the students' motivation for the satisfaction aspect is higher through conventional learning compared to the inductive reasoning strategy assisted by GeoGebra. However, in this study, time constraint might trigger dissatisfaction among the students in Group 1 in learning the topic of Functional Graph II using GeoGebra. It appears that adequate time is essential to ensure that a given treatment in an experimental group is effective [76]. Besides that, to ensure that students are satisfied in their lessons, they must be able to respond promptly. However, this was not possible for the students in Study Groups 1 and 2 because they took too much time to explore, observe and generalize the given examples. Consequently, they were unable to present their findings in front of the class with their peers. According to [77] and [78], students' satisfaction can be increased if they are given the chance to present their work or opinion to their friends so that they can promptly respond or comment.

The students in Control Group were centered on the teacher and the lesson could run smoothly according to the plan. Therefore, the students had the opportunity to receive prompt feedback from their teacher and friends. This situation successfully improved their confidence because they could identify their achievement after solving the mathematics problem given. This made them feel satisfied because they were able to end their lesson successfully [79]. Critically, the findings of the current study show that learning through an inductive reasoning strategy assisted by GeoGebra causes a low level in the satisfaction aspect among the students.

V. IMPLICATIONS AND LIMITATIONS OF THE STUDY

Through this study, it can be clearly seen that an inductive reasoning strategy assisted by GeoGebra plays a significant role in increasing students' motivation in the context of the ARCS model. The learning strategy is able to enhance three out of four motivation aspects in the ARCS model, namely the aspects of attention, relevance and confidence. However, in this study, the satisfaction aspect is not significantly different for Study Group 1. As for the aspect of attention, an inductive reasoning strategy assisted by GeoGebra succeeds in gaining the students' attention and interest in learning and engaging themselves in mathematics classrooms. In the aspect of relevance, the students may use the mathematics concepts constructed in the future. The learning strategy also meets the needs of the students for the topic of Functional Graph II. As for the confidence aspect, the students can build confidence by participating and enjoying their learning process during this GeoGebra-assisted inductive reasoning learning strategy. However, one of the limitations in this study is the lack of study time which may cause students' dissatisfaction with the new learning strategy. In order to improve the results, the study period should be extended. Therefore, it is recommended that future researchers should allocate more time so that students can familiarize themselves with the strategies used. In this way, the data obtained may be more accurate. However, the overall MANOVA results show that the students are more motivated in learning mathematics through an inductive reasoning strategy assisted by GeoGebra. This is because the students can be fully involved in constructing their understanding and visualization through GeoGebra. At this stage, it seems that an inductive reasoning strategy assisted by GeoGebra can be applied by teachers in mathematics classes for the topic of Functional Graph II in efforts to increase their students' motivation. It has been established that when students' motivation is high, their achievement can be improved.

This study focused on the topic of Functional Graph II involving Form-Four students in a secondary school in Pasir Gudang, Malaysia. The topic employed in this study can be further expanded to other appropriate topics such as Circles, Quadrilaterals and Pythagoras Theorem. The implementation of this learning strategy is in line with the objectives of secondary mathematics education in Malaysia, which include consistently practicing mathematical process skills such as reasoning, using technology to build concepts, mastering skills, exploring mathematical ideas, and solving problems.

VI. FUTURE RESEARCH

Among the improvement that can be considered for future research is to use additional instruments in order to obtain more information and clearer findings. An example of an additional instrument is an interview protocol. Interviews should be included in future studies because interview data will show clearer results and more in-depth qualitative input. Through interviews, the real motives and feelings of the participants can be gauged in greater depth. In addition, researchers can also make more subtle observations on several aspects that cannot be captured via quantitative data.

In addition, future researchers should provide an initial exposure on Geogebra to students involved so that the students can become more familiar and proficient in using the tools available in GeoGebra. In this study, we exposed to the students about the use of GeoGebra at the beginning of the study. However, the exposure period was limited and the students were only exposed to the tools and functions needed for the purpose of the current study. It is suggested that the exposure should be made longer in the future so that students can master the use of GeoGebra. This longer exposure can prevent errors; the extended period allotted can be used effectively by students in carrying out the activities provided. Future researchers also need to ensure that all students are equipped with appropriate skills in using this software before the actual study is conducted so that the data obtained is more accurate and the treatment given is more effective.

Finally, it is suggested that further studies should be conducted in order to examine the relationship between motivation and students' inductive reasoning after learning through a Geogebra-assisted inductive reasoning strategy. This suggestion can help researchers to observe clearly the strength of the relationship between students' motivation and their inductive reasoning through this learning strategy.

VII. CONCLUSION

This study presents the effectiveness of a strategy employed to increase students' motivation during problem solving in the Functional Graph II topic. The main impact can be seen clearly through an inductive reasoning strategy assisted by GeoGebra. Previously, most mathematics teachers were not ready to use the inductive reasoning strategy assisted by technology such as GeoGebra. Most students were also more comfortable learning conventionally via memorizing and doing exercises [68], [80]. Past research has shown that the Functional Graph II topic is too abstract and difficult [60]. This problem can be solved by using GeoGebra that provides visualization. Our findings show that, by using an inductive reasoning strategy assisted by GeoGebra, the students are more motivated to continue their mathematics class. The students can engage themselves fully in building understanding and the visualization made via GeoGebra can attract students throughout the lesson. Moreover, this strategy can clearly show how the mathematical concept is relevant in the students' real life. Thus, applying an inductive reasoning strategy assisted by GeoGebra in the education system is highly recommended. Teachers and students should embrace this strategy with an open mind so that it can run smoothly and efficiently. In the end, we hope that the findings of the current study can improve the quality of mathematics education in Malaysia and further contribute toward the success of the Malaysian Education Development Plan 2013-2025.

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