CHAPTER III METHODOLOGY

3.1 Research Method and Research Design

a. Research Method

The method used in this research is the Quasi Experiment. The design was a pretest-posttest non-equivalent control group design (Creswell &Creswell, 2018). In this study, two groups were observed: the experimental group through the renewable energy project and the control group using conventional methods. The differences in learning between the two research groups explained in Table 3.6.

b. Research Design

This research used the pretest-posttest non-equivalent control group design. This design shows in the table below:

Table 3. 1 Research Design of Non-Equivalent Control Group

Class	Pre-test	Experiment	Post-test
Experiment	O_1	X	O_2
Control	O_1	-	O_2

O_1: Pre-test of students' sustainability action

X: Implementation of the use of STEM-ESD learning on renewable energy project

-: Regular learning methods using self-directed learning through completion of worksheets

O_2: Post-test of students' creativity and sustainability action

3.2 Population and Sample

This research taken place at one of Bogor Junior High Schools, and the curriculum that is especially suitable for this research is Indonesia 2013 Curriculum. The samples in this study were two classes consisting of one experimental and one control class. The sample selection for this study used non probability sampling techniques specifically convenience sampling technique. Convenience sampling technique used because the number of classes available in the target school is limited, which is only 2 classes. So, both of the class should be a sample since this study design encompasses experimental and control class.

Since both of classes were said to have the same level of achievement so both classes have the same probability for being choosen as experimental and control.

3.3 Assumptions

a. The STEM-ESD based learning model offers students numerous opportunities to progress their comprehension of the crucial role of environmental protection, recognize the effects of human activity on the natural environment, cultivate a sense of accountability for the effects of their own actions on the environment, and look for appropriate actions to environmental problems. The STEM-ESD learning also provide the opportunities for students to influence society and organize community actions.
b. The STEM-ESD based learning exposed students to activities that can develop their skills for coming up with original ideas, coming up with novel approaches to problems, considering ecological concerns from various viewpoints so then students can choose proper solution, developing simple concepts into more sophisticated and advanced ones, working in groups to accomplish common objectives, as well as ability evaluating and revising ideas or solutions.

3.4 Hypothesis

The hypothesis of Sustainability Action as follows:

H0: There is no significant difference of students' sustainability action between STEM ESD learning class and conventional learning class

H1: There is a significant difference of students' sustainability action between STEM ESD learning class and conventional learning class

3.5 Research Instrument

Research data were collected with various instruments as seen in Table 3.2.

Table 3. 2 The Research Instrument

No	Data Needed	Instrument
1.	Sustainability Action	Questionnaire
2.	Creativity	Rubric

3.5.1 Questionnaire of Students' Sustainability Action

Instrument for sustainability action was adapted based on Environmental Citizenship Questionnaire (ECQ) with 3 main indicators which are past and present action, future action, and competency within 2 dimension that are individual and collective dimensions (Hadjichambis &Paraskeva-Hadjichambi, 2020). The instrument developed by integrating ECQ indicator with ESD learning goals in cognitive, socio-emotional, and behavior aspects. Items are the developed in the form of 4-likert scale that shown the level of students' frequency of action (past and present action), students' willingness to take action in the future (future action), and students' ability to take action (compentency). The indicator mapping of initial sustainability action instrument can be seen in Table 3.3.

Table 3. 3 The Initial Mapping for Sustainability Action Instrument

Action Indicator	**Sub-Topic *Clean and Affordable Energy***	**ESD *Learning Goals***		
		Cognitive	**Socio-Emotional**	**Behavioral**
Past, Present, and Future Action	Energy Production, Usage and its Impact	1,2	3,4,5,6	7,8
	Energy Efficiency	10,11	12,13,14,15	16,17,18
	Renewable and Sustainable Energy	19,20	21,22,23,24	25,26,27
Competencies	Energy Production, Usage and its Impact	28,29	30,31	32,33
	Energy Efficiency	34,35	36,37	38,39
	Renewable and Sustainable Energy	40,41	42,43	44,45

Validity of Sustainability Action Instrument

Validity pertains to the degree of precision, practicality, suitability, and importance of a certain outcome. Validity is the process of assessing whether a research instrument can actually measure the things that it is intended to test. Reliability refers to a consistency research results using various research methods in conditions (places and time) are different. The statements for the questionnaire of students' action then tested for the validity through correlations analysis and reliability through reliability analysis. If the Sig.2-Tailed result of the

questionnaire statement is less than 0.05 and Cronbach's alpha showed more than 0.06, then the statement categorized as valid and reliable. The result of validity and reliability test for all statements served in Table 3.4. While table of complete validity and reliability originally from SPSS can be seen in Appendix 1 and 2.

Table 3. 4 Recapitulation of Validity and Reliability Result of Past, Present, Future Action

Item Number	**Validity Sig. (2-tailed)**			**Reliability Cronbach's Alpha**	**Int**	**Notes**	**New Item Number**
	Past Action	**Present Action**	**Future Action**				
1	0.685	0.009	0.028	0.915 Reliable	NOT VALID	NOT USED	
2	0.013	0.004	0.006		VALID	USED	1
3	0.156	0.001	0.009		NOT VALID	NOT USED	
4	0.000	0.000	0.000		VALID	USED	2
5	0.005	0.000	0.001		VALID	USED	3
6	0.418	0.151	0.076		NOT VALID	NOT USED	
7	0.001	0.003	0.012		VALID	NOT USED	
8	0.000	0.000	0.003		VALID	USED	4
9	0.027	0.041	0.050		VALID	NOT USED	
10	0.015	0.051	0.015		VALID	USED	5
11	0.083	0.176	0.027		NOT VALID	NOT USED	
12	0.010	0.015	0.047		VALID	USED	6
13	0.000	0.001	0.006		VALID	USED	7
14	0.002	0.001	0.137		NOT VALID	NOT USED	
15	0.001	0.000	0.001		VALID	USED	8
16	0.000	0.000	0.000		VALID	NOT USED	

Item Number	Validity Sig. (2-tailed)			Reliability Cronbach's Alpha	Int	Notes	New Item Number
	Past Action	Present Action	Future Action				
17	0.162	0.106	0.014		NOT VALID	NOT USED	
18	0.417	0.156	0.005		NOT VALID	NOT USED	
19	0.029	0.051	0.040		VALID	USED	9
20	0.050	0.282	0.300		NOT VALID	NOT USED	
21	0.035	0.005	0.042		VALID	USED	10
22	0.268	0.187	0.395		NOT VALID	NOT USED	
23	0.054	0.049	0.005		VALID	USED	11
24	0.048	0.013	0.021		VALID	USED	12
25	0.010	0.111	0.237		NOT VALID		
26	0.622	0.836	0.725		NOT VALID		
27	0.025	0.018	0.039		VALID		

In addition to past, present, and future action indicators, the competency indicators were also tested for student validity and obtained validity and reliability results data as attached in table 3.5.

Table 3. 5 Validity and Reliability Result for Competency Indicator

Item Number	Validity Sig. (2-tailed)	Reliabilty Cronbach's Alpha	Int.	Notes	New Item Number
13	0.009	0.855	VALID	USED	13
14	0.001	Reliable	VALID	USED	14
15	0.000		VALID	USED	15
16	0.000		VALID	USED	16
17	0.009		VALID	USED	17
18	0.013		VALID	USED	18
19	0.001		VALID	USED	19
20	0.011		VALID	USED	20

Item Number	Validity Sig. (2-tailed)	Reliabilty Cronbach's Alpha	Int.	Notes	New Item Number
21	0.003		VALID	USED	21
22	0.000		VALID	USED	22
23	0.002		VALID	USED	23
24	0.001		VALID	USED	24
25	0.001		VALID	USED	25
26	0.000		VALID	USED	26
27	0.006		VALID	USED	27

Based on the validity results above, the final instrument consists of 12 statements that are valid and used out of 27 statements made for indicators of past, present, and future actions. While for competency indicators all statements made are valid and used. New students' action instrument mapping can be seen in Table 3.6 and for full instruments of students' sustainability action respective to SDGs point 7th "Clean and Affordable Energy served in attachment 3.

Table 3. 6 Final Mapping for Sustainability Action Instrument

Action Indicator	Sub-Topic *Clean and Affordable Energy*	ESD *Learning Goals*		
		Cognitive	Socio-Emotional	Behavioral
Past, Present, and Future Action	Energy Production, Usage and its Impact	1	2,3	4
	Energy Efficiency	5	6,7	8
	Renewable and Sustainable Energy	9	10,11	12
Competencies	Energy Production, Usage and its Impact	13,14	15,16	17
	Energy Efficiency	18,19	20,21	22
	Renewable and Sustainable Energy	23,24	25,26	27

3.5.2 Rubric of Students' Creativity

The students' Creativity in this study observed through the final product of renewable energy projects that students make. The rubric used is Creative Product Analysis Matrix (CPAM) with 3 creative dimensions provided are novelty,

resolution, and elaboration. The highest score is 3 and the lowest score is 1 (Besemer, 1998). This description of each criteria and score then constructed in Bahasa Indonesia and validate through the expert judgement. The initial rubric of creativity can be seen in Table 3.7.

Table 3. 7 Creativity Instrument before Revision

Creative Dimension	Criterion	Score 1	2	3
Novelty	Original	*Produk sebagian besar menggunakan temuan sebelumnya sebagai ide*	*Produk menggunakan temuan sebelumnya sebagai ide mereka, tetapi terdapat modifikasi pada produk*	*Ide produk berasal dari pemikiran siswa sendiri*
	Surprise	*Produk ini tidak mempunyai efek kejutan karena produknya sama dengan yang sudah ada dan umum digunakan.*	*Produknya punya efek kejutan, walaupun produknya beda dengan yang sudah ada tapi masih sesuai ekspektasi umum*	*Produk memberikan efek kejutan karena produknya berbeda dengan yang sudah ada dan diluar ekspektasi*
Resolution	Valuable	*Produk ini tidak dibuat menggunakan bahan daur ulang dan membutuhkan biaya tinggi*	*Produk ini dibuat menggunakan bahan daur ulang tetapi membutuhkan biaya tinggi*	*Berharga, produk ini dibuat menggunakan bahan daur ulang dan membutuhkan biaya rendah*
	Useful	*Produk dapat digunakan sekali saja*	*Produk dapat digunakan terus menerus dengan persyaratan tertentu*	*Produk dapat digunakan terus menerus tanpa persyaratan apa pun*
	Logical	*Fitur produk tidak menjawab tujuan*	*Product features answer the*	*Fitur produk menjawab tujuan*

Creative Dimension	Criterion	Score 1	2	3
		dan tidak berdasarkan konsep	*purposes but not based on the concept*	*yang berdasarkan konsep*
	Understandable	*Produknya tidak mudah dipahami oleh semua orang*	*Produk dapat dipahami oleh orang yang memiliki latar belakang pengetahuan terkait*	*Produk mudah dipahami oleh semua orang*
Elaboration	Elegant	*Produknya dibuat dengan baik*	*Produknya dibuat dengan baik dengan desain yang menarik*	*Siswa berusaha memberikan desain produk yang menarik dengan menggunakan beberapa bahan*
	Well Crafted	*Produk ini dibuat dengan kualitas yang sangat rendah*	*Produknya dibuat dengan kualitas buruk*	*Produknya dibuat dengan kualitas yang baik*
	Organic	*Produk disusun dengan menggunakan bahan yang tidak lengkap dan digunakan kurang sesuai dengan fungsinya*	*Produk disusun dengan menggunakan bahan yang tidak lengkap dan digunakan cukup sesuai dengan fungsinya*	*Produk disusun menggunakan bahan-bahan yang lengkap dan digunakan secara tepat sesuai fungsinya*

From the expert judgment the rubric has several revisions, for the Original and Surprise criteria, needs to be differentiated more clearly. For Understandable criterion, the way to assess someone's understanding of how the product works must be clearly measurable. Last, for the well-crafted criterion that highlight the product's quality should be measure by the ability of products to work well. For

overall, the description must not be biased and must be understandable to the assessor. Expert judgement form can be seen in appendix 15. Fixed rubric of creativity product used in this research can be seen in Table 3.8.

Table 3. 8 The Instrument of Creativity after Revision

Indicator	Criteria	Description		
		1	2	3
Novelty	Original	*Ide produk terinsipirasi dari karya orang lain yang sudah ada*	*Ide produk berasal dari karya orang lain sebelumnya, namun ada sedikit perubahan dari ide aslinya*	*Ide produk benar-benar baru dan murni berasal dari pemikiran anggota kelompok*
	Surprise	*Produk terlihat biasa saja karena mirip dengan produk yang sudah ada*	*Produk cukup keren karena ada sedikit perbedaan dari produk yang sudah ada*	*Produk sangat keren kerena amat berbeda dengan produk yang telah ada*
Resolution	Valuable	*Produk dibuat dengan bahan bahan yang mahal dan bukan daur ulang*	*Produk dibuat dengan campuran dari bahan yang mahal dan bahan daur ulang*	*Produk dibuat hanya dengan bahan daur ulang dengan harga terjangkau*
	Useful	*Produk hanya bisa digunakan sekali*	*Produk bisa digunakan berkali-kali dengan beberapa syarat*	*Produk bisa digunakan berkali-kali tanpa syarat*
	Logical	*Produk bukan solusi dari permasalahan energi dan tidak sesuai konsep IPA*	*Produk merupakan solusi dari permasalahan energi namun tidak sesuai konsep IPA*	*Produk merupakan solusi dari permasalahan energi dan sesuai konsep IPA*
	Understandable	*Cara kerja produk sulit dimengerti*	*Cara kerja produk hanya dimengerti oleh sebagian orang*	*Cara kerja produk mudah dimengerti untuk semua orang*

Indicator	Criteria	Description		
		1	2	3
Elaboration and Synthesis	Elegant	*Produk diselesaikan tanpa dihias dan diwarnai*	*Produk diselesaikan dengan tampilan warna yang cukup baik*	*Produk diselesaikan dengan tampilan, hiasan, warna yang menarik*
	Well Crafted	*Produk tidak bekerja dengan baik dan semestinya*	*Produk bekerja dengan baik namun masih harus ada yang diperbaiki*	*Produk bekerja dengan baik dan semestinya*
	Organic	*Komponen produk tidak lengkap dan tidak gunakan sesuai fungsi*	*Komponen produk tidak lengkap namun digunakan sesuai fungsi*	*Komponen produk lengkap dan digunakan sesuai fungsi*

3.6 Research Procedure

3.6.1 Preparation Stage

Several pre-research activities are being carried out throughout the preparation stage. Early initiatives involved developing research instruments such as creativity and sustainability action questionnaires. The instrument was examined by the lecturer and proceeded through numerous revision rounds before being checked for legibility, which was followed by validity and reliability testing.

This includes the development of research equipment for use in teaching and learning activities. Learning designs in the form of lesson plan, learning resources, and student worksheets are the research equipment. Discussion with the teacher was also done to elaborate the lesson plan and worksheet application in classroom settings.

3.6.2 Implementation Stage

The implementation stage consists of several activities carried out as follows:

1) Giving the student pre-test

The pre-test is carried out during the first meeting, which is held in both the control and experimental classes. Before executing the renewable energy project on

organisms and their environment in the experimental class and before conventional learning in the control class, a pre-test was administered to measure students' beginning abilities connected to creativity and students' sustainable activity.

2) Treatment in class activity

After the pre-test was held for students, they started learning about the chapter of environmental issues. The experimental class was treated through renewable energy project activities, while the control class did not carry out the project activities. Full lesson plans for both classes are presented in Appendix 4 and 5. The differences in the implementation of the control class and the experimental class are showed in Table 3.9

Table 3. 9 Comparison of Learning Activities in Control and Experiment Class

Meeting	Experiment Class	Stages of Learning		Control Class
		STEM Model	Conventional Model	
1.	STEM learning ESD based through a renewable energy project. 1. Students recall their knowledge about source of energy (Renewable and Non-Renewable) 2. Students divide into several groups to do the worksheet in the part of analyzing problem of "fossil fuel dependency and the effect"	Formula-ting problem	Analyzing problem	Learning is carried out conventionally learning to support renewable energy learning. 1. Students recall their knowledge about source of energy (Renewable and Non-Renewable) 2. Students divide into several groups to do the worksheet in the part of analyzing problem of "fossil fuel

Meeting	Experiment Class	Stages of Learning		Control Class
		STEM Model	Conventional Model	
	1. Students carry out group worksheet to investigate and explore the solution of the problem given by using technology	Think		dependency and the effect"
2.	1. Students design projects in renewable energy to solve a problem (**fully done outside learning hours in the form of assignments**)	Design	Solution Formulation	1. Students carry out group worksheet to investigate and explore the solution of the problem given by utilizing renewable energy
	1. Students creates the actual product (**completed outside learning hours**)	Create		
3.	1. Students conduct testing of a product. 2. Student get evaluation from peer and teacher	Test	Draw Solutions' Design	1. Students draw their design for renewable energy that has been chosen as the solution for energy problem
	1. Students redesign the product by improving the initial design (**completed outside learning hours as assignment**)	Redesign		

Meeting	Experiment Class	Stages of Learning		Control Class
		STEM Model	Conventional Model	
4.	1. Students disseminate information related to the products they make through social media	Socialization	Communicate the result	1. Students present their findings and get teacher and peer's evaluation
	1. Students and teacher evaluate the final product through final presentation	Final Presentation		

3) Completion Stage

The completion of the treatment was marked by conducting a post-test. For sustainability action, both classes filled out the questionnaire as in the pre-test that was conducted before treatment. As for creativity, post-test data collection was only carried out in the experimental class through the product assessment by peers, teacher, and researcher. After all the required data was collected, the organized data analysis uses numerous tests, including the prerequisite and hypothesis tests. Data interpretation performs after the data evaluation. The investigation findings are then contrasted and evaluated in light of previous literature and research. As the final step, the discussion conclusion is the essence of the research form. Flowchart of research procedure can be seen in Figure 3.1 below.

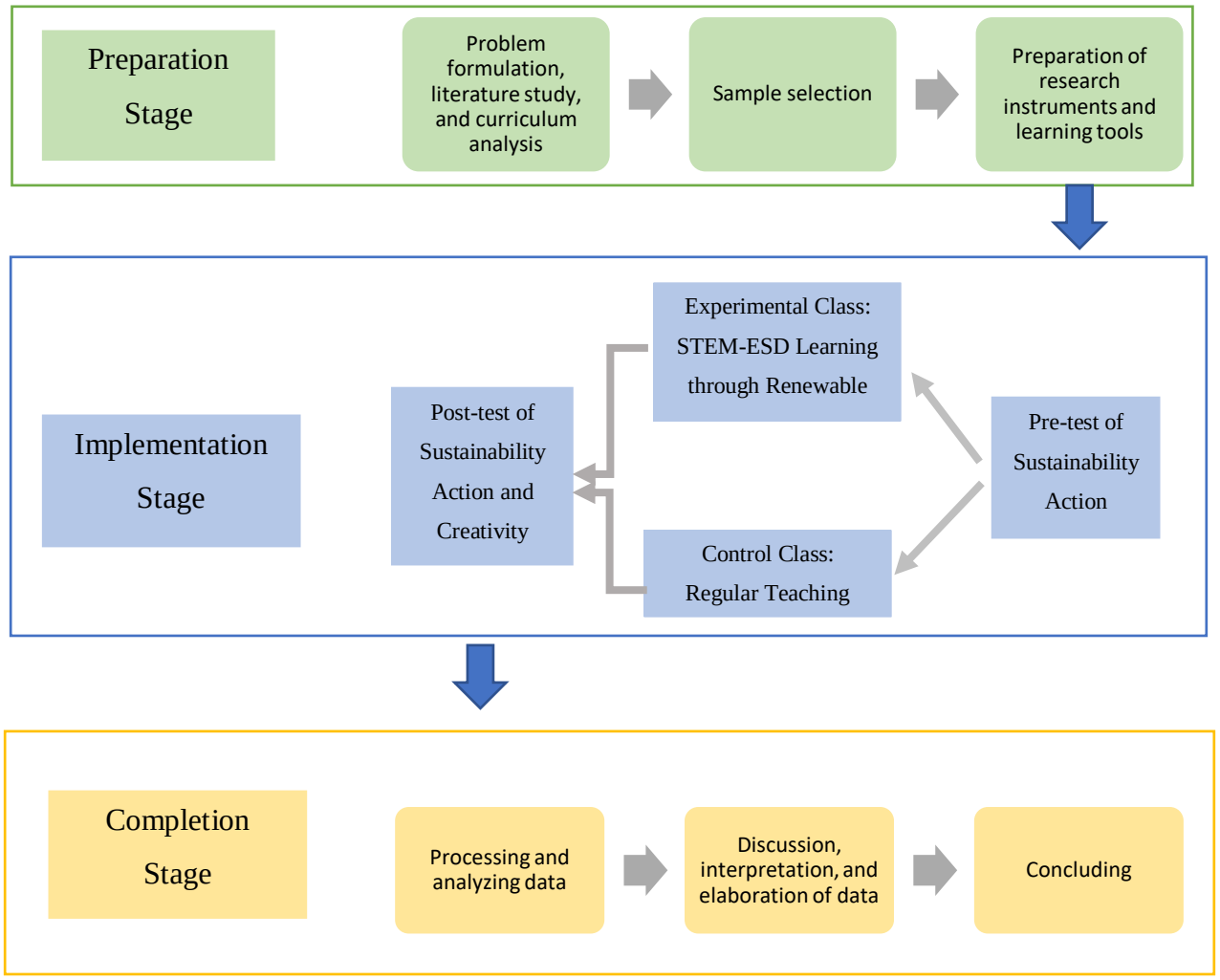

Figure 3. 1 Flowchart of Research Procedure

3.7 Data Analysis

3.7.1 Students Sustainability

Pre-test and post-test data already collected then converted in the form of numbers based on the Likert-scale. The lowest score for positive statement is 1 while the highest is 4, and the negative statement scored opposite. The series of tests that have been conducted to analyze students' sustainability actions are described as follows.

A. Pre-requisite (Normality and Homogenity)

Pre-requisite test conducted to see if the student sustainability action data that has been obtained has a normal distribution. From the normality tests that have been

carried out, the sig. value is 0.265 for control class pretest data, 0.668 for control class post test data, 0.955 for experimental class pretest data, and 0.955 for experimental class posttest data. Homogeneity test results for experimental and control class pretest data show a sig. value of 0.644 and 0.738 for post test data in both classes. All the following values are appeared to be greater than 0.05, hence it can be concluded that all the data of students sustainability action are normally and homogeny distributed.

B. Hypothesis Test

To answer the research question, data of students' sustainability action analyzed through hypothesis test. As stated before, data was normally distributed and homogeny. Hence, independent t-test conducted to determine the significant difference between experimental and control class results. Independent t-test as the form of parametric test can be used to analyze Likert scale response (Sullivan &Artino, 2013). The test was conducted using IBM SPSS by entering the average score of each child in the control and experimental classes as in the data tabulation available in the appendix 6-9.

C. Mean Score Calculation

Mean score of past, present, and future actions are calculated for each students. Then classified to three categories of shift which are decrease, increase, and constant. Then the number of students for each category calculated separately for control and experimental class. For each indicator of sustainability action which are past, present, future action, and competencies the elaboration is done by calculating the mean score of pre-test and post-test for both classes, and compared to see the shifting. Once the average score is obtained, the shift in students' actions from the past, present, and future is tracked. From the results of the data tabulation in appendix 8-9, 7 categories were found in the shift of student actions in time representation. The next analysis is calculated the number of students in each category. This data is then presented in percent form. The calculation of the mean score is also carried out to compare the sustainability score obtained by the experimental and control classes in each action indicator, namely past, present, future action and competence.

3.7.2 Students' Creativity

Analysis of creativity aspects begin with scoring students' product of renewable energy based on the rubric of creativity by peer, teacher and researcher. The lowest score for each criterion is 1, while the highest is 3. Two calculations were carried out in analyzing student creativity data as described below.

a. Mean Score Calculation

This calculation is done by averaging the scores from 3 assessments (peer, teacher, and researcher assessment) for each creativity dimension namely novelty, resolution, and elaboration and synthesis. Average score calculation is done to determine the score obtained by each group in the experimental class. In further elaboration of each dimension of creativity, the calculation of the average score obtained by each group on each criterion was also carried out. Full data tabulation of creativity mean score can be seen in appendix 10.

b. Conversion of Mean Score to Scale of 100

After all the required average scores are calculated, the scores are then converted from a scale of 1,2,3 to a scale of 100 through the formula.

$$NP = \frac{GS}{MS} \times 100\%$$

Where:

NP = Percentage Value GS = Gained Score MS = Maximum Score