CHAPTER III
RESEARCH METHODOLOGY

3.1. Research Method and Research Design

3.1.1. Research Method

The method used in this research was the Quasi Experiment. A pretest-posttest non-equivalent control group design was used. In this study, two groups were observed: the experimental group working on an environmental pollution project using STEM ESD learning steps and the control group learning about the same subject using the teacher's regular teaching strategies. The same teacher instructed both groups.

3.1.2. Research Design

This research used the pretest-posttest non-equivalent control group design. The design is shown in Table 3.1 below:

Table 3. 1 Research Design of One Group Pre-test and Post-test

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 the environmental pollution learning project

-: Teacher's regular learning methods

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

3.1.3. Operational Definition

1) STEM ESD-based learning through the environmental pollution project

The process of STEM and ESD projects focus on students' involvement in finding solutions to the stem pollution problem using the stem learning stages. The

Preventing Environmental Pollution project is learning on environmental pollution topic by creating a project.

2) Sustainability action

Students' sustainable action competency was measured by a questionnaire using a 4-point Likert scale. The questionnaire is related to the SDGs goals number 3, which is good health and well-being. In the very first meeting, students was given the questionnaire as a pre-test, and at the last meeting, students also was given the same questionnaire as a post-test so the researcher can compare it with the pre-test to see the difference. The data that has been obtained then be processed using SPSS software.

3) Creativity

The students' product creativity was measured using a rubric with 3 indicators in the form of novelty, resolution, and elaboration indicators. The prototype products was collected at the end of the learning process, then the researcher and the teacher assessed the product using the creativity product analysis matrix (CPAM) rubric that was developed by Besemer and Treffinger in 1981 to score each criterion group's product.

3.2. Population and Sample

The population in this study was 7th-grade students at one of the private junior high schools in Bandung. Merdeka Curriculum was selected as the specific curriculum for this study. The research license used can be seen in Appendix 1. Two classes, one experimental and one control, made up the samples for this investigation. The sampling method used was a convenience sampling technique, the sampling was drawn from the availability of the elements as well as the ease of obtaining them. A class that was thought to have similar baseline knowledge and had not previously been exposed to the environmental pollution issue was chosen as the sample.

3.3. Assumption

1. STEM ESD-based learning provides an opportunity for students to develop the ability to generate new ideas, uniqueness in approach or solution, the ability to think from various points of view, the ability to adapt approaches in different situations, the ability to develop basic ideas into more complex and mature, cooperation in teams to achieve common goals and the ability to assess and revise ideas or solutions.
2. STEM ESD-based learning provides an opportunity for students to increase their understanding of the importance of protecting the environment, realize the impact of human activities on the environment, develop a sense of responsibility for the impact of personal actions on the environment, and seek creative and innovative solutions to environmental problems.

3.4. Hypothesis

1. H_0: There is no significant difference in students' sustainability action between the experiment class and the control class after learning Environmental Pollution by Preventing Environmental Pollution project
2. H_1: There is a significant difference in students' sustainability action between the experiment class and the control class after learning Environmental Pollution by Preventing Environmental Pollution project

3.5.Research Instrument

The research instrument used in this research is shown in Table 3.2

Table 3. 2 The research instrument

No	Data needed	Instrument
1.	Sustainable action	Questionnaire
2.	Creativity	CPAM rubric

Research data were collected with various instruments as follows:

3.5.1. Sustainability Action Questionnaire

Sustainable action was measured using the Environmental Citizenship Questionnaire (ECQ), it is served as the basis for the development of an instrument for understanding sustainability. Environmental Citizenship Questionnaire (ECQ) is a validated measure for assessing secondary school students' environmental citizenship. The purpose of this questionnaire is to assess students' responsible pro-environmental conduct and social participation in addressing environmental issues and supporting sustainable development. It assesses secondary school students' environmental citizenship using six essential elements, such as general citizenship, which evaluates the student's understanding and practice of general citizenship principles, such as social participation and engagement in societal issues, key sustainability, which assesses the student's knowledge, skills, and attitudes related to sustainability, including their understanding of environmental issues and their ability to act sustainably, and socio-environmental awareness, which measures the students' awareness of social and environmental issues (Hadjichambis & Paraskeva-Hadjichambi, 2020).

Indicators of good health and well-being actions are past, present, and future actions, and competency outcomes from the environmental citizenship questionnaire. The score used is a 1-4 Likert scale, with a minimum score of 1 and a maximum score of 4, with a choice of various options according to the indicator, namely, never, rarely, often, always for past and present indicators, won't do, maybe will do, trying to do, sure will do for future indicators and really incapable, unable, able and very capable for competences indicators. The instrument is tested before (Pretest) and after (Post-test) the learning activities in both experiment and control class. The analysis of student action descriptions is presented in Table 4.1 using a scoring range of 1-4. The scores of students' pretest and post-test results are analyzed using statistical calculation through difference tests to see the influence of STEM-ESD-based learning. pretest results are used to identify students' initial actions before learning activities are carried out, while the results of post-test scores are used to measure the actions taken by students after the learning process.

The explanation will begin with the meaning of data that has been processed statistically. Then continue to the discussion of the result of implementing STEM learning activities while making the product. Then, finally will end up with a detailed analysis of students' sustainability action through the topic using SPSS. An explanation of each action indicator is detailed in this subchapter. The research results include quantitative and qualitative data that were analyzed systematically. As the prerequisite, normality tests and homogeneity tests are carried out first. The questionnaire consists of 36 items: the past, present, and future action indicator is covered by 18 items and the competencies are covered by 18 items. The detailed action instrument can be seen in Appendix 2. Respondents were asked to indicate how much they agreed with both the positive and negative statements on a 4-point Likert scale. Table 3.3 shows the blueprint of sustainability action instruments before validation.

Table 3. 3 Blueprint of sustainable action questionnaire (before validation)

No	**Indicator**	**Number of questions**			**Total number**
		Health	Disease prevention	Health promotion	
1	Past, present, and future actions	1,2,3,4,5,6	7,8,9,10,11,12	13,14,15,16,17,18	**18**
2	Competences	1,2,3,4,5,6	7,8,9,10,11,12	13,14,15,16,17,18	**18**

(Source: Hadjichambis & Paraskeva-Hadjichambi, 2020)

3.5.1.1. Sustainable Action Instrument Analysis

Before being distributed, the instrument was validated by experts' judgment. The result is attached in the Appendix 3. Then the instrument was revised and tested by the student. After measuring the scores of the pre-test and post-test, the data was analyzed using IBM SPSS to see the validity and reliability.

a) Validity

Validity refers to a given result's accuracy, usefulness, and significance. The interpretation of the validity score is shown in Table 3.4.

Table 3. 4 Validity Interpretation

rValue	Interpretation
$r \geq 0.37$	Valid
$r \leq 0.37$	Not valid

The result of the validation analysis of the sustainable action questionnaire on past, present, and future indicators is presented in Table 3.5.

Table 3. 5 Recapitulation of sustainable action questionnaire past, present, and future indicator

Item number	First trial Validity			Reliability	Valid	Second trial Validity			Reliability	Conclusion
	Past action	Present action	Future action			Past action	Present action	Future action		
1	0.20	0.38	0.48	0.70	Not valid	0.04	0.38	0.48	0.72	**Rejected**
2	0.31	0.31	0.73	0.70	Not valid	0.43	0.61	0.73	0.66	**Accepted**
3	0.20	0.47	0.38	0.71	Not valid	0.55	0.47	0.38	0.64	**Accepted**
4	0.13	0.60	0.63	0.69	Not valid	0.43	0.60	0.63	0.64	**Accepted**
5	0.46	0.53	0.37	0.71	Valid					**Accepted**
6	0.09	0.39	0.13	0.72	Not valid	0.68	0.39	0.44	0.62	**Accepted**
7	0.19	0.03	0.09	0.73	Not valid	0.60	0.25	0.10	0.68	**Rejected**
8	0.32	0.46	0.36	0.71	Not valid	0.40	0.46	0.53	0.66	**Accepted**
9	0.14	0.20	0.15	0.71	Not valid	0.33	0.09	0.13	0.68	**Rejected**
10	0.35	0.21	0.54	0.70	Not valid	0.39	0.37	0.54	0.66	**Rejected**
11	0.46	0.42	0.23	0.71	Not valid	0.46	0.42	0.43	0.65	**Accepted**
12	0.39	0.22	0.27	0.71	Not valid	0.39	0.36	0.41	0.63	**Rejected**
13	0.41	0.38	0.51	0.70	Valid					**Accepted**
14	0.49	0.55	0.55	0.70	Valid					**Accepted**
15	0.36	0.50	0.66	0.69	Valid					**Accepted**
16	0.56	0.57	0.55	0.70	Valid					**Accepted**
17	0.24	0.51	0.49	0.70	Not valid	0.40	0.51	0.49	0.62	**Accepted**
18	0.56	0.44	0.31	0.71	Not valid	0.56	0.44	0.41	0.64	**Accepted**

After the first and second trials, it was found that 5 out of 18 questions were invalid, but since the valid statements already represented all sub-indicators, the number of statements used for the instrument to measure students' sustainability of good health and well-being in the past, present, and future indicators was 13 numbers. The result of the validation analysis of the sustainable action questionnaire on the competencies indicator is presented in Table 3.6.

Table 3. 6 Recapitulation of sustainable action questionnaire competencies indicator

Number of test items	Validity	Reliability	Conclusion
1	0.38	0.72	**Accepted**
2	0.47	0.72	**Accepted**
3	0.67	0.71	**Accepted**
4	0.50	0.72	**Accepted**
5	0.58	0.72	**Accepted**
6	0.49	0.73	**Accepted**
7	0.54	0.72	**Accepted**
8	0.72	0.73	**Accepted**
9	0.39	0.72	**Accepted**
10	0.66	0.71	**Accepted**
11	0.50	0.72	**Accepted**
12	0.55	0.71	**Accepted**
13	0.35	0.73	**Rejected**
14	0.51	0.72	**Accepted**
15	0.39	0.72	**Accepted**
16	0.56	0.71	**Accepted**
17	0.59	0.71	**Accepted**
18	0.55	0.72	**Accepted**

The process of developing an instrument starts with understanding each indicator that has been developed (Hadjichambis & Paraskeva-Hadjichambi, 2020). The researcher then modifies the instrument items by the topic of sustainable

development that has been raised, which is environmental pollution, which is linked to the topic of science learning. For this reason, the researcher has prepared 36 items that will be tested. Before that, the instrument went through the stages of expert judgment, and revision to see the diction, suitability of indicators, and the provision of concepts by the junior high school level. Then the researchers tested the instrument on 30 students, the results showed that 25 out of 36 items were declared valid after being processed using SPSS software. The instrument trial aims to test the validity and degree of reliability of the instrument, to ascertain whether the statements can be accepted and understood by the respondents, and to determine the length of time needed to fill out the instrument. All valid items will be used in measuring students' good health and well-being actions.

Because in the competency indicator, the health promotion aspect does not meet the criteria, statement number 13 is revised so that it can be used. So, the number of good health and well-being action instruments used in the study after conducting the validity test was 31 statement items with a choice of various options according to the indicator, namely, never, rarely, often, always for past and present indicators, won't do, maybe will do, trying to do, sure will do for future indicators and really incapable, unable, able and very capable for competences indicators. The complete instrument items can be seen in the appendix. The blueprint of the sustainable action questionnaire after validation is given in Table 3.7. The tabulation of data is shown in Appendix 4.

Table 3. 7 Blueprint of sustainable action questionnaire (after validation)

No.	**Indicator**	**Number of questions**			**Total**
		Health	Disease prevention	Health promotion	**number**
1	Past, present, and future action	1,2,3,4	5,6,7,8	9,10,11,12,13	**13**
2	Competences	1,2,3,4,5,6	7,8,9,10,11,12	13,14,15,16,17,18	**18**
	Total	10	10	11	**31**

The instrument uses simple language and is easily understood by junior high school students. Examples of instruments that have passed the validity test and reliability test can be seen in Table 3.8.

Table 3. 8 Sample statement of the good health and well-being action instrument

Indicator	Statement
Past, present, and future action Competences	*Saya membawa bekal makan dan botol minum sendiri dari rumah* *Saya bertanggung jawab terhadap kesehatan diri sendiri dengan cara menerapkan gaya hidup sehat*

3.5.2. Creativity CPAM rubric

Besemer and Treffinger (1981) developed the Creative Product Analysis Matrix (CPAM) which consists of Novelty, Resolution, Elaboration, and synthesis. The final products of students' projects were assessed using the CPAM rubric to asses students' creativity. The instrument of CPAM can be seen in Table 3.9.

Table 3. 9 Instrument for Creative Product Analysis Matrix (CPAM)

Creative Dimension	Criterion	Description	Score
Novelty	1. Originality 2. Surprise	1. Look for aspects that have not been previously seen or used. 2. Evaluate how much the product or idea challenges expectations.	1 2 3
Resolution	1. valuable 2. logical 3. usefulness 4. understandable	1. The extent to which the product provides significant benefits or utility to its users. 2. The solution should be internally consistent and	

Creative Dimension	Criterion	Description	Score
		rational. 3. Assess the practical benefits of the product or idea. 4. The degree to which the product is easy to comprehend and use.	
Elaboration	1. Organic qualities 2. Elegance 3. Well-crafted	1. How naturally the product fits into its environment or context, and how well its components work together in harmony. 2. The simplicity and gracefulness of the product's design and function. 3. The level of skill and attention to detail involved in the creation of the product.	

source: (Treffinger, 1981)

According to this criteria, each score represents the degree of student product creativity. The highest score is 3, and the lowest score is 1.

3.6. Research Procedure

The procedure in this study was divided into three stages, namely research preparation, research implementation (data collection), and completion (data processing, analysis, and conclusion drawing). The details of the activities are described as follows.

3.6.1. Preparation Stage

At the preparation stage, researchers did several pre-research activities. For example, conducted a literature review, and gathered information related to environmental pollution topics and projects STEM ESD-based learning, and students' sustainability action and creativity. Additionally, a research proposal was developed, which outlined the study problem, research questions, and operational definitions to direct the research procedure. Moreover, research materials were created and employed in instructional activities. The lesson plan, media, and student worksheet were among the research tools. The development of research instruments was done through the sustainability action and creativity of students. Before being subjected to the validity and reliability testing, the instrument was evaluated by the lecturer and underwent several revision steps. The researcher also held discussions with the teacher regarding the class to be used as a sample, determining the control and experimental classes, teacher training on how the STEM lesson plan that the researcher made and other things. Additionally, administrative preparations were completed, including speaking with the school's science instructor about the study methods and requesting official research permits from the school.

3.6.2. Implementation Stage

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

a. Giving a pre-test to students

Pretests of sustainability actions were administered at the start of each activity or the first meeting for the control and experimental groups. Before beginning the environmental pollution project in the experimental class and before engaging in the teacher’s regular learning in the control class, students were given a pre-test to ascertain their initial abilities for sustainability action. The students were given the sustainability action instruments using paper.

b. Giving treatment in a class

After the pre-test was held, the students started learning about environmental pollution. The experimental class was treated through environmental pollution project activities with project STEM ESD-based learning, while the control class

was treated as the teacher usually does. Teaching materials in the form of lesson plan worksheets used in experimental and control classes can be seen in Appendix 5. The differences in the implementation of the control class and experimental class are presented in Table 3.10.

Table 3. 10 Differences in Learning Activities of the Control Class and Experiment Class

Meeting	**Control class**	**Learning stages**		**Experiment Class**
		STEM model	**Teacher's regular model**	
1	a) Pray before learning begins b) Attendance/checking student attendance c) The teacher gave students pre-test questions about sustainability action. d) The teacher gave students pre-test questions about sustainability action. e) The teacher focuses attention on displaying the	Orientation Stimulation	Introduction Problem formulation	a) Pray before learning begins b) Attendance/checking student attendance c) The teacher gave students pre-test questions about sustainability action. d) The teacher gave problems related to the polluted cities in Indonesia and its consequence e) students divide into 4 groups f) The teacher

Meeting	Control class	Learning stages		Experiment Class
		STEM model	Teacher's regular model	
	photos in the PowerPoint about environmental pollution around us f) The teacher asks questions to students related to environmental pollution images g) The teacher explains brief material about environmental pollution h) The teacher distributes worksheets to each group i) The teacher conveys the steps that students will take j) Teachers provide	Problem statements	Think	distributes worksheets to each group g) Students carry out group discussions to investigate and explore problems by filling in the worksheet

Meeting	Control class	Learning stages		Experiment Class
		STEM model	**Teacher's regular model**	
	opportunities for students to ask things that are not understood in the LKPD questions			
2	a) The teacher guides students to collect and explore the observation data and answer questions on the LKPD b) Each group completes the data requested on LKPD c) The teacher guides students to process data obtained from the results of observations and answers questions on the LKPD	Data collection Data processing	Design Create	a) Students sketched their product design on the worksheet b) Students create the product guided by the teacher c) Students continue their work at home in groups

Meeting	Control class	Learning stages		Experiment Class
		STEM model	**Teacher's regular model**	
	d) The teacher goes around to each group giving guidance			
3	a) The teacher provides opportunities for group representation to present the results of the discussion b) Teachers as moderators, motivators, and facilitators guide students in discussions c) The teacher gives opportunities to other groups to respond, give comments, and question. d) Students together with the teacher conclude the	Generalization	Test Re-design	a) Students presented the product b) Students conducted testing of a product. c) Researcher and teacher assess the product by CPAM rubric d) Students redesign the product by improving the initial design.

Meeting	Control class	Learning stages		Experiment Class
		STEM model	**Teacher's regular model**	
	topic			
4	a) Students made a poster and shared it on social media b) The teacher gives students post-test questions about sustainability action	Socialize	Socialize	a) Students made a poster and shared it on social media b) The teacher gives students post-test questions about sustainability action.

c. Giving a post-test to students

Post-tests are administered at the end of the activity on the last meeting for the control and experimental groups. The students were given the sustainability action instruments using Google Forms. The post-test of students' creativity was also given in the experiment class, and the CPAM rubric given to students for peer assessment, and also judged by the teacher and researcher.

3.6.3. Completion Stage

After collecting the data, the researcher analyzed the data using a questionnaire and rubric results. Interpret the result to become a discussion and conclusion. And completing the research paper.

3.7.Research Flow

The following is a flowchart that summarizes the entire research flow:

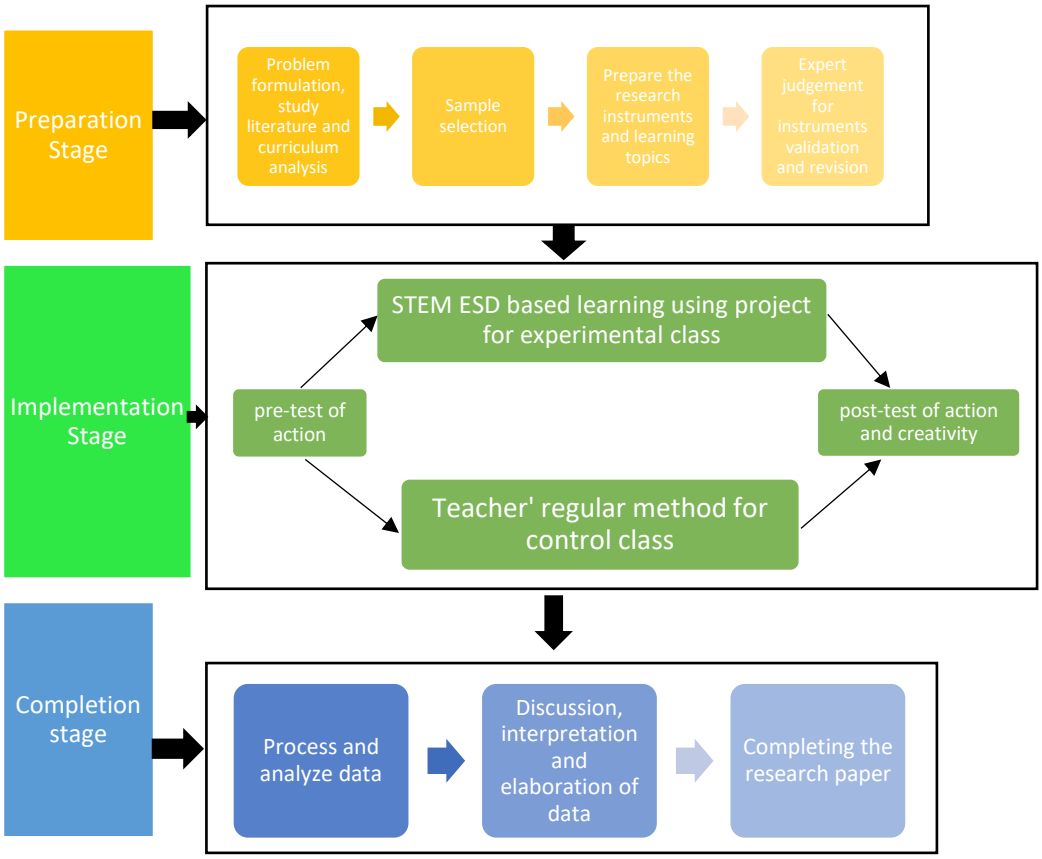

Figure 3. 1 Research Flow

3.8. Data Analysis of Result

The data resulted in the form of scoring both sustainable action and creativity variables. After data was collected, the data was grouped by using Microsoft Excel 2019 software first, then it through several stages of analysis using SPSS software. It aims to obtain further information regarding the difference or relationship between the control group and the experimental group through the pre-test and post-test scores. The stages are explained below:

3.8.1. Sustainable action

The pre-test and post-test data generated in the form of statements were converted into numbers to facilitate data processing and interpretation. The lowest score of each statement is 1 and the highest is 4. In this study, the Likert scale is

interval data which is then tested with a parametric test in the form of a t-test if it meets data normality (Sullivan & Artino, 2013). Negative and positive statements differ in that the highest and lowest scores are reversed.

Data processing for experimental and control classes was carried out with a prerequisite test, namely the normality test and also the homogeneity test. After the prerequisite test is carried out, it is continued with the average test on the initial and final data of the sustainability action for the experimental and control classes. In addition, a gain test was also carried out by reducing the value of each learner's post-test results by the pre-test value. After that, the N-gain test was carried out to determine whether the achievement of students was at a low, medium, or high level. The N-Gain test is widely used to measure the effectiveness of educational interventions across various disciplines. In statistics education, it demonstrated significant improvement in student learning outcomes (Wahab et al., 2021).

3.8.1.1. Normality test

The purpose of the normality test was to ascertain whether or not the collected data originated from regularly distributed populations. Since there are only a few research participants or around 30 participants, the Saphiro-Wilk test was used. The $\alpha = 0.05$ significance level was applied. Normal data is data with p value > $(\alpha) = 0.05$.

Based on the results of the normality test using SPSS software, the significance of the experimental and control class sustainable action data on the pretest data is 0.833 and 0.097. However, the control class's post-test value is 0.207 and the experiment class's is 0.129. Both values were regarded as normal data distributions since the results were higher than the significance level of 0.05 (p>0.005). The detailed data is shown in the Appendix.

3.8.1.2. Homogeneity test

In addition to the normality test, the homogeneity test is also a prerequisite for conducting parametric tests. The homogeneity test is carried out to show the homogeneity of a variant or whether several population variants are the same or

not. The significant level used is $(\alpha) = 0.05$. The significance value of the homogeneity test is 0.00, this can be interpreted as the initial data of continuous action is not homogeneous.

3.8.1.3. Hypothesis test

The following phase of analysis was the use of a non-parametric test to determine the influence of the STEM ESD-based learning project on the secondary students' sustainable action, given the participant count for the experiment class was only 32, while the control class had 36. Considering Sig (2-tailed) values less than 0.005 (=0.00) indicate that H1 is accepted and H0 is rejected, the result of 0.000 indicates that the hypothesis is significant.

3.8.2. Creativity

Students' creativity was investigated based on their product results. Students' creativity indicators were assessed by using rubric scoring under the creativity dimension from Besemer and Treffinger (1981) and converted into percentages. The formula for converting the score is as follows:

$$NP = \frac{R}{SM} \times 100\%$$

Where:

NP = the percent expected

R = raw score obtained

SM = maximum score

Students' creativity is assessed by the products they make. In groups, students make various kinds of tools that they think can help solve existing environmental pollution problems. The assessment is seen from several indicators, namely novelty, resolution, elaboration, and synthesis. Assessment data was obtained during the assessment process carried out by peers, teachers, and researchers when students presented and tested their products in class. The scores they get are initially on a scale of 1 to 4, which means 1 is the lowest score and 4 is the highest score. After combining the results of peer, teacher, and researcher

assessments, the data was converted into a 100 percent scale using the formula mentioned.