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THE INTEGRATION OF 5E INQUIRY-BASED LEARNING AND GROUP INVESTIGATION MODEL: ITS EFFECTS ON LEVEL FOUR SCIENCE PROCESS SKILLS OF FORM FOUR STUDENTS

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Abstract

Studies found that the mastery of Level-4 Science Process Skills (L4SPS) among secondary school students is still relatively weak. Thus, the purpose of this research was to determine the effects of 5E Inquiry-based Learning and Group Investigation (I5E-GI) model on the five constructs of L4SPS, namely Identifying Manipulated, Responding, and Constant Variables, Forming Hypotheses, Making Observations, Making Inferences, and Defining Operationally. A teaching and learning (TL) module was developed to guide teachers in implementing the I5E-GI method for the five L4SPS constructs. The L4SPS Test Instrument was constructed to measure the level of L4SPS mastery at the end of intervention. The quasi-experimental research design was conducted on 180 Form Four students taking Core Science subjects. A total of three groups were assigned, namely i) 5E Inquiry-based Learning and Group Investigation method (I5E-GI, n = 60), ii) 5E Inquiry-based Learning method (5E, n= 60), and iii) Traditional Learning (TR, n = 60) in an urban secondary school in Sarawak, Malaysia. Data were analyzed using the inferential statistical tests of MANOVA, MANCOVA, ANCOVA, and effect size. The results showed that there was a statistically significant effect across the three groups of TL methods. There is a statistically significant effect of the I5E-GI method compared to the 5E and TR methods on the five L4SPS constructs. As for the effect size, the I5E-GI method provides a more significant effect size than the 5E and TR learning methods. Overall, the findings prove that the I5E-GI method has positive implications for the mastery of L4SPS among Form Four students.

Keywords: *5E inquiry-based learning, Form Four students, Group Investigation, level-4 science process skills*

Introduction

Science process skills are one of the two components of scientific skills students need to master in learning science. According to Gagne (1968), science process skills are the basis for learning science. These science process skills have become increasingly important and are made the objective of the science curriculum in South Asia (Ong et al., 2014). Many previous studies found that students' science learning at school is greatly influenced by their mastery of science process skills (Awelani, 2002; Bayir, 2019). There have been several studies conducted on the level of achievement of science process skills among students in Indonesia and Nigeria, and the findings from these studies show the low achievement of students in the science process

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skills (Ekon & Eni, 2015; Kusuma & Rusmansyah, 2021). Parallel findings were reported by Ismail (1998), Yew and Tajuddin (2015) and Wun and Sunita (2015), who observed that the overall performance of the acquisition of science process skills of Malaysian students was unsatisfactory.

The findings of Wun and Sunita's (2015) research on 150 Form Four students related to mastery of level-4 science process skills show that the overall level of student achievement is moderate in terms of identifying manipulated variables, responding variables, and constant variables, building hypotheses, and making observations, while a weak level is found in terms of making inferences and defining operationally. Among the reasons for the weakness in the mastery of science process skills are that students rarely practice scientific skills, the teaching style lacks emphasis on thinking skills as suggested in the Science curriculum; students are less exposed to science process skills; teachers themselves do not understand science process skills resulting in difficulties in planning lessons; teachers themselves are less confident because they do not know the characteristics of each science process skill and do not know how to combine both knowledge and skills in teaching and so on. This shows there are still weaknesses in the mastery of science process skills among students and teachers.

For secondary School A in Lawas district, Sarawak, Malaysia, the results of Form Four students entering 2020 for the Science subject were very unsatisfactory. This can be seen from the examination results for Form Four Science in March 2020, which is quite worrying, where the Average Subject Grade of the Science subject was found to be very low (8.75), which is close to 9.00. In addition, the analysis of the results of the March 2020 examination shows that only 20 (12.4%) students out of a total of 160 students passed the examination for the Form Four Science subject. Based on the analysis of the items that were made, the researcher found that the main cause of students failing in the Science subject is students being unable to properly answer the questions on paper Two in part A, which consists of Level-4 science process skills. Therefore, an intervention needs to be implemented so that the students can achieve better results and also to increase the average subject grade of Science subjects for the upcoming exams.

Therefore, in the context of this research, the researcher developed a module based on the 5E cycle inquiry-based learning model (I5E) and cooperative learning based on Group Investigation (GI) Model, which is also known as the I5E-GI Module to improve the Level-4 science process skills of students. The researcher applies the learning module developed as a medium to deliver content in the teaching and learning of the Science process skills. The 5E cycle inquiry-based learning model was chosen because there is an evidence from previous studies found that the science process skills of the students who used the 5E cycle inquiry-based learning model turned out to be better than students who received the conventional learning method (Simsek & Kabapınar, 2010). The same findings were also found with a group of students who followed the Group Investigation Model (Parinduri et al., 2017; Siregar & Motlan, 2016). Therefore, the effort to change the Science teaching and learning (TL) method from traditional to student-centred is necessary. Therefore, a research study on integrating the I5E-GI method was conducted to improve the level-4 science process skills of Form Four students.

Literature Review

Level-4 Science Process Skills

In general, process skills refer to the processing strategies that a person brings to solve problems (Satyaprakasha & Behera, 2014). Science process skills refer to skills that help science learning, appreciation of active learning methods, develop a sense of individual responsibility while learning, and increase the permanence of knowledge (Dogan & Kunt, 2017). In the

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Malaysian Science Secondary School Standard Curriculum. Level-4 science process skills include five processes, namely controlling variables, making observations, making inferences, building hypotheses, and defining operationally (Curriculum Development Department, 2018). Controlling a variable is the process of converting a constant variable into a manipulated variable and specifying a new responding variable, while hypothesizing is describing an expected outcome of a designed scientific investigation. Next, observing is a process where qualitative and quantitative observations are made to make generalizations based on patterns or sequences of objects or phenomena and present the results of further observation of objects or phenomena in an analytical and specific manner. Making inferences is the process of generating various possibilities to explain a complex situation. Defining operationally explains the interpretation made about the choice of equipment or method about what is observed.

Several literature studies show a positive relationship between students' science process skills and their achievement in Science (Aktas, 2013; Cakir, 2017; Ozturk & Dokme, 2015). Therefore, Science teachers need to be aware of the importance of improving students' science process skills. However, previous studies have found that students can not use science process skills appropriately (Burak, 2009; Lue, 2020). In the context of Malaysia, Lue (2020) found that students in Malaysia experience difficulties in mastering science process skills such as defining operationally, interpreting data, stating inferences, and making predictions. This situation may occur due to the science process skills applied among students happening indirectly while students are carrying out activities (Rauf et al., 2008). In addition, among other factors is due to the activities in the laboratory, especially those carried out by students, are guided by a list of instructions from the teacher or textbooks, and the student's understanding of the science process skills is not emphasized by the teacher (Sembak & Abdullah, 2017). According to Karamustafaoğlu (2011), science process skills are very important for students to gain meaningful learning because learning occurs continuously throughout life, and each individual is always looking for, interpreting, and evaluating the phenomena and problems they face daily.

5E Inquiry-Based Learning Model

Inquiry-based learning is one of the pedagogical approaches to learning that combines various elements of 21st-century learning. In this approach, learning is based on questions and questions to unravel the topic studied. Guided by the title, some questions are constructed, and then activities are carried out to answer those questions. Inquiry-based learning can be implemented by using various models according to the appropriateness of related subjects, and one of the general models that are suitable for implementing inquiry-based learning is the 5E learning model (Curriculum Development Department, 2019). The 5E Model, also known as the '5E Learning Cycle', is a model built using constructivist learning theory through an inquiry approach that is carried out to create an effective TL session (Yuksel, 2019).

There are five phases that need to be followed in the 5E Inquiry-Based Learning Model, namely engagement (engage), exploration (explore), explanation (explain), development (elaborate), and evaluation (Curriculum Development Department, 2016). In the engagement phase, the teacher stimulates students' minds to arouse students' curiosity, introduce context, and unearth students' existing knowledge. The exploration phase includes students building an understanding of concepts based on hands-on activities, conducting guided or open investigations to answer questions that have arisen, finding information/data using various sources, and carrying out investigations. Next, in the explanation phase, students develop explanations and extension ideas through reflection on the exploration that has been carried out, and the teacher gives input to check the understanding of the concepts that the students have formed. The development phase involves students developing their understanding of concepts through application in new situations, and the evaluation phase takes place in each

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phase to assess student development and encourage students to evaluate their understanding and abilities.

Previous studies have often shown that using the 5E Model can help improve student performance in Science subjects. For example, intervention research conducted by Abdi (2014) on primary school students in Kermanshah, Iran, showed that students exposed to the 5E inquiry learning approach were more successful and highly understood Science subjects. Campbell (2006) found that students' knowledge of science concepts increased by using the 5E learning model. Karsli and Ayas (2014) in their research stated that there was an increase in the percentage of students' science process skills test results because students were trained to use science process skills such as scientifically observing, formulating hypotheses, determining variables, interpreting data, and presenting experimental results in explanation phase.

Cooperative Learning - Group Investigation Model

The cooperative learning method is a teaching strategy where students help each other in small groups (Mohamed, 2012). Yahya and Bahuri (2010) stated that the number of members for this cooperative learning usually consists of four to six members, and this cooperative learning requires students to be responsible for the learning of their teammates in addition to their learning. Aziz and Bustam (2011) also agreed that in cooperative learning, students need to help each other in groups to achieve academic performance. This is in line with previous studies where, apart from cooperation, cooperative learning emphasizes the achievement of team goals and success. This can be achieved when all members of the team give the necessary commitment (Esa & Mahbib, 2014).

According to Asma (2006), Group Investigation Model (GI) is defined as a cooperative learning model where students seek information (ideas, opinions, data, and solutions) from various sources (books, institutions, and people) inside and outside the classroom. Students evaluate and synthesize all the information each group member presents and finally produce a group product. In this research, cooperative learning through GI means that students learn together in small groups to complete the given task. Students are divided into groups of four people only. Each group member is given his/her responsibility, and the success of the group members depends on each other. This means that the more skilled students guide and help the weaker students in the group and work together to achieve the maximum level of learning and not just for themselves. This research follows the six steps of GI suggested by Suardi (2015): planning, investigation, organizing, presenting, and evaluating.

Most of the findings from previous studies show that the GI model of cooperative learning positively affects student learning. A research study by Suartika et al. (2013) concluded a difference in the understanding of science concepts between students who followed the GI and those who followed conventional learning. Meanwhile, the research of Dewi et al. (2012) also stated that the GI model can improve learning outcomes and student activities on chemicals in food for Science subjects. Siregar and Motlan (2016) and Parinduri et al. (2017) also found that students who followed the GI model performed better in science process skills than students who followed conventional learning.

Integration of 5E Inquiry-Based Learning and Group Investigation in Level-4 Science Process Skills Learning

In this research, the researcher integrates the 5E inquiry-based learning model and the Group Investigation (GI) model to cultivate Level-4 science process skills. The 5E Learning Model refers to the five phases of learning, which are Engagement, Exploration, Explanation, Development, and Evaluation, while GI requires students to explore and acquire knowledge

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through group learning, which consists of six steps, namely planning, investigation, organizing, presenting, and evaluating. During the Engagement phase, the teacher attracts students' attention by using various methods, such as watching videos or providing situations related to the topic to be learned in the lesson. Students respond and engage actively. Then, students are divided into several groups based on the first step in the GI, which is grouping. Each group consists of four members. Assignments are given to each group after group division. Students answer Level-4 science process skills questions after conducting an investigation.

At the Exploration phase in the 5E cycle inquiry-based learning model, the group leader explains the task to each group member. Then, students discuss in groups and plan the steps to investigate the assigned task. Like the planning step in a GI, the group leader assigns tasks to each group member to carry out the exploration. Students discuss the strategies that need to be used together. During the discussion, students identify manipulated variables, responding variables, and constant variables. In addition, students also learn from group members who are more skilled in creating hypotheses for experiments that are conducted. After planning, the investigation is carried out in groups, and all members are actively involved in the investigation step. At the same time, each group member makes observations on the experiment's results and is able to express those observations correctly. Students are also able to analyze the data obtained based on the results of experiments and group discussions. Group members help each other to complete their assignments. So, skilled members guide weak members when analyzing data, such as making inferences and defining operationally. Teachers monitor and help students from table to table.

The organizing step in GI requires group members to produce their assignments to be presented in the presenting step. This presenting step is also parallel to the explanation phase in the inquiry-based learning model of the 5E cycle, i.e. the students explain the results they get in various ways determined by the teacher, whether it is a presentation in front of the class or a Gallery Walk and the question and answer session takes place afterwards. During this explanation or presenting step, students try to learn and consolidate knowledge about the Level-4 science process skills learned while in the group through presentations from other groups. Other students ask the presenting group questions, and the presenting groups answer the questions addressed openly.

Improvements to the results of each group's answers are made. Next, each group is given a new situation or task at the Development stage in the inquiry-based learning model of the 5E cycle. Students discuss and answer the Level-4 science process questions and display their answers. Students ensure they have mastered Level-4 science process skills by answering the questions given. They ask for guidance from more skilled friends. Finally, the Evaluation stage in the 5E cycle inquiry-based learning model and GI allows students to ask questions, reflect on the learning that has been carried out, and make corrections to the assignment. Finally, the closing stage requires students to conclude the learning gained.

Research Purpose

This research aimed to examine the effects of integrating the I5E and GI methods, namely the I5E-GI method, using a 5E cycle inquiry-based learning module and cooperative learning based on explicit GI. The operational definition of Level-4 science process skills was based on the Curriculum Development Division (2018) of Form Four Science which is Identifying Manipulated, Responding, and Constant Variables, Building Hypotheses, Making Observations, Making Inferences, and Defining Operationally. Specifically, the research questions are as follows:

Will the students taught using the I5E-GI method produce a higher post-test mean score compared to students taught using the I5E method and the Traditional learning method in the

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mastery of Level-4 science process skills i) Identifying Manipulated, Responding, and Constant Variables, ii) Constructing Hypotheses, iii) Making Observations, iv) Making Inferences, and v) Defining Operationally?

Research Methodology

Research Design

This research used a quasi-experimental quantitative approach that only involved pre-tests and post-tests. In this research, the quasi-experimental research design was based on unequal groups (Campbell & Stanley, 1996) and did not involve a random selection of respondents (Fraenkel & Wallen, 2008). This design is always used when it involves research on the effectiveness of a teaching method, module or program in various situations that a pure experimental design cannot be applied, especially in real situations at schools (Chua, 2011; Mok, 2010).

Population and Sample

The population of this research consisted of 400 students from four schools in Lawas district, Sarawak, Malaysia. In this research, the researcher used purposive sampling to select a sample based on several criteria. According to Reinard (2001), the researcher needs to use judgment to choose the most suitable respondent for his/her research. Therefore, the sample was selected based on the specific purpose of the research, and the researcher selected the sample based on the experience and knowledge of the sample groups to be taken (Cohen et al., 2011). In this research, Form Four students at national secondary school A in the Lawas District were selected as the research sample. School A was chosen after considering several things, namely: 1) School A has a similar socioeconomic background of students; 2) School A does not group students into high- and low-achieving classes but combines high-achieving and low-achieving students in one class; 3) school selection has considered various other indicators that are considered important (Marshall & Rossman, 1995) such as getting cooperation and permission from School A to carry out the research, having good facilities such as laboratories; and 4) the quality and credibility of the research data obtained is guaranteed by considerating the energy, financial costs, and school hours are appropriate for the research period. Overall, the sample of this research involved 180 students who were randomly selected from six classes in School A, where each class consisted of 30 students as an intact group. Two classes received the complete treatment of the learning method based on the 5E inquiry-based learning and GI model (I5E-GI, n = 60), while the other two classes only received treatment based on the 5E Inquiry-based Learning Model (I5E, n = 60). The remaining two classes received Traditional Learning (TR, n = 60). All 180 students were given the intervention in the same week but with different TL methods for six weeks between October – November 2021.

Instrument

In this research, an instrument was developed, which is the Level-4 Science Process Skills (L4SPS) Test. This instrument has evidence of good construct validity and reliability assessed using the Rasch Measurement Model (MPS) based on the findings of a pilot research involving 60 students.

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Level-4 Science Process Skills Test (L4SPS)

The L4SPS instrument is a structured test developed by the researcher based on the Form Four Science content about Level-4 science process skills. The L4SPS instrument contains five constructs and 26 items: 1) Identifying Manipulated, Responding, and Constant Variables (7 items) – Example: "State the variables in this experiment."; 2) Building a Hypothesis (5 items) – Example: "State a hypothesis for this experiment."; 3) Making Observations (3 items) – Example: "State an observation about the diameter of the indentation in Figure 2.2."; 4) Making Inferences (5 items) – Example: "State the inferences that can be made based on the observations in 3(b)(i)."; and 5) Define Operationally (6 items) – Example: "Based on this experiment, state the operational definition of inertia.". The content of the L4SPS question set for the pre-test and post-test is the same. However, the researcher made changes in terms of item position and some item stimuli without disturbing the meaning of the item. This is intended to make the given question look like a new question (Mohamed, 2012). The pre-test and post-test use the same set of questions to measure the extent of the student's development and improvement in mastering the requirements of the questions. The suggested time to answer was 1 hour 30 minutes, equal to three minutes for each question.

In this research, the validity of the L4SPS instrument was tested based on item fit analysis using Rasch Measurement Model. Three criteria can be used to evaluate the item fit (Boone et al., 2014), namely: 1) Outfit Mean Square Values (MNSQ) – the value range is between 0.50 and 1.50; 2) Outfit Z-Standardized Values (ZSTD) – the value range is between -2.00 and 2.00; and 3) Point Measure Correlation (PTMEA-CORR) – the value range is between 0.40 and 0.85. Findings from the evaluation of item fit analysis indicate that all items in the L4SPS instrument have accepted a range of Outfit MNSQ and ZSTD values. Meanwhile, all items in L4SPS have a positive PTMEA-CORR value. This is supported by Bond and Fox (2015), who stated that an item with a positive PTMEA-CORR value means that it measures the intended construct. In addition, for the reliability of the L4SPS instrument, which was also analyzed using Rasch analysis, the index value for item reliability (0.76) and the reliability of the research subject (0.73) were good and acceptable.

Data Analysis

Several inferential statistics, namely Multivariate Analysis of Variance Test (MANOVA), Analysis of Covariance Test (ANCOVA), and Multivariate analysis of covariance (MANCOVA), were used in this research to answer research questions that aim to examine the effect of the TL method (independent variable) which is I5E-GI, I5E, and Traditional Learning on the mastery of Level-4 science process skills (dependent variable). MANOVA was used to analyze the comparison of TL method groups using the mean scores obtained from the pre-test. This research used the pre-test of Level-4 science process skills as a covariate before the intervention. MANCOVA was used to evaluate the effect of three different TL methods on the post-test of Level-4 science process skills after the intervention by controlling for covariates. Suppose the overall MANCOVA results are statistically significant. In that case, the Univariate F test (ANCOVA) was conducted on the post-test mean score with the pre-test mean score as a covariate to assess further whether there was a statistically significant effect of the TL method on each post-test. In addition, the effect size (d) and partial Eta Square (η^2) were also used to measure the strength of the effect by referring to the value suggested by Cohen (1998), where $d<0.2$, $0.2\leq d<0.5$, $0.5\leq d<0.8$, and $d\geq 0.8$ refer to very small, small, medium, and large effect sizes, respectively. While for the interpretation of η^2, $0.010\leq\eta^2\leq 0.039$ is small, $0.039<\eta^2\leq 0.110$ is moderate, and $0.11<\eta^2\leq 0.20$ is large. Before testing the multivariate statistical findings, the researcher has conducted a preliminary analysis to assess whether the prerequisite assumptions

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of MANOVA/MANCOVA have been met, such as multivariate normal distribution, equality of covariance, linear relationship between the covariate and the dependent variable, multicollinearity, and homogeneity of the variance of the dependent variable (Tabachnick & Fidell, 2019). In this regard, all prerequisite assumptions of MANOVA/MANCOVA were met before data analysis was carried out to answer the research questions.

Research Results

Table 1 shows the descriptive statistical analysis results of the pre and post-test for the Level-4 science process skill constructs. Based on Table 1, it was found that there was an increase in the mean score of students who followed the I5E-GI and I5E methods for all constructs in science process skills. In addition, an increase in the mean score was also seen in the group that followed the traditional learning except for the construct of Identifying Manipulated, Responding, and Constant Variables, where there was a decrease in the mean score in the post-test.

Table 1
Descriptive Statistical Analysis of Level-4 Science Process Skills Constructs

Construct	TL method	*N*	Pre-test		Post-test	
			M	*SD*	*M*	*SD*
Identifying Manipulated, Responding, and Constant Variables (MRC)	I5E-GI	60	1.789	0.852	3.811	0.701
	I5E	60	1.767	0.936	3.033	0.765
	TR	60	1.550	0.867	1.267	0.756
Building Hypothesis (BH)	I5E-GI	60	2.717	0.885	5.756	0.812
	I5E	60	2.550	1.016	4.800	0.925
	TR	60	2.717	0.804	2.883	0.667
Making Observations (MO)	I5E-GI	60	1.400	0.924	2.511	0.503
	I5E	60	1.283	0.922	2.033	0.765
	TR	60	1.267	0.880	1.383	0.904
Making Inferences (MI)	I5E-GI	60	1.067	0.880	3.667	0.983
	I5E	60	1.100	0.775	3.000	0.695
	TR	60	1.150	0.755	1.150	0.936
Defining Operationally (DO)	I5E-GI	60	1.900	0.933	4.922	0.738
	I5E	60	1.850	0.880	4.400	0.770
	TR	60	1.700	0.997	1.933	0.972

The results of the MANCOVA analysis in Table 2 show that there is a significant effect of the independent variable (TL method) on the dependent variable (science process skill constructs) [$F(2, 176) = 31.819$, $p < .05$]. This shows that the TL method impacts the mastery of the constructs of Identifying Manipulated, Responding, and Constant (MRC) Variables, Building Hypotheses (BH), Making Observations (MO), Making Inferences (MI), and Defining Operationally (DO).

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Table 2
Summary of Multivariate MANCOVA and Univariate ANCOVA Test Results based on Teaching and Learning Methods

Effect (TL method)	MANCOVA			ANCOVA			
	Pillai's Trace F	*df*	*p*	*F*	*df*	*p*	η^2
MRC	31.819	2, 176	*p* <.05	1.305	2, 172	*p* <.05	.917
BH	31.819	2, 176	*p* <.05	208.033	2, 172	*p* <.05	.632
MO	31.819	2, 176	*p* <.05	40.833	2, 172	.012	.306
MI	31.819	2, 176	*p* <.05	1.727	2, 172	*p* <.05	.675
DO	31.819	2, 176	*p* <.05	13.475	2, 172	*p* <.05	.700

Further, an ANCOVA test was conducted to identify whether the independent variable (TL method) affected the dependent variables. ANCOVA analysis showed that there was a significant effect of the TL method on the construct of Identifying Manipulated, Responding, and Constant Variables [$F(2, 172) = 1.305$, $p < .05$, $\eta^2 = .917$], Building Hypotheses [$F(2, 172) = 208.033$, $p < .05$, $\eta^2 = .632$], Making Observations [$F(2, 172) = 40.833$, $p = .012$, $\eta^2 = .306$], Making Inferences [$F(2, 172) = 1.727$, $p < .05$, $\eta^2 = .675$], and Defining Operationally [$F(2, 172) = 13.475$, $p < .05$, $\eta^2 = .700$]. The ANCOVA analysis also shows that there is a high relationship between the TL method with the Level-4 science process skills constructs, where the I5E-GI method contributes 91.7%, 63.2%, 30.6%, 67.5%, and 70.0% to the mastery of the construct of Identifying Manipulated, Responding, and Constant Variables, Building Hypotheses, Making Observations, Making Inferences, and Defining Operationally respectively.

Post hoc analysis was also performed to determine the effect of the independent variable on the dependent variable. Table 3 shows the results of pairwise comparison tests and effect sizes for the effect of the TL method on the constructs of Level-4 science process skills. A pairwise comparison shows that the I5E-GI method is significantly higher than the I5E method for all constructs in Level-4 science process skills (p<.05). Meanwhile, the pairwise comparison also shows that the I5E-GI method is significantly higher than the TR method for all constructs in Level-4 science process skills (p<.05). The same findings are also seen in the pairwise comparison between the I5E and TR methods, where the I5E method is significantly higher than the TR method for all constructs in Level-4 science process skills (p<.05).

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Table 3
Pairwise Comparison Test Results and Effect Sizes

Construct	Pair Comparison	*MD*	*p*	*d*	Cohen's interpretation (1988)
MRC	I5E-GI vs I5E	0.78	*p* <.05	0.67	Big
	I5E-GI vs TR	2.54	*p* <.05	1.01	Big
	I5E vs TR	1.77	*p* <.05	1.56	Big
BH	I5E-GI vs I5E	0.96	*p* <.05	0.81	Big
	I5E-GI vs TR	2.87	*p* <.05	1.31	Big
	I5E vs TR	1.92	*p* <.05	1.76	Big
MO	I5E-GI vs I5E	0.48	.002	0.67	Big
	I5E-GI vs TR	1.13	*p* <.05	1.01	Big
	I5E vs TR	0.65	*p* <.05	1.56	Big
MI	I5E-GI vs I5E	0.67	*p* <.05	0.75	Big
	I5E-GI vs TR	2.52	*p* <.05	1.51	Big
	I5E vs TR	1.85	*p* <.05	1.86	Big
DO	I5E-GI vs I5E	0.52	*p* <.05	0.77	Big
	I5E-GI vs TR	2.99	*p* <.05	1.21	Big
	I5E vs TR	2.47	*p* <.05	1.46	Big

For effect size analysis, the findings of the research found that students who followed the I5E-GI method showed a significant effect size compared to the I5E method for all constructs:- Identifying Manipulated, Responding, and Constant Variables, Building Hypotheses, Making Observations, Making Inferences, and Defining Operationally, each has a Cohen's d value of 0.67, 0.81, 0.67, 0.75, and 0.77. The findings also show that students who follow the I5E-GI and I5E methods show a larger effect size than the TR method for all constructs in Level-4 science process skills. Statistically, the I5E-GI method effectively improves the mastery of students' Level-4 science process skills.

Discussion

Integration of 5E Inquiry-Based Learning and Group Investigation (I5E-GI)

In this research, the I5E-GI method is proven to be more effective than the I5E and Traditional Learning methods in increasing the mastery of Level-4 science process skills constructs among Form Four students, particularly in the construct of Identifying Manipulated, Responding, and Constant Variables, Building Hypotheses, Making Observations, Making Inference, and Defining Operationally. The findings of this research are consistent with Piaget's Theory of Cognitive Development (Piaget, 1964) and Vygotsky's Theory of Social Constructivism, which states that social interaction is a force in mental development (Vygotsky, 1978). Effective learning is through communication skills (Wan Husin et al., 2016), creativity and collaboration skills (Ayob et al., 2015), critical thinking skills, and problem-solving skills (Bell, 2010). While communicating with group members, students will obtain new information from other students and exchange information during the exploration process. According to Aziz and Andin (2018), teaching should be carried out actively to apply thinking skills in student learning.

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In this research, activities in the I5E-GI Module promote productive interaction among Form Four students with different knowledge backgrounds, where intelligent and proactive students act as experts. Students explore new knowledge together through positive interaction and effective communication among group members. Integrating group investigation with I5E allows students to learn independently, safely and respectfully among group members (Johnson & Johnson, 2009). This situation encourages students to develop their Level-4 science process skills through learning activities carried out in groups. This kind of cooperative learning aligns with Vygotsky's theory, where students allow each other and their friends in the group to give their opinions during the discussion to plan the investigation. During the discussion process, the weak students and the expert students exchange information, and the weak students get guidance on determining the variables from the expert students.

Based on the I5E-GI module, students in groups also plan and carry out joint investigations under the guidance of the group leader. The group leader ensures that each group member has mastered the construct discussed before moving on to the next construct. Meanwhile, weak students ask for guidance and follow guidance from expert friends. Form Four students in the I5E-GI group are also actively involved in the group by discussing solutions or information for activities that have been planned, as in the I5E-GI module, with peers. Students with lower achievement than other members are helped by friends to make a complete picture with unique and interesting information and understand the meaning of each Level-4 science process skill. The nature of openness to the ideas and views of each student forms a positive practice in acquiring knowledge. The results of this research are supported by Gillies (2003), who suggests that students exposed to cooperative learning are exposed to different relationships, such as giving and receiving help, learning other people's perspectives, expressing their views, and finding new ways to solve problems.

The I5E-GI Module contains six hands-on activities, lasting about three hours each, so students have more fun while learning. Students also better understand the concepts learned by conducting investigations in groups because students can discuss with others. The findings in this research align with the learning theory proposed by Piaget and Vygotsky, who consider interaction with peers to be an important factor in improving cognitive and social development (Gullo, 2006). Therefore, students need to adapt to others in the group and interact effectively to build self-understanding. Learning based on the 5E inquiry-based and Group Investigation model successfully enriches students' knowledge and improves Level-4 science process skills. This finding is also proven by Karsli and Ayas (2014) in a research study which found that the increase in the percentage of students' science process skills test results occurred because students were trained to use science process skills using the 5E learning model such as scientific observation, formulating hypotheses, determining variables, interpreting data, and present the experimental results in the explanation phase.

The implementation of I5E-GI learning is suitable to form a TL environment that is active and not passive, as demanded in 21st-century learning. This is because I5E-GI learning is one method that allows students to learn and teach each other. Somasundram and Mahamod (2017) support this finding through their research, proving that cooperative learning encourages students to teach and learn among themselves. The discipline of knowledge and responsibility in understanding, mastering, and re-explaining to other friends indeed helps produce students who are responsible, actively seek knowledge, and have good communication and social interaction with the demands of 21st-century learning.

5E Inquiry-Based Learning (I5E)

On the other hand, students who only follow the I5E method are not exposed to cooperative learning. The I5E method used in this research only requires students to act on

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their own and carry out all investigations individually with less emphasis on group work. This causes students to have less opportunity to discuss in groups and less to communicate with other students. In addition, they also do not share opinions and listen to criticism from other friends compared to the group of students who follow the I5E-GI learning method. Learning that is implemented individually will cause students' critical thinking to be less developed, so students are weak in giving reasons and solving problems (Klimoviene et al., 2006).

According to Rissi (2010), when students are not actively involved in activities such as solving problems and exchanging ideas, they cannot develop abstract thinking or see their sketches more deeply and diversely. Furthermore, the students who were taught with the I5E method alone lacked an understanding of how to implement group investigation throughout the learning process. In this research, passive students will act as observers who do not contribute to problem-solving and generate ideas. Kagan (1992) agreed that when groups do not organize equal participation, group discussion sessions only involve participation exclusively by high-performing students. Passive students will act as observers who do not contribute to producing sketches and products. Thus, I5E learning without GI is less satisfactory and effective in improving Level-4 science process skills among students when compared to the I5E-GI method.

Traditional Learning (TR)

The teaching that uses the TR method obtained the lowest post-mean scores compared to the I5E-GI and I5E methods at the end of this research. The TR teaching method only relies on the teacher to deliver information during the TL process, and the students only act as receivers. This situation shows that students are not actively involved in group activities or discussions and that TL is teacher-centred. A supportive learning community, as suggested by Johnson and Johnson (2009) and Kagan (1992), is lacking within the TR learning group for the development of Level-4 science process skills. Thus, students are completely dependent on the teacher to obtain new knowledge and information, and it is difficult for students to learn hands-on Level-4 science process skills. In other words, students who follow the TR method do not discuss and share information with other students. Specialists are not needed because only teachers are referred to if there are any problems or questions. In the TR method, teaching is singular, where the teaching process is focused on teachers. Students become passive in the classroom, and this causes students to become listeners and put the teacher at the centre of learning. Indirectly, knowledge becomes limited, and resources are lacking. Students also do not have the opportunity to think and present their own opinions. As a result, their freedom to creatively explore ideas is somewhat limited to sharing ideas or resolving contradictions between their perspectives or with other students. Therefore, students in the TR learning group did not foster as much Level-4 science process skills as students who had participated in the I5E-GI and I5E learning group.

Conclusions and Suggestions

This research aims to answer research questions about the effects of I5E-GI in improving the mastery of the five Level-4 science process skill constructs among Form Four students. The results of the research have shown the positive effect of the I5E-GI method in improving the five Level-4 science process skill constructs, i.e. i) Identifying Manipulated, Responding, and Constant Variables, ii) Constructing Hypotheses, iii) Making Observations, iv) Making Inferences, and v) Defining Operationally. This clearly shows that integrating the I5E-GI method that assimilates 5E inquiry-based learning and group investigation-type cooperative learning has been a catalyst and factor in increasing student mastery of Level-4 science process skills more effectively.

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However, only the topics in the Form Four Core Science syllabus that include experiments were selected in this research. The findings of this quantitative research explain the effects of the I5E-GI method based on the difference in the mean scores of the pre-and post-test. For future studies, it is suggested that qualitative data is also collected through observation, document analysis of student work, and interviews with students involved in the research. With that, the findings of extended research can provide a more detailed explanation of the extent to which the implementation mechanism of I5E-GI affects the research variables.

This research involved only 60 students per teaching method, and may not be representative of the secondary school students' population as a whole. The data in this research were collected after 18 hours of students' learning experiences to analyse its effects quantitatively. Future research will need to employ a larger sample size and a longer period with extra learning activities compared to the current research to extensively assess the learning effects of the I5E-GI method in science lessons.

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Declaration of Interest

The authors declare no competing interest.

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