CHAPTER III
METHODOLOGY

3.1 Research Method

The method used in this study is pre-experimental research methods. Throughout the pre-experimental method of research, researchers study only one experimental group and provide interventions during the experiment. The researchers have no control group to compare with the experimental group using this design. There are four types of pre-experimental designs which are: one-shot case study, one-group pretest-posttest design, posttest-only with nonequivalent groups, and posttest-only with nonequivalent groups design (Creswell, 2017). Referring to the case example of the designs, the pre-experimental method was considered as an appropriate method to support this study's purpose.

The design of one-group pre-test system design was continued to carry out in this study, meaning that only a group of experiments is taken to measure the dependent variable (01), commonly referred to as a pretest. A further step is to conduct an experimental stimulation (X) before the posttest (02) (Creswell, 2017). Table 3.1 demonstrates the research design used in this research.

Table 3.1
One Group Pre-test Post-test Design

Pretest	Treatment	Post-test
01	X	02

(Creswell, 2017)

In this research, the treatment used is to implement STEM project-based learning in the topic of heat transfer.

3.2 Participant

The participant involved in this study was 7th grade students from two junior high schools located in Cikancung, Bandung that implement Indonesia 2013 National Curriculum, consisting of 26 students with 6 males and 20 females with an middling age of 12-13 years old. Despite the COVID-19 pandemic currently taking place in Indonesia, researchers are unable to carry out research in one specific school because schools have changed direct class learning into online home learning. Participants who participated in the study were very limited by using 7th graders who live in a researcher's region so that the number of male students was smaller than females. Distribution of participants of this research were divided into populations and samples, which expressed in Table 3.2.

Table 3.2
The Distribution of Participant

Population	Sample		
	Gender	Number of Students	Percentage
7th Grade Students	Male	6	23 %
	Female	20	77 %
	Total	26	100%

In considering data collection limitations, researchers need research techniques that are appropriate to this study. Therefore, the quota sampling used in this study is called convenience sampling technique. Convenience sampling technique was used to identify the nearest participants to serve as respondents, and this technique continues until the appropriate sample size has been reached (Cohen et al., 2013).

3.3 Research Instrument

The instrument to obtain the data is required. For this study, there were three types of data required, which are: The implementation of STEM project based learning, the creativity of students, and the motivation of students. All the required data assess instruments used are shown in Table 3.3 as follow:

Table 3.3
Research Data and Instrument

Data Required	Instrument Used
Implementation of STEM Project-Based Learning	Observation Sheet
Students' Motivation	Motivation towards Science Learning (SMTSL) questionnaire
Students' Creativity	Creative Product Analysis Matrix (CPAM) rubric

Below is a detailed overview of the instrument which consists of creative product analysis matrix rubric, motivation towards science learning questionnaire, and observation sheet that used in this study:

3.3.1 Implementation of STEM Project-Based Learning

The STEM project-based learning implementation is observed on the classroom observation. The observation sheet in this study involves several stages to be performed by a researcher adapted to heat transfer learning activities in the form of a checklist containing the columns 'yes' and 'no' to see the extent to which STEM project-based learning is applied. STEM project-based learning comprises five stages, which are: preparation, implementation, presentation, evaluation, and correction (Lou et al., 2017). This observation sheet was used to investigate the implementation of project-based STEM learning as the appropriate non-test instrument during the learning process. Observers analyzed the learning activity based on the STEM project-based learning stages in the observation sheet that was arranged. These data were obtained by monitoring the lesson at the beginning to the end of the lesson and by making the checklist in the parameters in the observation sheet as defined in Table 3.4 below.

Table 3.4
Observation Sheet (STEM Project-Based Learning)

No	STEM PjBL Stages	Activity	Implementation	
			Yes	No
1	Preparation	Triggering prior knowledge.		
		Dividing individual task.		
		Determining the material.		
		Creating the design project.		
2	Implementation	Creating the project based on the design project.		
		Conducting the test of the product.		
		Identifying the problem of product.		
3	Presentation	Presenting design idea and product.		
		Sharing problem.		
		Sharing the solution to resolve the problem		
4	Evaluation	Evaluating the project.		
5	Correction	Correcting the product based on the evaluation.		

3.3.2 Students' Creativity

The Creative Product Analysis Matrix (CPAM) heading is used to interpret the creativity of students in learning heat transfer using STEM project-based learning. The Creative Product Analysis Matrix (CPAM) heading is used to interpret the creativity of students in learning heat transfer using STEM project-based learning. This instrument has been adapted to the category of creativity developed by Besemer and Treffinger (1981) as another required non-testing instrument. There are three creative product dimensions were used as the basis for assessing the students' project creativity, such as: novelty, resolution, and elaboration & synthesis.

3.3.2.1 Instrument Development and Analysis

Investigating creative products has long played a key part in creativity research, and remains to be a major consideration among those engaged in creativity evaluation. Analysis of creative product aims to separate the design components and decide what makes them somewhat creative (O'Quin & Besemer, 1989). Based on the three dimensions of creativity in the Creative Product Analysis Matrix (CPAM), multivariate statistical analysis was performed to conduct simultaneous research on more than two variables. As a result, the Multivariate Repeat Measure analysis was significant, with average multivariate $F(11,1441) = 30.30$, $p<.0001$ (S. Besemer & O'Quin, 1986).

3.3.2.2 Instrument Development and Analysis Result

Through expert judgement, the CPAM rubric is deemed relevant to the objective of this study, and therefore there is no modification on the criteria used to analyze students' creative product throughout STEM project-based learning implementation. The creativity rubric design is set out in the Table 3.5.

Table 3.5
The Creative Product Analysis Matrix (CPAM) Design

No.	Creative Product Dimension	Criteria	Score		
			1	2	3
1	Novelty	Germinal			
		Original			
		Transformational			
2	Resolution	Adequate			
		Adequate			
		Appropriate			

No.	Creative Product Dimension	Criteria	Score		
			1	2	3
3	Elaboration & Synthesis	Logical Useful Valuable Attractive Complex Elegant Organic Well-crafted Expressive			

(Adopted from Besemer & Treffinger, 1981)

In this rubric, each score is interpreted as the level of student product creativity. Score 3 indicate as "High", 2 indicate as "Medium", and 1 indicate as "Low". In contrast, an additional expert judgment brings a suggestion to explain more clearly the indicators provided in the form of creative assessment of the product. The schematic indicator for CPAM is shown in Table 3.6.

Table 3.6
The Schematic Indicator of CPAM Rubric

Creative Product Dimension	Criteria	Score
Novelty (The degree of newness of the product)	Germinal: generate ideas for promote original product	1. The product inspires other to try out something new. 2. The product is inspiring other to try something new.

Creative Product Dimension	Criteria	Score
		3. The product is inspiring other to try something new by directly give ideas to develop more product design.
	Original: Being infrequent just out of the usual product that has ever been made	1. Students mostly used previous finding as their product ideas. 2. Students use previous finding, but they made some modification of product. 3. Students used their own ideas for their product
	Transformational: Represent a different perspective which surprising in first impression	1. The product doesn't combines new concept which surprising in first impression. 2. The product combines two concept which surprising in first impression. 3. The product combines three concept which surprising in first impression
Resolution (The degree to which product applies to the accuracy of the	Adequate: The product encounters the desires of the problem condition adequately	1. The product doesn't answers the desires of the problem condition. 2. The product answers enough the desires of the problem condition. 3. The product truly answers the desires of the problem condition.

Creative Product Dimension	Criteria	Score
problem solution)	Appropriate: The product suits the problematic condition	1. The product is not certainly well-suited with the determination problem and not relates with the problematic condition. 2. The product is certainly well-suited with the determination problem but not relates with the problematic condition. 3. The product is certainly well-suited with the determination problem and relates with the problematic condition.
	Logical: The product adheres to accepted and grasped disciplinary rules	1. The product doesn't follows the agreed and doesn't known procedural rules. 2. The product follows the agreed but doesn't known procedural rules. 3. The product follows the agreed and known procedural rules.
	Useful: The product is obvious and fits the practical application	1. The product can be used once. 2. The product be able to be used endlessly with certain requirement. 3. The product can be use continuously without any.
	Valuable: The product is valued by users as it meets a	1. The products are not made using recycled materials and require high costs.

Creative Product Dimension	Criteria	Score
	financial or physical requirement	2. The products are made using recycled materials but require high costs. 3. The products are made using recycled materials and require low costs.
Elaboration & Synthesis (The degree of product aesthetic qualities)	Attractive: The product demands the viewer's attention	1. The product is decorated 0-1 elements that benefit the product. 2. The product is decorated using 2 elements that benefit the product. 3. The product is decorated using 3 or more elements that benefit the product.
	Complex: The product comprises several elements in one step or more	1. The product only use one material for the project. 2. The product features a lot of materials (2 different) which support product use. 3. The product features a lot of materials (3 different) which support product use.
	Elegant: The product communicates in a manner understandable	1. The product explained using only 1 concept related to the topic. 2. The product explained using 2 concept related to the topic. 3. The product explained using 3 or more concept related to the topic.

Creative Product Dimension	Criteria	Score
	Organic: The product has a sense of wholeness or completeness about it.	1. The products are arranged using incomplete materials and used less neatly based on their functions. 2. The products are arranged using incomplete materials and used neatly enough according to their functions. 3. The products are arranged using complete materials and used very neatly according to their functions.
	Well-crafted: The product has been working to develop to its highest possible level	1. The product is executed well. 2. The product is executed well with a look good design. 3. The product try to give interesting design through the use of some materials.
	Expressive: The product is presented in such a way that is understandable and communicative	1. The product is delivered with lacking body of language, not comprehensible, and need to control speaking volume. 2. The product is delivered with lacking body of language, comprehensible, and need to control speaking volume. 3. The product is delivered in a way that is communicative (using effective body language and clear voice) and comprehensible.

3.3.3 Students' Motivation

To examine the effect of STEM project-based learning on student motivation in learning heat transfer, the Students' motivation towards science learning (STMSL) questionnaire is used in this study. STMSL is a questionnaire consisting of 35 statements that contain six motivation scales settled by Tuan et al., (2005). This questionnaire includes two types of statements, that is, positive and negative statements. The positive statement scoring includes 5 for "strongly agree". 4 for "agree", 3 for "no opinion", 2 for "disagree", and 1 for "strongly disagree". As far as the negative statement is concerned, the ranking is reversed from 1 for "strongly agree" in series to 5 for "strongly disagree".

3.4.3.1 Instrument Development and Analysis

The effectiveness of the instruments used in the development and analysis is very important, since the conclusions of the researchers are based on data collected obtained using these tools. Therefore, almost all researchers use a range of processes to confirm that the conclusions they gain are valid and reliable, regarding the data they gather.

1) Validity

   The validity of the researchers' specific inferences has been interpreted as responding to the suitability, rightness, meaninglessness and usefulness of the information they collect. Simply put, the test of validity is how much a test measures what is meant to be measured. The three main types of validation tests are the content-related proof referring to the instrument's content and structure, the criterion-related proof referring to the relationship in between scores obtained using the instrument and the construct-related proof referring to the data analytical by the instrument (Fraenkel, Wallen & Hyun, 1993).

2) Reliability

   Reliability relates to the consistency of the measurements obtained for each item through one instrument over another, and from one item collection over another. Simply put, the reliability test is to what degree the scores are relatively consistent (Fraenkel et al., 1993).

3.4.3.2 Instrument Development and Analysis Result

According to Tuan et al., (2005), they confirmed that the STMSL questionnaire is valid and reliable. For the whole questionnaire the Cronbach alpha was 0.89 and the alpha ranged from 0.70 to 0.89 for each scale. Moreover, there is significant correlations ($p<0.01$) of the SMTSL questionnaire with student attitudes ($r=0.41$). Nevertheless, based on the suggestion of one of the judges, the "no opinion" option for Likert scale point 3 has been changed to "agree enough" to make the opinion given more reasonable. The final blueprint of motivation towards Science Learning (SMTSL) questionnaire shown in Table 3.7.

Table 3.7
The Blueprint of Students' Motivation towards Science Learning (SMTSL) Questionnaire

Scale	Category	Number	Total	Percentage
Self-efficacy	Positive Statement	1, 3	7	20 %
	Negative Statement	2, 4, 5, 6, 7		
Active Learning Strategies	Positive Statement	8, 9, 10, 11, 12, 13, 14, 15	8	22 %
	Negative Statement	-		
Science Learning Value	Positive Statement	16, 17, 18, 19, 20	5	14 %
	Negative Statement	-		
Performance Goal	Positive Statement	-	4	11 %
	Negative Statement	21, 22, 23, 24		
Achievement Goal	Positive Statement	25, 26, 27, 28, 29	5	14 %
	Negative Statement	-		
	Positive Statement	30, 31, 32, 33, 34, 35	6	17 %

Scale	Category	Number	Total	Percentage
Learning Environment Stimulation	Negative Statement	-		
	Total Statement		35	100 %

(Adopted from Tuan et al., 2005)

The original STMSL questionnaire was written in English. Therefore, the questionnaire was translated into Bahasa Indonesia in order to support the student's condition. The translated questionnaire of STMSL questionnaire is shown in Table 3.8.

Table 3.8
Translated Students' Motivation Towards Learning Science (STMSL) Questionnaire

No.	*Pernyataan*	*STS*	*TS*	*CS*	*S*	*SS*
1	*Walaupun konten IPA sulit ataupun mudah, saya yakin saya bisa memahaminya.*					
2	*Saya tidak yakin tentang memahami konsep IPA yang sulit. (-)*					
3	*Saya yakin saya bisa mengerjakan tes IPA dengan baik.*					
4	*Tidak peduli berapa banyak usaha yang saya lakukan, saya tidak bisa belajar IPA. (-)*					
5	*Ketika kegiatan IPA terlalu sulit, saya menyerah atau hanya melakukan bagian yang mudah. (-)*					
6	*Selama kegiatan IPA, saya lebih suka meminta jawaban orang lain daripada berpikir untuk diri saya sendiri. (-)*					
7	*Ketika saya menemukan konten IPA sulit, saya tidak mencoba mempelajarinya. (-)*					

No.	*Pernyataan*	*STS*	*TS*	*CS*	*S*	*SS*
8	*Ketika mempelajari konsep IPA baru, saya berusaha memahaminya.*					
9	*Ketika mempelajari konsep IPA baru, saya menghubungkannya dengan pengalaman saya sebelumnya.*					
10	*Ketika saya tidak memahami konsep IPA, saya menemukan sumber daya yang relevan yang akan membantu saya.*					
11	*Ketika saya tidak memahami konsep IPA, saya akan berdiskusi dengan guru atau siswa lain untuk memperjelas pemahaman saya.*					
12	*Selama proses belajar, saya berusaha membuat hubungan antara konsep yang saya pelajari.*					
13	*Ketika saya melakukan kesalahan, saya mencoba mencari tahu mengapa.*					
14	*Ketika saya menemukan konsep IPA yang tidak saya mengerti, saya masih mencoba mempelajarinya.*					
15	*Ketika konsep IPA baru yang telah dipelajari bertentangan dengan pemahaman saya sebelumnya, saya mencoba memahami mengapa.*					
16	*Saya pikir belajar IPA itu penting karena saya bisa menggunakannya dalam kehidupan sehari-hari.*					
17	*Saya pikir belajar IPA itu penting karena merangsang pemikiran saya.*					
18	*Dalam IPA, saya pikir penting untuk belajar memecahkan masalah.*					
19	*Dalam IPA, saya pikir penting untuk berpartisipasi dalam kegiatan penyelidikan.*					

No.	*Pernyataan*	*STS*	*TS*	*CS*	*S*	*SS*
20	*Penting untuk memiliki kesempatan untuk memuaskan rasa ingin tahu saya sendiri ketika belajar IPA.*					
21	*Saya berpartisipasi dalam pembelajaran IPA untuk mendapatkan nilai bagus. (-)*					
22	*Saya berpartisipasi dalam pembelajaran IPA untuk tampil lebih baik daripada siswa lain. (-)*					
23	*Saya berpartisipasi dalam pembelajaran IPA sehingga siswa lain berpikir bahwa saya cerdas. (-)*					
24	*Saya berpartisipasi dalam pembelajaran IPA supaya guru memperhatikan saya. (-)*					
25	*Selama pembelajaran IPA, saya merasa paling puas ketika saya mendapat nilai bagus dalam ujian.*					
26	*Saya merasa paling puas ketika saya merasa yakin tentang konten dalam pembelajaran IPA.*					
27	*Selama pembelajaran IPA, saya merasa paling puas ketika saya mampu memecahkan masalah yang sulit.*					
28	*Selama pembelajaran IPA, saya merasa sangat puas ketika guru menerima ide saya.*					
29	*Selama pembelajaran IPA, saya merasa sangat puas ketika siswa lain menerima ide saya.*					
30	*Saya bersedia berpartisipasi dalam pembelajaran IPA ini karena isinya menarik dan dapat diubah.*					
31	*Saya bersedia berpartisipasi dalam pembelajaran IPA ini karena guru menggunakan berbagai metode pengajaran.*					

No.	*Pernyataan*	*STS*	*TS*	*CS*	*S*	*SS*
32	*Saya bersedia berpartisipasi dalam pembelajaran IPA ini karena guru tidak banyak menekan saya.*					
33	*Saya bersedia berpartisipasi dalam pembelajaran IPA ini karena guru memperhatikan saya.*					
34	*Saya bersedia berpartisipasi dalam pembelajaran IPA ini karena ini menantang.*					
35	*Saya bersedia berpartisipasi dalam pembelajaran IPA ini karena para siswa terlibat dalam diskusi.*					

(Adopted from Tuan et al., 2005)

3.4 Research Procedure

3.4.1 Preparation Stage

The preparation stage of this study consist of the following actions:

1) Analysis the research problem to be investigated in this study.
2) Analysis of each variable related to this study and the making of instruments, consisting of: curriculum analysis, STEM project-based learning analysis, the creativity of students analysis, the motivation of students analysis, and the topic of heat transfer analysis.
3) Perform the study of literature to guide in the development of the instruments used in this study, consisting of: the syntax for STEM project-based learning, the instrument of students' creativity, and the instrument of students' motivation.
4) Design instrument comprising of creativity product analysis matrix (CPAM) rubric and students' motivation towards science learning (SMTSL) questionnaire. Meanwhile, the observational sheet arranged as a guide for learning activities.
5) Construct a lesson plan, presentations and worksheets that are used as teaching material to assist in the implementation of STEM project-based learning.
6) Validate the research instrument by expert judgment.
7) Revise the instrument of research based on the advice of expert judgment.

3.4.2 Implementation Stage

The implementation stage of this study consist of the following actions:

1) Conduct the pretest of students' motivation using students' motivation towards science learning (SMTSL) questionnaire.
2) Conduct the teaching-learning process using STEM project-based learning as a treatment for students. The STEM project-based learning implementation regulations are evaluated on the basis of observations sheets relating to the stages of STEM project-based learning which are: preparation, implementation, presentation, evaluation, and correction stages.
3) Assess students' creativity using creativity product analysis matrix (CPAM) rubric based on students' projects in STEM project-based learning implementation.
4) Distribute the posttest of students' motivation using students' motivation towards science learning (SMTSL) questionnaire.
5) Recap collected data to be analyzed and processed at the next stage.

3.4.3 Completion Stage

The completion stage of this study consist of the following actions:

1) Process and analyze the finding data, based on the type of instrument used for each variable, and describe further conclusions from the data collected.
2) Arrange further discussions focused on interpretation of the results.
3) Create conclusion and recommendation based on result and discussion.
4) Completing the research paper.

The researcher designed a flow chart that is shown in Figure 3.1 to provide an overview of the procedure.

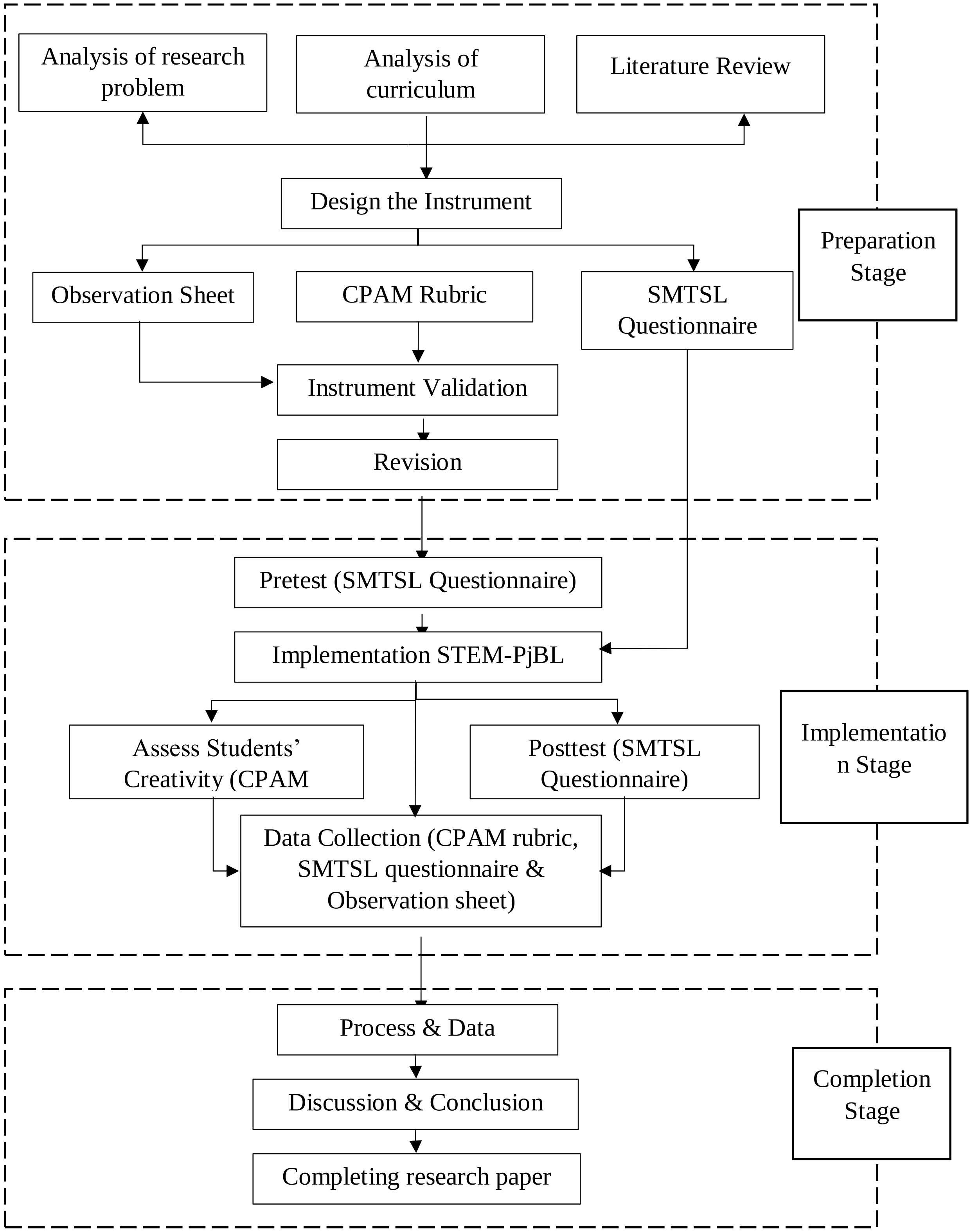

Figure 3.1 Flow Chart of Research Procedure

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3.5 Data Analysis

The data were derived both from quantitative and qualitative data. All these data are used to assess the implementation of STEM project-based learning, the creativity of students, and the motivation of students in learning science. The following was some description for data analysis:

3.5.1 Implementation of STEM Project-Based Learning

Data on the implementation of STEM project-based learning was obtained using the observation sheet. Implementation of STEM project-based learning. The data collected from the learning implementation observation sheet are quantitative data, which will be analyzed descriptively by measuring the percentage. After counting the number of responses to "yes" and "no" in the observation sheet. The observation sheet analysis is achieved by transforming the raw score into a percentage type. The technique of converting the score into a percentage was to use the following formula:

$$\% \, LI = \frac{\Sigma \, IA}{\Sigma \, \mathrm{TA}} \times 100\%$$

Description:

LI : Implementation of Learning Method (STEM-PjBL)

IA : Implemented Aspect

TA : Total Aspect

(Source: Riduwan M B A (in Fitriani, 2017))

The percentage observation sheet on the implementation of the STEM project-based learning may be categorized according to criteria as shown in Table 3.9.

Table 3.9
Interpretation of Learning Implementation

Percentage (%)	Interpretation
LI = 0	Neither activity is executed

Percentage (%)	Interpretation
0 < LI < 25	There are small number of activities are execute
25 ≤ LI < 50	Almost half of the activity are execute
LI = 50	Half of the activity are execute
50 ≤ LI < 75	Most of the activity are execute
75 ≤ LI < 100	Nearly all the activity are execute
> 100	All the activity are execute

(Source: Riduwan M B A (in Fitriani, 2017))

3.5.2 Students' Creativity

The score on the CPAM (Creative Product Analysis Matrix) rubric is performed by the conversion of the raw score in a percentage form for each group. In addition, the percentage result can be segmented into certain categories.

The technique used to turn the score into percentage is the following:

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

Description:

PS : Percentage Score

R : Raw Score

SM : Maximum Score

(Source: Purwanto, 2000)

According to Purwanto (2000), the students' score percentage interpretation of creativity is classified into some criteria, as shown in Table 3.10.

Table 3.10
Interpretation of Score Percentage Criteria

Percentage (%)	Criteria
86-100	Very Good
76-85	Good
60-75	Enough
55-59	Low
<54	Very Lack

(Source: Purwanto, 2000)

3.5.3 Students' Motivation

The score on the STMSL questionnaire (Students' Motivation to Science Learning) was measured in such a way that the maximum score on each statement is the sum of the number of statements on the rating received. The motivation questionnaire contains of 35 statements with a Likert scale of 1-5. Afterward, tests of effectivity, normality, and hypothesis were carried out to assess the effect of STEM project-based learning on the motivation of the students

1) Gain Score and Normalized Gain

The gain score is derived from the difference between the pretest and the posttest. The formulation used for determining the Gain Score is as follows:

$$G = S_f - S_i$$

Description:

G = gain score

S_f = posttest score

S_i = pretest score

(Source: Hake, 1998)

2) Normality Test

The effect of STEM project-based learning on the motivation of the students was determined by the result of a normalized gain using the following formula:

$$< g >= \frac{< G >}{< G > max} = \frac{(< S_f > - < S_i >)}{(175 - < S_i >)}$$

Description:

$<g>$: Normalized gain

$<G>$: Actual gain

$<G>$ max : Maximum gain possible

$<S_f>$: Average of posttest score

$<S_i>$: Average of pretest score

(Source: Hake, 1998)

The value of the Normalized gain achieved is interpreted with the table of interpretation as follows in the Table 3.11:

Table 3.11
Interpretation of Normalized Gain

No.	Value	Classification
1	$< g > \geq 0.7$	High
2	$0.3 > < g > \geq 0.7$	Medium
3	$< g > < 0.3$	Low

(Source: Hake, 1998)

3) Hypothesis Test (Paired Sample T-Test)

The t-test can be used to test the hypothesis to determine the difference among average pretests and posttests. The Paired Sample T-test can be analyzed if the data were performed normality of data. After analyzing the data, it can draw the conclusion shown in Table 3.12 as follows:

Table 3.12
Interpretation of Paired Sample T-Test

No.	Significant Value	Classification
1	Sig.2-tailed < 0.05 (α)	H_0 Rejected (There is a significant difference between pretest and posttest)
2	Sig.2-tailed > 0.05 (α)	H_0 Accepted (There is no significant difference between pretest and posttest)

(Source: Hake, 1998)

3.6 Assumption

The assumption in which this study is built on as follows:

1) STEM-I project-based learning activities will encourage diverse ability growth and stimulate their creativity in project-based practice (Lou et al., 2014).
2) STEM project-based learning will boost the creativity of the students, including exploration, enthusiasm, imagination, and competition in learning science (Lou et al., 2017).
3) Students gained amazing experiences through STEM project-based learning and improved their motivation and interest in learning science (Afriana et al., 2016).

3.7 Hypothesis

The hypothesis being checked in this study are as follows:

1) H_0: There is no effect on students' motivation in learning heat transfer topic using STEM project-based learning.
2) H_1: There is an effect on students' motivation in learning heat transfer topic using STEM project-based learning.

3.8 Operational Definition

1) The creativity of students in this research is measured by the CPAM (Creativity Product Analysis Matrix) rubric, which divides the dimension of creativity into three aspects, such as novelty, resolution, and elaboration & synthesis (Besemer & Treffinger, 1981).
2) The motivation of students in science learning in this research is measured by six motivational scales, including self-efficacy, active learning strategies, the value of science learning, performance goal, achievement goal, learning environment, and stimulation of the learning environment in the SMTSL (Students' Motivation Towards Science Learning) questionnaire (Tuan et al., 2005).
3) This research divides the implementation of STEM project-based learning into five stages, including the preparation stage, implementation stage, presentation stage, evaluation stage, and correction stage based on Lou et al., (2017). All these five steps are observed by the researcher and measured using an observation sheet previously drawn up.