CHAPTER III
METHODOLOGY

3.1 Research Method and Research Design

1) Research Method

The method of this research is quantitative method. Quasi-experiment was used in this study. Two groups were observed throughout the quasi-experiment method of research: the experimental group and the control group. The researcher chose a quasi-experiment because it does not assign student participants to the groups randomly. The independent variable in this research is the use of the Climate Hero project in ESD-based STEM learning, while the dependent variable in this study is sustainability action and creativity.

2) Research Design

The research design used in this research was the pretest-posttest non-equivalent control group design. In this design, there are two groups namely experimental and control groups. Both groups took pre-tests and post-tests, but only the experimental group conducted a treatment. The treatment used is to implement ESD-based STEM learning through working on the Climate Hero project in learning climate change. Meanwhile, the control group did not work on Climate Hero project, instead, they used regular practice learning. This design is shown in the Table 3.1.

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

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 : Learning implementation through ESD-based STEM learning on Climate Hero project

\- : Regular practice learning methods

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

3.2 Population and Sample

The group that became the population consisted of all grade 7 students in one of the private junior high schools in Bandung that implemented the Merdeka Curriculum. Meanwhile, the sample in this study was divided into two classes: experimental class, which consisted of 49 students (7A and 7D) and control class, which consisted of 41 students (7C and 7E). The convenience sampling technique was used in this research because of the limited number of classes in the school and the sample fulfilled the requirements to study the topic. Convenience sampling involves the selection of participants based on their frequent readiness and availability (Taherdoost, 2016).

3.3 Assumptions

1) The ESD-based STEM learning on Climate Hero project provides students with an overview of the climate change phenomenon and provides an opportunity to solve the problem by making a technology-based product, so that students become creative and innovative individuals who have a high concern for climate issues by taking concrete actions.
2) Through working on the Climate Hero project in ESD-based STEM learning, students can understand the relationship and the urgency of sustainability action and creativity in addressing climate issues to achieve Sustainable Development Goals 13, Climate Action.

3.4 Hypothesis

The hypothesis of the research is:

H_0: There is no significant difference in sustainability action between the experimental class and control class.

H_1: There is a significant difference in students' sustainability action between the experimental class and control class.

3.5 Research Instrument

The instrument to obtain the data was required. For this study, there were two instruments for measuring each of the dependent variables: students' sustainability action and creativity (Table 3.2).

Table 3. 2 Research Instrument

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

3.5.1 Students' Sustainability Action

To measure students' sustainability action, the Environmental Citizenship Questionnaire (ECQ) was used, which was developed by (Hadjichambis & Paraskeva-Hadjichambi, 2020). Moreover, the questionnaire statement was made by considering the SDGs Climate Action learning objective, which was divided into four sub-topics: greenhouse gases, climate change's impact, adaptation to climate change, and prevention & mitigation. In addition to considering the learning objectives that have been compiled, making statements also follows the aspects of learning objectives, namely cognitive, socio-emotional, and behavioural aspect. This instrument measured learner action through two indicators: past, present, and future actions and competence. There are two types of questionnaire statements which are positive and negative.

For the positive statement scoring in the past and present action indicator, the scale used was 1 for "never", 2 for "seldom", 3 for "often" and 4 for "always". For the future action indicator, the scoring includes 1 for "certainly not do this", 2 for "hesitate to do this", 3 for "try to do this", and 4 for "certainly do this". Moreover, for the competency indicator, the scale used was 1 for "very incapable", 2 for "incapable", 3 for "capable", and 4 for "very capable". Meanwhile, the negative

statement scoring is reversed from 1 for “always”, “certainly do this”, or “very incapable” in series to 4 for “never”, “certainly not do this”, or “very incapable”.

After writing an instrument that has been represented each indicator of sustainability action and ESD learning goals aspects, the instrument was checked by the supervisor. Then, the instrument was given judgment by the experts. For the sustainability action instrument, the feedback given from the experts was 1) Revise the statement to be more relevant to junior high school students' daily activities 2) Revise the complex words so that junior high school students could easily understand the context of the statements 3) Complete the reference of the instruments. The initial indicator mapping of the sustainability action instrument can be seen in Table 3.3.

Table 3. 3 The Initial Mapping of Sustainability Action Instrument

Indicator of Sustainability Action	**Sub-Topic *Climate Action***	**ESD *Learning Goals***			**Total**
		Cognitive	Socio-emotional	Behavioural	
Past actions, present actions, and future actions	Greenhouse gases	1,2	3,4,	5,6	30
	Climate change’s impact	7,8	9,10,11	12,13,14	
	Adaptation to climate change	15,16,17	18,19,20	21,22,23	
	Prevention and mitigation	24,25	26,27	28,29,30	
Competencies	Greenhouse gases	1,2	3,4	5,6	24
	Climate change’s impact	7,8	9,10	11,12	
	Adaptation to climate change	13,14	15,16	17,18	
	Prevention and mitigation	19,20	21,22	23,24	

The next step involved testing the validity and reliability of the questionnaire with junior high school students. The validity test was conducted in two phases with 30 students and 32 students to ensure all indicators and ESD learning goals were met. The instrument trials aimed to assess the validity and readability of each statement to ensure that the statement can be accepted and understood by respondents. SPSS software was utilized to check the validity and reliability of the instrument. Cronbach's alpha was utilized to analyze the instrument's reliability. The past action obtained a reliability score of 0.683, the present action score was 0.599, and for the future action, the reliability score was 0.528. This indicates that the instrument was reliable (Cronbach's alpha > r table $_{(0.361)}$). The outcome of the first and second trial validity tests for past, present, and future actions are presented in Table 3.4. Meanwhile, the validity and the reliability result competence indicator can be seen in Table 3.5.

Table 3. 4 The First and Second Trial Results of Validity in Past, Present, and Future Action

Item Number	First Trial Validity Sig. (2-tailed)			Valid	Second Trial Validity Sig. (2-tailed)			Valid	Notes
	Past Action	Present Action	Future Action		Past Action	Present Action	Future Action		
1	0.53	0.02	0.11	No	0.03	0.00	0.00	valid	Used
2	0.19	0.00	0.60	No	0.12	0.01	0.00	No	Not used
3	0.05	0.09	0.26	No	0.00	0.00	0.00	valid	Used
4	0.22	0.18	0.34	No	0.06	0.03	0.00	No	Not used
5	0.23	0.36	0.10	No	0.04	0.01	0.19	No	Revised & used
6	0.98	0.88	0.64	No	0.07	0.00	0.93	No	Not used
7	0.00	0.01	0.00	valid					Used
8	0.00	0.00	0.38	No	0.05	0.28	0.00	No	Not used
9	0.01	0.08	0.03	No	0.01	0.00	0.00	valid	Used
10	0.00	0.12	0.00	No	0.00	0.00	0.00	valid	Used
11	0.10	0.60	0.08	No	0.22	0.02	0.04	No	Not used

Item Number	First Trial Validity Sig. (2-tailed)			Valid	Second Trial Validity Sig. (2-tailed)			Valid	Notes
	Past Action	Present Action	Future Action		Past Action	Present Action	Future Action		
12	0.20	0.03	0.27	No	0.62	0.46	0.71	No	Not used
13	0.08	0.64	0.46	No	0.74	0.46	0.98	No	Not used
14	0.07	0.20	0.03	No	0.00	0.00	0.00	valid	Used
15	0.50	0.12	0.26	No	0.31	0.51	0.52	No	Not used
16	0.00	0.00	0.10	No	0.00	0.00	0.00	valid	Used
17	0.01	0.00	0.00	valid					Used
18	0.00	0.06	0.02	No	0.01	0.00	0.00	valid	Used
19	0.00	0.03	0.16	No	0.00	0.00	0.00	valid	Used
20	0.03	0.05	0.01	No	0.01	0.00	0.00	valid	Used
21	0.01	0.01	0.00	valid					Used
22	0.35	0.08	0.04	No	0.00	0.06	0.78	No	Not used
23	0.00	0.00	0.01	valid					Used
24	0.00	0.00	0.27	No	0.00	0.01	0.04	valid	Used
25	0.59	0.75	0.49	No	0.46	0.21	0.95	No	Not used
26	0.06	0.17	0.14	No	0.00	0.04	0.00	valid	Used
27	0.03	0.23	0.03	No	0.00	0.00	0.08	No	Not used
28	0.10	0.03	0.00	No	0.04	0.06	0.33	No	Not used
29	0.00	0.00	0.04	valid				used	Used
30	0.03	0.58	0.04	No	0.22	0.32	0.27	No	Not used

Table 3. 5 The First and Second Trial Results of Validity and Reliability in Competence Indicator

Item Number	First Trial Second Trial Validity Sig. (2-tailed)	Valid	Reliability (Cronbach alpha)	Notes
31	0.00	Valid	0.855	Used
32	0.00	Valid		Used

Item Number	First Trial Validity Sig. (2-tailed)	Second Trial	Valid	Reliability (Cronbach alpha)	Notes
33	0.60	0.058	No	(Reliable)	Not used
34	0.12	0.00	Valid		Used
35	0.45	0.00	Valid		Used
36	0.28	0.00	Valid		Used
37	0.00		Valid		Used
38	0.00		Valid		Used
39	0.584	0.91	No		Not used
40	0.05		Valid		Used
41	0.00		Valid		Used
42	0.005		Valid		Used
43	0.10	0.01	Valid		Used
44	0.00		Valid		Used
45	0.00		Valid		Used
46	0.00		Valid		Used
47	0.00		Valid		Used
48	0.00		Valid		Used
49	0.00		Valid		Used
50	0.00		Valid		Used
51	0.00		Valid		Used
52	0.85	0.03	Valid		Used
53	0.00		Valid		Used
54	0.00		Valid		Used

After conducting validity and reliability tests, it is known that the total number of valid questionnaire items was 38. However, there was one aspect of the SDGs learning objective that did not fulfilled. Therefore, 1 statement item was revised to

fulfil one of the aspects of the SDGs learning objective and used in the questionnaire. Furthermore, based on the results of instrument validation and reliability, the final sustainability action instrument grid used is shown in Table 3.6 and the detailed questionnaire statements are attached in Appendix 1.

Table 3. 6 The Final of Sustainability Action Questionnaire Grid

Indicator of Sustainability Action	**Sub-Topic Climate Action**	**ESD Learning Goals**			**Total Item**	**%**
		Cognitive	Socio-emotional	Behavioural		
Past actions, present actions, and future actions	Greenhouse gases	1	2	3	17	44
	Climate change's impact	4	5,6	7		
	Adaptation to climate change	8,9	10,11,12	13,14		
	Prevention and mitigation	15	16	17		
Competencies	Greenhouse gases	1,2	3	4,5	22	56
	Climate change's impact	6,7	8	9,10		
	Adaptation to climate change	11,12	13,14	15,16		
	Prevention and mitigation	17,18	19,20	21,22		
	Total				**39**	**100**

The distribution of positive and negative statements in the sustainability action questionnaire is presented in Table 3.7. At the same time, examples of instruments that have undergone validity and reliability testing are shown in Table 3.8.

Table 3. 7 The Distribution of Positive and Negative Statement in Questionnaire

Indicator	Category	Number	Total	%
Past, Present, and Future Actions	Positive Statement	1, 2, 5, 6, 9, 10, 12, 13, 16, 17	17	44
	Negative Statement	3, 4, 7, 8, 11, 14, 15		
Competence	Positive Statement	1, 2, 3, 4, 6, 7, 9, 10, 11, 12, 15, 16, 17, 18, 19, 20, 21, 22	22	56
	Negative Statement	5, 8, 13, 14		
	Total		39	100

Table 3. 8 Translated Example of Sustainability Action Instrument Question

Indicator	Item
Past, Present, and Future Actions	*Saya membakar sampah karena itu adalah cara yang paling mudah dilakukan untuk pengendalian sampah (-)*
Competence	*Saya berkolaborasi dengan orang lain untuk melakukan program penanaman tanaman di pot untuk menghiasi lingkungan sekitar (+)*

3.5.2 Students' Creativity

To measure students' creativity, a creativity instrument has been developed from the Creativity Product Analysis Matrix (CPAM) rubric that has been developed by (Besemer, 1998) which consists of three dimensions of creativity. These three dimensions include nine criteria. The dimensions of creativity are novelty, resolution, and elaboration and synthesis. The criteria employed in this research are original, surprise, valuable, logical, useful, understandable, organic,

elegant, and well-crafted. Students' creativity was assessed on a scale of 1 to 3 for each creativity criterion. Table 3.9 shows the grid of student creativity instruments.

Table 3. 9 Student Creativity Instrument Grids

Creative Product Dimension	Criteria	Criteria for Assessment
Novelty	Original	Technology products that are authorised by the manufacturer, new, original, and have novelty from previous products.
	Surprise	Technology products have the effect of surprise because they are different from what already exists, unexpected, and beyond expectations.
Resolution	Valuable	Technology products have value, are useful and beneficial to address climate issues.
	Logical	Technology products that are clear, reasonable, reasonably correct, and rational.
	Useful	Technology products that have practical benefits, are valuable, useful, can be used according to their function, and bring goodness when used.
	Understandable	Technology products can be accepted and understood for their usefulness.
Elaboration And Synthesis	Organic	A complete and complete technology product is seen from the components that make up the material tools.
	Elegant	Technology products have solutions that offer quality, good aesthetics, and neatness.

	Well-crafted	Technology products made are done seriously, detailed, complete, so the quality of the results is good.

The student creative product assessment rubric has been developed in Table 3.11 based on the creativity grids above. The creative product assessment rubric was translated into Bahasa Indonesia and has been judged by the experts. For the creativity rubric, the experts were given the feedback to 1) Revise the words feature in the statement of assessment rubric to be more specific and fit the criteria 2) Make the instrument assessment rubric in English and Bahasa version, 3) Complete the reference/ sources of the instruments. The final rubric to assess students' creativity product used in this research can be seen in Table 3.10.

Table 3. 10 Final Translated Creative Product Assessment Rubric

No	Creative Product Dimension	Criteria	Score
1.	Novelty	Original	*1. Produk teknologi dibuat dengan ide yang sudah ada sebelumnya.* *2. Produk teknologi dibuat dengan mengubah dan modifikasi ulang dari produk yang sudah ada.* *3. Produk teknologi memiliki kebaruan dari produk sebelumnya, dibuat asli, berdasarkan inovasi pemahaman atau ide sendiri, dan tidak pernah ada yang membuatnya.*
		Surprise	*1. Produk teknologi yang dibuat memberikan sedikit efek kejutan dan produk biasa saja dari yang sudah ada.* *2. Produk teknologi yang dibuat memberikan efek kejutan meskipun dimodifikasi dari produk yang sudah ada.* *3. Produk teknologi yang dibuat tak terduga dan diluar ekspektasi.*
2.	Resolution	Valuable	*1. Produk teknologi yang dibuat tidak berhubungan dengan tujuan dan konsep dalam mengatasi masalah climate issues.*

No	Creative Product Dimension	Criteria	Score
			2. *Produk teknologi yang dibuat dapat digunakan untuk mengatasi masalah climate issues tetapi tidak berhubungan dengan konsep.* 3. *Produk teknologi yang dibuat memiliki nilai guna yang baik, sesuai dengan tujuan dan konsep, serta dapat mengatasi masalah climate issues.*
		Logical	1. *Produk teknologi yang dibuat tidak jelas dan kurang rasional dengan penalaran.* 2. *Produk teknologi yang dibuat sudah sesuai tetapi masih ada sedikit hal yang kurang masuk akal.* 3. *Produk teknologi yang dibuat masuk akal untuk digunakan dan benar menurut penalaran.*
		Useful	1. *Produk teknologi yang dibuat memiliki manfaat dan dapat digunakan sekali saja.* 2. *Produk teknologi yang dibuat dapat mengatasi masalah climate issues digunakan terus menerus dengan beberapa persyaratan.* 3. *Produk teknologi memiliki manfaat, dapat digunakan sesuai fungsinya, dapat mengatasi masalah climate issues tanpa ada beberapa persyaratan.*
		Understandable	1. *Produk teknologi yang dibuat kurang dapat dimengerti kegunaan serta fungsinya dalam mengatasi masalah climate issues.* 2. *Produk teknologi yang dibuat dapat dimengerti kegunaannya dengan baik dalam mengatasi masalah climate issues.* 3. *Produk teknologi dapat dimengerti kegunaan dan fungsinya dengan sangat baik dalam mengatasi masalah climate issue*
3.	Elaboration and synthesis	Organic	1. *Produk teknologi yang dibuat penyusunnya masih kurang lengkap dan utuh.* 2. *Produk teknologi yang dibuat tersusun utuh tetapi kurang lengkap.*

No	Creative Product Dimension	Criteria	Score
			3. Produk teknologi yang dibuat tersusun sangat lengkap dan utuh bagian-bagiannya.
		Elegant	*1. Produk teknologi yang dibuat rapi tetapi kurang menawarkan solusi yang berkualitas*
			2. Produk teknologi yang dibuat dapat menawarkan solusi yang berkualitas tetapi kurang rapi
			3. Produk teknologi yang dibuat rapi, memiliki nilai estetika, dan menawarkan solusi yang berkualitas
		Well-crafted	*1. Produk teknologi yang dibuat dengan baik tetapi nilai estetika masih kurang.*
			2. Produk teknologi yang dibuat sudah baik dengan nilai estetika yang bagus.
			3. Produk teknologi yang dibuat secara sungguh-sungguh dengan detail dan lengkap

3.6 Research Procedures

1) Preparation Stage

The preparation stage involves several important steps:

a. The researcher started by formulating the research problem.

b. The researcher conducted a literature review by exploring the variables from various sources to find out information about ESD-based STEM learning, the Climate Hero project, creativity, and sustainability action. Then, the researcher determines the learning material that is considered appropriate for measuring students' creativity and sustainability action.

c. The researcher proposed ideas to the supervisor according to the results of the literature, including the instruments of sustainability action and creativity that will be used.

d. The researcher was developed a research proposal, research proposal seminar, and revised the research proposal.

e. The next stage is the process of making a research instrument which consist of rubrics and questionnaire to measure two variables.

f. The instruments were assessed and validated by the experts. After the instrument was revised based on the experts' suggestion, the questionnaire then was validated by the students to know whether the instrument can be used, readable, valid, and reliable.
g. The preparation of teaching-learning materials which consist of media, lesson plan, and student worksheet. Researcher also look for the population and sample that will be used in this research that meets the requirements.

2) Implementation Stage

The implementation stage consists of the implementation in class and pre-test and post-test to the students. The implementation of ESD-based STEM learning was conducted within 6 meetings. The detailed activities of implementation are:

a. Giving the pre-test

   Both control and experimental classes are given the pre-test of sustainability action at the beginning of the learning activity. The pre-test was given to determine students' initial abilities related to sustainability action.
b. Conducting the learning activities using ESD-based STEM learning for the experimental class, while the control class carries out the learning process using regular practice learning (Table 3.11).

Table 3. 11 Experiment Class and Control Class Differences in Learning Activities

Meeting	Experiment Class	Control Class
1	**Problem formulation** • Observe and interpret graphs of average carbon emissions in Indonesia and natural disasters due to climate change in Indonesia.	**Observe and ask questions** • Observe the phenomenon in YouTube and had question and answer session. **Seek information**

Meeting	Experiment Class	Control Class
	• Identify problems related to carbon emissions, and causes of climate change that can be solved by developing technology by inviting students to observe carbon emission problems that cause climate change globally and locally. • Analyse the impact of climate change problems on sustainable development. **Thinking** • Thinking of technology to solve the problem of carbon emissions that cause climate change and identifying the advantages and disadvantages of the proposed technology. • Analyse the relationship between technological solutions to climate change and sustainable development.	• Explore information related to climate change through textbooks and answer the questions in worksheets.
2	**Design** • Design by drawing a sketch of the project to be made • Consult the design **Construction**	**Communicate and conclude** • The answer of the worksheet question

Meeting	Experiment Class	Control Class
	Outside school hours, students are: • Gather materials and tools and think about the procedure for making the product • Create a technology-based climate hero project	are discussed with the teacher's guide • Listening to material about climate change through PowerPoint slideshows
3	**Construction** • Create a technology-based climate hero project	**Try** • Divide students into 5 groups based on student readiness (there are low, middle, and high categories) to create a solution to the problem of climate change **Communicate through presentation** • Present the results of discussions related to the solutions offered to overcome climate change
4	**Testing** • Testing the project that has been made • Identify the strengths and weaknesses of the product	**Communicate** • Present the results of discussions related to the solutions offered

Meeting	Experiment Class	Control Class
	that has been made by writing down the obstacles encountered in each stage of the manufacture.	to overcome climate change • The teacher concludes the learning that has been done and reflects
5	**Redesign** • Communicating the results • Improve technology design	
6	**Redesign** • Communicating the results • Improve technology design • Socialising the product by publishing on social media	

c. Students were given the post-test to measure their sustainability action and the product of the experimental class was assessed using the CPAM rubric.

3) Completion Stage

The third stage is the completion stage, the data on students' creativity and sustainability actions that have been collected are analyzed which involves the use of statistical methodologies. The data that have been analyzed is being interpreted and discussed referring to the literature and previous research that has been conducted. When the discussion and conclusion are completed, the research paper is finalized. The flow chart of the research procedure is shown in Figure 3.1.

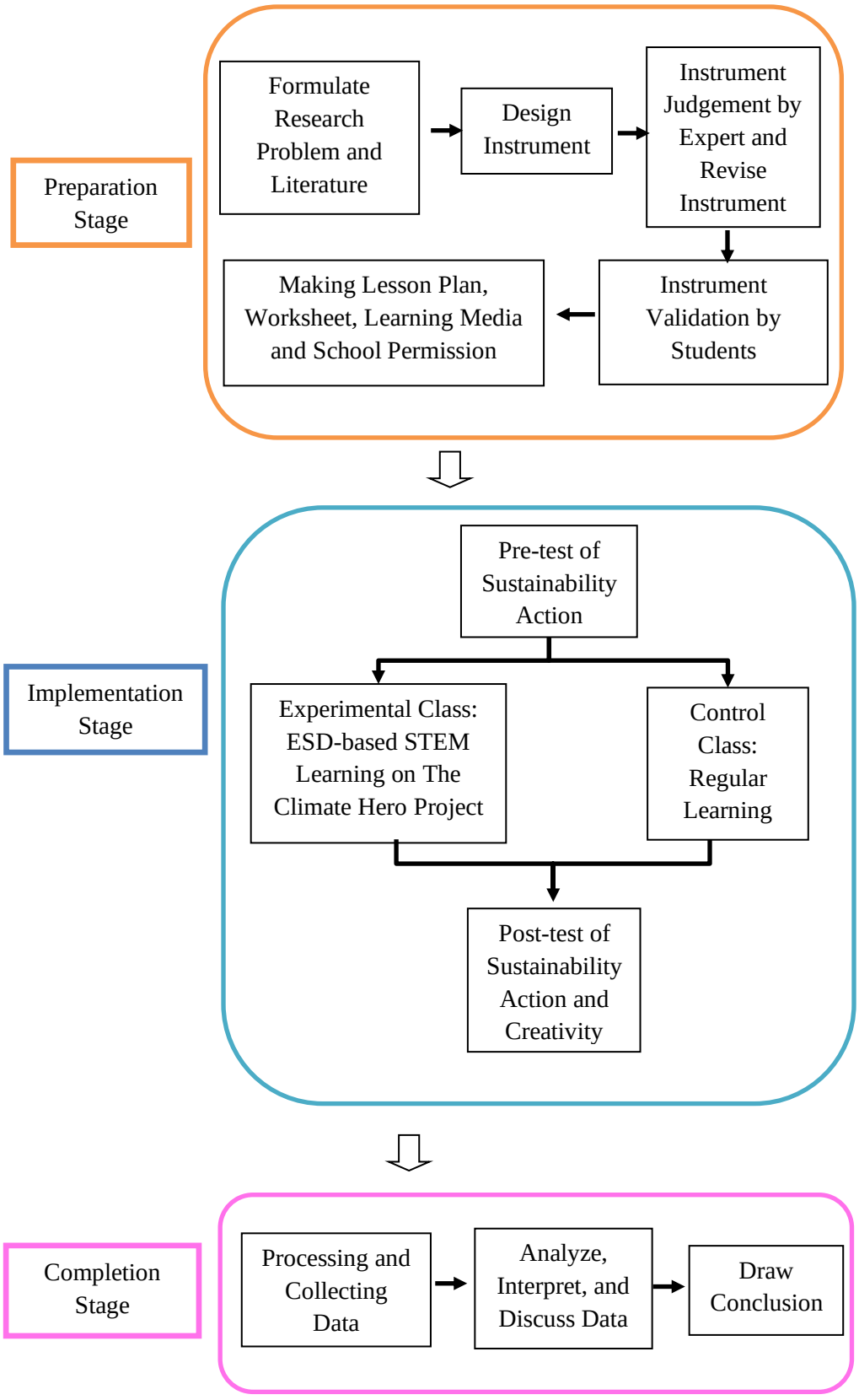

Figure 3. 1 Research Procedure Flow Chart

3.7 Data Analysis

1) Sustainability Action

The instrument of sustainability action is in the form of questionnaires. The data collected in the form of statements were converted into numbers to facilitate the data analysis and interpretation. The questionnaire includes two types of statements which are positive and negative. For the positive statement scoring in the past and present action indicator, the scale used was 1 for "never and 4 for "always". For the future action indicator, the scoring includes 1 for "certainly not do this" and 4 for "certainly do this". Moreover, for the competency indicator, the scale used was 1 for "very incapable" and 4 for "very capable". Meanwhile, the negative statement scoring is reversed from 1 for "always", "certainly do this", or "very incapable" in series to 4 for "never", "certainly not do this", or "very incapable". The total item of the questionnaire was 39 items, so the total maximum score is 156.

Furthermore, to obtain accurate results on students' sustainability action after doing the Climate Hero project in ESD-based STEM learning, then the statistical tests were carried out on both classes, the experimental class and control class.

a. Prerequisite Test

The prerequisite test has been used to determine whether the data is normally distributed and homogeneous as a determinant of the use of the mean difference test as a hypothesis test. The first prerequisite test was the normality test using the Shapiro-Wilk. The Shapiro-Wilk normality test was carried out because the sample was less than 50 students. From the normality tests that have been carried out, the sig. value is 0.188 for control class pretest data, 0.491 for control class post-test data, 0.267 for experimental class pretest data, and 0.845 for experimental class posttest data. The complete table of normality test is attached in Appendix 2. The second prerequisite test was the homogeneity test to find out whether samples from experimental class and control class is from uniform populations or not. The homogeneity test used in this study was the Levene test. Homogeneity test results for experimental and control class pretest data showed a sig. value of 0.549 and 0.598 for post-test data in both classes. The complete table of homogeneity test is attached in Appendix 3.

b. Hypothesis Test

According to the prerequisite test, the parametric test is carried out because the data is normal and homogenous. The parametric test is carried out using independent samples t-test. Independent sample t-test has been used with the aim to see the average difference between two groups of unpaired data, namely data on experimental and control classes. The results of testing the pre-test data show a significance value of more than 0.05, which is 0.355, which means there is no difference between the experimental class and the control class. The posttest test results show a significance value of less than 0.05, which is 0.032, which means there is a significant difference between the experimental class and the control class. The more complete independent sample t-test results are attached in Appendix 4.

2) Creativity

The instrument of creativity is in the form of a Likert scale with ranges from 1 up to 3. Student creativity data was obtained based on product groups in the experimental class. The score of students' creativity was obtained from two acessors. They are the teacher and observers who assess the group product. After that, the average score from the observer and teacher has been calculated. The collected data was then converted into percentages forms. The equation used is shown below.

$$\mathrm{NP} = \frac{\mathrm{GS}}{\mathrm{MS}}\ X\ 100\%$$

Where:

NP = Percentage

GS = Gained Score

MS = Maximum Score