CHAPTER III
RESEARCH METHODOLOGY

3.1. Research Design

The research methodology utilized has a significant impact on the product being created. One of the most significant aspects is the accuracy with which the model is chosen; so, researcher expect that the chosen model make research more effective and efficient in line with the aims of the study. It is intended that this research would result in a learning model that overcome issues in one of the learning processes, hence benefiting education in Indonesia. The Design and Development Research (DDR) model was defined by Richey and Klein (2007) as "the systematic study of design, development, and evaluation processes with the goal of establishing an empirical basis for the creation of instructional and non-instructional products and tools, as well as new or enhanced models that govern their development." The DDR, according to Richey and Klein (2007) , is a systematic study of the design, development, and evaluation process with the purpose of establishing an empirical foundation for the creation of instructional and non-instructional goods and tools, as well as new or improved models.

The DDR is a study approach whose primary goal is to offer information to Instructional Designers (ID) that an issue in education has been experimentally and systematically handled via a series of studies on the design, development, and assessment process (Richey and Klein, 2007) . Research that employs the DDR is more than just creating a tool/application for learning; (J. Ellis & Levy, 2010) underline the need of distinguishing between DDR and Product Development, despite the fact that both model create a product for specific goals. Design and development as a research model focuses not only on the end product, but also on the insights from research on previously created goods.

This study aims to develop ethno-STEM learning model to enhance pre-service teachers' sustainability literacy. This research based on the need of sustainable development goals concerning in environmental issues, so that the

development of learning model is needed through collaborative across disciplines. The development process is carried out through several stages of research including preliminary study stages on identify the problems, describe the objective, design and develop the artefact, test the artefact, evaluate testing result and communication the testing result (Richey and Klein, 2007).

The main question of this research problem is the development of learning model, namely the ethno-STEM learning model. To be able to answer problems and research questions throughly, the research choosed a Design and Development Research. Design and Development Research, according to result Richey and Klein (2007), is "the systematic study of the design, development, and evaluation process with the goal of establishing an empirical basis for the creation of instructional products and tools a new or enhanced models that govern their development."

The purpose of this study is to create an ethno-STEM learning model to improve pre-service teachers' sustainability literacy. At the conclusion of the study, the use of learning models in lectures was used to determine the implementation and accomplishment of boosting pre-services teachers' sustainability literacy. The third part of the study employed the Quasi Experiment method using a one group pretest-posttest design to collect data on growing literacy (Creswell & Garrett, 2008).

The DDR model, in general, employs a mixed methods research methodology that incorporates qualitative and quantitative methodologies. Spector et al. (2014) state that "the bulk of design and development studies employ multimethod techniques, often integrating both qualitative and quantitative methodologies." However, Spector et al. (2014) conducted a review of various research that used the DDR model.

This research used the DDR Type 2 Research Model, this is carried out into three stages, namely model development, model validation, and model use. The first stage is model development carried out by looking at the needs of the learning model developed, the curriculum that answers the needs of the skills

developed, and the characteristics of the model being developed. While the second stage is model validation carried out with two stages, namely internal validation of model and external validation of model. In this stage, internal validation is carried out by means of a forum group discussion process with course lecturers and stakeholders on the campus where the research was conducted. Meanwhile, the external validation of the model is carried out with focus group discussions with environmental education course experts and lecturers. Unfortunately, the condition of covid19 pandemic forced the process into online activities. Those process done by online activities through a form of validation sheet. This is done by researchers to improve the analysis that is appropriate and needed by lecturers who teach courses.

Referring to the DDR Type 2 research model (Richey, 2007), the Design and Development Research framework carried out in this study is depicted in the following figure 3.1:

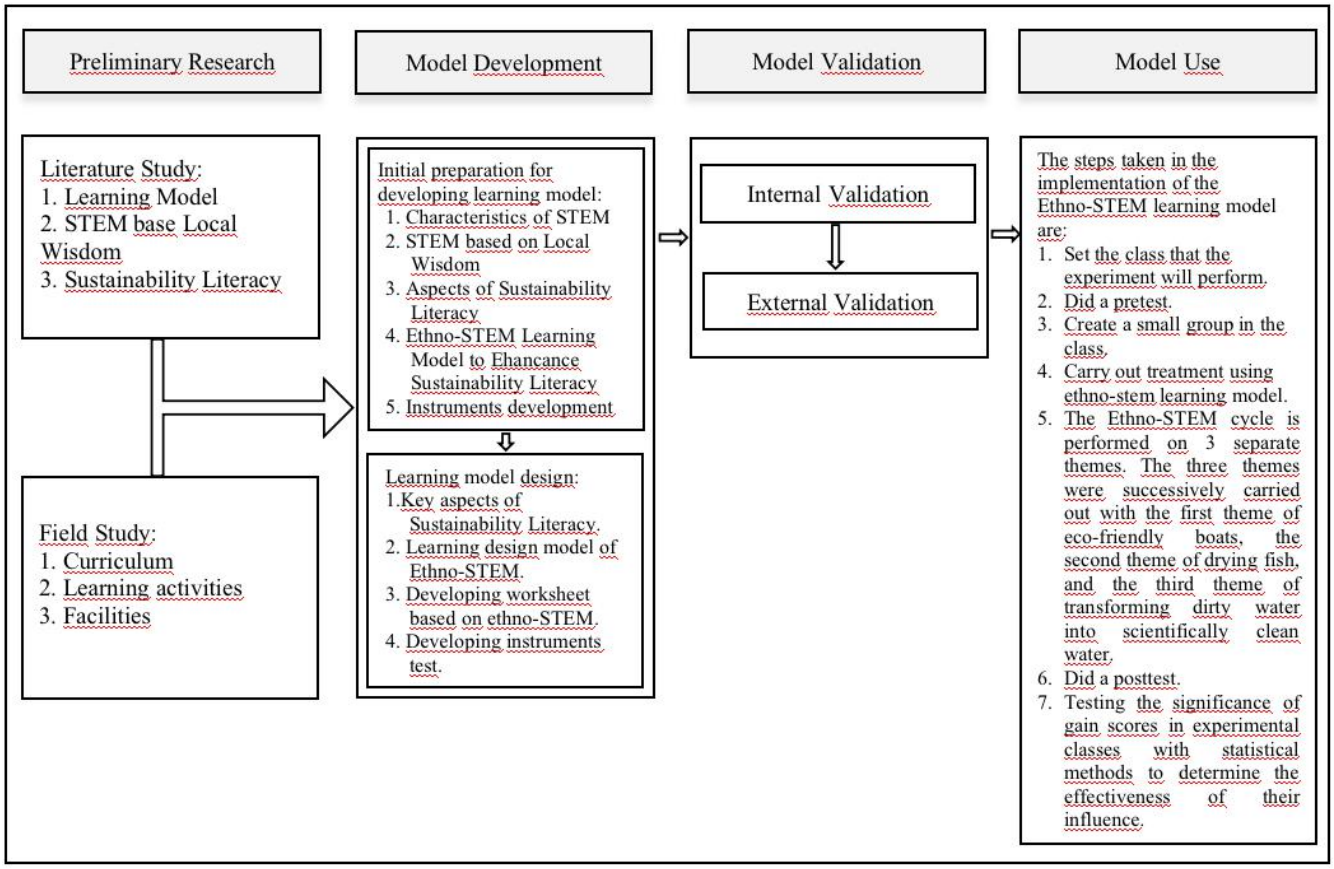

Figure 3.1 Research procedure

3.2. Research Subject

The Ethno-STEM learning model has been developed, validated and implemented in the Faculty of Teacher Training and Education at Esa Unggul University in West Jakarta City in the even semester of the 2020/2021 academic year. The population of this research were all pre-service teachers of the Faculty of Teacher Training and Education at Esa Unggul University in West Jakarta City. The sampling technique in this research was purposive sampling by selecting classes that were taking the environmental education course in semester 4 of the 2020/2021 academic year which weighed 3 credits. A total 47 pre-service teachers of elementary education involved in this research. This research was conducted during some part of the semester, because the research was especially preferred pre-service primary teacher at the selected course.

3.3. Research Variable

According to (Creswell & Garrett, 2008) research variables are things which determined by researchers to be studied and tested, so that information about it will obtained. The variables in this study are divided into three, there are independent, dependent, and control variables as mentioned below:

a. Independent Variable is a variable that influences or causes a change or the emergence of a dependent variable. The independent variable in this study is developing learning model for environmental education course based on ethno-STEM learning model.
b. Dependent Variable is a variable that is influenced by independent variables. Dependent variables are also called outcome variables and variables used in statistical calculations. The dependent variable in this study is sustainability literacy.
c. Control Variable (Control Variable) is another independent variable than the main independent variable that gives influence but the effect is controlled by the researcher. The control variables are instructor, and time of implementation of learning.

3.4. Operational Definition

To avoid misinterpretation of terms used in this study, a researcher described the important to explain definition of those terms to make it more effective. Those terms summarize in the below:

a. Environmental education course based ethno-STEM learning model has been developed in this research. The lesson has been implemented through STEM approach. Lesson implementation has been measured through observational sheets consisting lecturer and pre-service teachers' activities within the lecturer program. Key aspect of Ethno-STEM used to ensure the learning process follow the cycle.

b. Ethno-STEM learning model is defined as an approach conducted with environmental issues as its context. Lesson implementation has been measured through observation sheets consisting lecturer and pre-service teachers' activities within the lesson. Measuring the effectivity of the model by referring to the key components of the Ethno STEM learning model, namely, defining local-wisdom problems/local wisdom products design challenges, developing possible solutions to solve local-wisdom problems/products design challenges, constructing functioning products of local wisdom, testing the prototypes of local wisdom products, and redesigning the prototypes of local wisdom products and communicating the solution of local-wisdom products. To confirm the validity of the study, the researcher assesses each cycle conducted.

c. Sustainability literacy refers to the ability of pre-service teachers about environmental, social, and economic issues. Pre-service teachers' sustainability test has been measured by sustainability literacy test and further be interpreted using two-dimensional scale and categories. Key aspect of sustainability literacy is Conceptual development (Conceptual awareness of sustainability issue), Identity development (Personal identity & value), Skill development (Competence in skills), and Developing confidence (Confidence in an ability in contribute to achieving sustainability). Qualitative and

quantitative data (tested model through long steps of validation, learning process, implementation result data, teacher response, student response)

3.5. Instruments

The data in this study were obtained from the beginning to the end of the research. Table 3.1 describes in detail the data collected, data sources and the types of data collected which are then analyzed according to the type of data and research objectives that have been determined.

Table 3.1. Instrument which is used to collect the data in this research.

No	Data	Instruments	Data processing	Sources
1	The implementation of environmental education course through ethno-STEM learning model	Observation sheet (Appendix 3)	Percentage	Lecturer and pre-service teachers
2	Sustainability literacy of pre-service teachers	Sustainability literacy test aligned with conceptual understanding test (Appendix 2)	Gain score	pretest and posttest
3	Pre-service's teachers' response towards environmental education course through ethno-STEM learning model	Survey Instrument (Appendix 4)	Percentage	Pre-service teacher who enrolled course program

3.5.1. Implementation of Environmental Education Course Through Ethno-STEM Learning Model Observation Sheet

The implementation of environmental education course through ethno-STEM learning model were observed by using observation sheet that was developed based on characteristics and the learning cycle of ethno-STEM learning model. The aspect that ensures that the learning stages accommodate the achievement of sustainability literacy refers to the results of the key aspect of Sustainability Literacy analysis which can be seen from each step in the Ethno STEM Leaning Model. The blueprint of observation sheet is provided on Table 3.2.

Table 3.2 Observation Sheet of Course Implementation

No.	Ethno-STEM learning model	Indicators	Statements
1	Defining local-wisdom problem/local wisdom products design challenge	Understanding the design challenge	Preservice teachers define a problem and recognize the need for a new product
			Preservice teachers recognize the need for a new product and establish criteria for success in which the specifications a design solution must meet to be considered
		Build knowledge/do research	Preservice teachers gather pertinent information/do investigations and research to learn about the problem or relevant cases
2.	Build possible solution to solve local wisdom problem/products design challenge	Generate and represent ideas	Preservice teachers perform several types of analysis on each design (Analysis that may need to be considered consists of functional analysis, ergonomics, strength analysis, testability, product safety and liability, economic and market analysis
		Making decision	Preservice teachers use words and graphics to display and weigh both benefits and tradeoffs of all ideas before picking a design
3.	Constructing functioning product of local wisdom	Conduct experiment	Preservice teachers prepare tools and materials, determine the procedures
			Preservice teachers build a prototype of the product based on the design
4.	Testing the prototypes of local wisdom products	Troubleshooting the solution	Preservice teachers troubleshooting devices and proposing ways to fix problem
			Preservice teachers test the

			prototype extensively under real conditions in order to identify the part that would have to be redesigned and the process completed until a satisfactory solution was reached
5.	Redesign the prototypes of local wisdom products and communicate the solution of local -wisdom problems	Revise and iterate the solution	Preservice teachers revise the solution/product and do the redesign in a managed way, where ideas are improved iteratively via feedback.
		Reflect on process	Preservice teachers do tacit designing through practice reflective thinking while working on redesign process

3.5.2. Sustainability Literacy

Sustainability literacy and conceptual test in form of multiple-choice questions were administered to assess students' sustainability literacy and conceptual understanding about the environment topic, a pre-test and post-test were given before and after implementation of environmental education course through Ethno-STEM learning model. The test was aim to capture students' sustainability literacy and learning gain, a comprehensive multiple-choice examination was administered at the first meeting and the same instrument were administered as a posttest at the last session. Each question item of test was developed based on indicators that were formulated from sustainability literacy categories and adjusted with the concept of environment that has been choose as main topic. The theme itself consist of eco-friendly boat to reduce energy consumption, utilization of global warming effect to help drying fish and water purification by using charcoal. Each topic consists of 10 test items that embodies sustainability literacy categories and indicators.

Table 3.3. Blueprint of Sustainability Literacy Test

No	Sustainability literacy categories (Diamond, 2013)	Indicators	Item number	Total item
1	Conceptual awareness of sustainability issues in the world	Understand the interrelated nature of complex	2,5,6,13,15	5
		Able to investigate sustainability issue and intractable to sustainability issues in the real world	1,4, 9,10, 17, 21, 26	7
2	Personal identity and values aligned with achieving sustainability	Ability to reflect/self-evaluate alone and consolidation of personal values and identity aligned with achieving sustainability	16, 18, 29,34	4
		Commit to taking action	19,22, 23,24, 27	5
3	Compete in skills which can contribute to achieving sustainability	Perform analysis of environmental or social impacts	3,7,8,11,12,14, 20	7
		Create product/solution to solve sustainability problem	28, 30, 35,36,40	5
4	Confidence in an ability in contribute to achieving sustainability	Empower to solve sustainability problems	25,31,32,33	4
		Belief one can initiate and reinforce personal and systemic changes towards sustainability	37,38,39	3

There are eight indicators that were observed on this research based on 4 categories. Each of indicators was rated from 1 to 4 where each rating represents the scale of sustainability literacy. The rating of each scale shows the percentage of correct answer in test item. The categorization of sustainability literacy was presented in Table 3.4 and the check list table is provided on Table 3.5.

Table 3.4 Scale of Sustainability Literacy

No	Scale	Categorization	Criteria (% of correct answer on each category)
1	1	Non awareness of environment and social impact	0-25
2	2	Awareness of environment and social impact	26-50
3	3	Responsibility	51-75
4	4	Taking on leadership role for sustainability	76-100

Table 3.5 Checklist table of Sustainability Literacy

No	Sustainability literacy categories (Diamond, 2013)	Scale of sustainability literacy (Décamps, 2017)			
		Non awareness of environment and social impact	Awareness of environment and social impact	Responsibility	Taking on leadership role for sustainability issues
		1	2	3	4
1	Conceptual awareness of sustainability issues in the world				
2	Personal identity and values aligned with achieving sustainability				
3	Compete in skills which can contribute to achieving sustainability				
4	Confidence in an ability in contribute to achieving sustainability				

Source adopted from Décamps et al. 2017) Diamond & Irwin (2013)

3.5.3. Survey Instrument of Pre-service's teachers' response towards environmental education course through ethno-STEM learning model.

Pre-service teachers' response towards the implementation of environmental education course through ethno-STEM learning model are identified through a Survey Instrument consist of 20 statements that were extracted from five aspects consist of preservice teachers' engagement in environmental education course, interest in environmental education course and sustainability issues, collaborative activities and problem solving during ethno-STEM project and the goal of ethno-STEM project to increase creativity and innovation skills to answer sustainable development goals. The blueprint of Survey Instrument is provided on table 3.6.

Table 3.6 Blueprint of Survey Instrument of Pre-service's teachers' response

No	Aspects	Indicators	Test item number
1	Engagement in environmental education course	Understand the aims of course program	1,3
		Understand the cycle of instruction	11
		Understand the topics/concept during the instruction	12
2	Interest in environmental education course and sustainability issue	The interest of pre-service teachers in environmental education course	5
		Demonstrate the interest in sustainability/sustainable development	13
		Activity level in sustainability/sustainable development	14
		Keep up with the news about sustainability	15
3	Collaborative activities during ethno-STEM Project	The advantages of teamwork	16,17
		Enthusiasm about working as a team	18,19
4	Problem solving activities during the implementation	Understand the design challenge/problem	2
		Solving the problem/design challenge	4,10
5	Ethno-STEM project to increase creativity and innovation skills to answer sustainable development goals	Physical prototypes help develops better understanding about how the system/design work	6
		Communicate the design plan	8
		Improving ideas and prototypes based on feedback and cycling back to upgrade their understanding of the problem of sustainability	7, 9, 20

3.5.4. Data Collecting Technique

Based on the activities in the three stages of learning model development research (model development, model validation, and model use), the data collection techniques used in this study are:

3.5.4.1. Survey Instrument Technique

The Survey Instrument technique is used in the preliminary stage of research, trial and model validation. The instrument is made in the form of a closed question. In the preliminary research stage with a total of 117 science teachers, the Survey

Instrument was used to find out the understanding of science teachers about STEM Education (Nugroho, 2019), while the trial and validation of the model, the Survey Instrument was used to find out the response of pre-service teachers to the implementation of the Ethno-STEM learning model.

3.5.4.2. Interview Technique

During the preliminary research stage, interviews were employed. The interview instrument consists of unstructured, open-ended questions, since responses to situations encountered and actions performed are unrestricted. In the preliminary research phase, interviews are utilized to supplement and triangulate the data acquired through open interviews with resource individuals and subject matter experts. The interview approach was administered to the director of LP4TK Bandung, the director of the study program, and the instructor of the environmental education course. The purpose of the interview with the head of LP4TK was to learn about the movement of STEM Education in Indonesia, government initiatives supporting teachers' abilities to use STEM learning models, and difficulties in the area from the government's perspective. Interview with the study program director to obtain information regarding the study program curriculum, the schedule of environmental education course lectures, the name and number of teams of lecturers who teach environmental education courses, and the number of students enrolled in environmental education courses. To collect information on course descriptions, course objectives (syllabus), pre-service teachers' circumstances, and the learning model employed, lecturers are interviewed.

3.5.4.3. Observation Technique

Observations were made at each stage of the learning model trial. Observations were made to collect data on ethno-STEM learning model activities. Observations are carried out using observation sheets, and are adjusted to the ethno-STEM learning model stages. In the trial stage, observations were made to observe whether the learning model developed still had weaknesses that needed to be corrected and

whether the lecturer had implemented the learning model developed in accordance with the learning scenario that had been created.

3.5.4.4. Test

Tests were used to measure the effectiveness of using ethno-stem learning models to enhance sustainability literacy. Therefore, the test in this study was used to answer research questions related to the learning model test. The tests were used to measure pre-service teachers' sustainability literacy and the level of material mastery ability before and after learning (pre and post test). The test instrument in this study is in the form of multiple choices, meaning that the pre-service teacher only needs to choose one of the alternatives that have been provided.

3.5.4.5. Document Analysis Technique

Document analysis is used in order to collect various information, especially to complete the data in the preliminary study, namely to answer research questions related to the planning and implementation of environmental education course lectures that have been taking place.

3.6. Research Frameworks

Richey (2000) put forward four research frameworks, namely need analysis, model development, model validation, and model use.

3.6.1. Need analysis (preliminary research)

Preliminary Studies are the initial stage of development research carried out by conducting field surveys and literature studies. This field survey was conducted with the aim of obtaining data on the current conditions and empirical situation of learning environmental education courses. The aspects studied include: (1) lecturers' perceptions of environmental education course teaching and lecturer self-actualization in improving the quality of learning, and (2) planning, implementing, and evaluating environmental education course lectures. Meanwhile, the literature

study was carried out with the aim of collecting various theories and concepts about STEM Education and also examining various studies that had existed.

3.6.2. Model development

The second stage carried out in this study is the development of a learning model which includes steps: preparation of the initial design / draft of the learning model and the implementation of the learning model trial. From the results of the implementation of this learning model trial, a final design was obtained that was ready to be validated.

3.6.2.1 Initial preparation for developing learning model

Preparing an initial draft incorporating a learning plan and learning stages to enhance the quality of the learning interaction process is a component of preparing the original design. On the basis of the findings of the preliminary survey conducted beforehand, the initial draft of the model was written. This draft includes the creation of learning objectives, learning materials, learning processes, methodologies, and media, as well as the evaluation of environmental education learning courses. Researchers and professors who teach environmental education courses work together to design a learning strategy.

3.6.2.2 Learning model design

Using the idea of quasi-experiment, the planned learning model contains actions for generating learning plans, executing learning, assessing and revising the design of learning models.

In the trial of the learning model, research focuses on process assessment and results evaluation. As a result, the researcher was responsible for implementing the experiment, while the peers served as observers who documented and assessed the entire procedure. Observation of the process of conducting model trials focuses primarily on analyzing and evaluating the efficacy of employing ethno-STEM

learning model with pretest-posttest designs in one group to improve the sustainability literacy of pre-service teachers.

3.6.3. Model validation

Validity is a condition or status that describes how far a learning model meets the supporting criteria in order to be used to achieve learning objectives. Validity is one of the assessment parameters of the Ethno-STEM learning model. The procedure to guarantee the model is tested begins with the validation model, which includes both internal and external validation. After passing validation, the created model will proceed to the model usage step.

3.6.3.1 Internal Validation of Model

The initial model of the Ethno-STEM Learning Model to enhance the sustainability literacy of preservice teachers, followed by the revision stage and internal validation, is accomplished through a forum group discussion process with course lecturers and stakeholders on the campus where the research was conducted. Internal validation is undertaken at this level by way of a forum group discussion process involving course instructors and stakeholders on the research campus. Unfortunately, the process forced to be online activities due to covid-19 pandemic. Internal validation focuses on confirming the components and processes of a learning model that combines the Ethno-STEM Learning Model's qualities.

Delphi-Three Stage Study

Delphi's study, which aims to validate the learning model developed, is actually an iterative process, which depends on the process, but in this study the author estimates that in three stages of validation this learning design model can be completed.

First Stage

In Delphi Study Phase I, an Academic Manuscript is given to a learning design expert to be revised and validated. The Academic Manuscript contains: 1) a brief background of the research, 2) Selection of components of the learning model design along with the reasons for choosing these components, 3) design of an ethno-STEM-based initial learning model, 4) function of the learning model design and 5) an interview guide.

The interview guide contains five *open-ended* questions. Learning design experts are given one week to answer the following five questions:

1. *Apakah aspek kunci dari pembelajaran berbasis* ethno-STEM learning model *yang dikembangkan ini telah mencakup semua indikator untuk meningkatkan* preservice teachers' sustainability literacy*?*
2. *Bagaimanakah pendapat Bapak/Ibu tentang kejelasan aspek kunci dari pembelajaran berbasis* ethno-STEM learning model *untuk meningkatkan* preservice teachers' sustainability literacy*?*
3. *Apakah aspek kunci dari pembelajaran berbasis* ethno-STEM learning model *yang dikembangkan akan mampu meningkatkan preservice teachers' sustainability literacy melalui pendekatan STEM?*
4. *Apakah model desain pembelajaran ini memiliki nilai kemudahan bagi para penggunanya, baik bagi para pemula dan para ahli (*expert*)?*
5. *Pada bagian manakah dari aspek kunci dari pembelajaran berbasis* ethno-STEM learning model *ini yang perlu direvisi?*

The aspects that result from the five fundamental issues are classified according to the following topics: the components of the learning design model, the order of components, the value of ease of use, and the portions that require revision.

Second Stage

As a result of the effects of phase 1's review, an ethno-STEM learning model cycle was developed to increase sustainability literacy. The researcher must validate the ethno-STEM learning model cycle with a learning design expert. In phase II, validation is conducted by posing questions to specialists for

reexamination. The interview guide offers five open-ended questions. The expert in learning design is given one week to respond to the following five questions. After revision, do the components of this developed learning design model include all factors to improve teachers' sustainability literacy preservice through a local wisdom-based STEM approach?

1. *Secara teoritis, apakah komponen-komponen model desain pembelajaran yang telah dikembangkan akan mampu meningkatkan* preservice teachers' sustainability literacy *melalui pendekatan STEM berbasis* local wisdom*?*
2. *Setelah direvisi, apakah model desain pembelajaran ini memiliki nilai kemudahan bagi para penggunanya, baik bagi para pemula dan para ahli (*expert*)?*
3. *Setelah direvisi, apakah kesenjangan penafsiran terhadap model desain pembelajaran antara para pemula dan para ahli dapat diperkecil?*
4. *Apakah fungsi tiap-tiap komponen berpeluang* meningkatkan preservice teachers' sustainability literacy *melalui pendekatan STEM berbasis* local wisdom*?*
5. *Pada bagian manakah dari model desain pembelajaran ini yang perlu direvisi?*

Third Stage

In Delphi Study Phase III, an Academic Manuscript containing: 1) improvements as suggested by learning design experts, 2) an interview guide consisting of 1 final question based on the results of a review of the Delphi Study

Fourth Stage:

The interview guide contain1 question that contains the final view of the learning design expert on the developed learning design model. The question is only answered with the following:

1. Can you agree with this stem learning design model based on local wisdom to improve preservice teachers' sustainability literacy?

3.6.3.2 External Validation of Model

External Validation of the Ethno-STEM Learning Model to enhance the sustainability literacy of preservice teachers, followed by the modification phase.

External validation is undertaken through a forum group discussion with course teachers and stakeholders on the research campus and outside research campus. In this step, the model is externally validated through focus group talks with environmental education course specialists and lecturers. Two questions are posed to learning design practitioners on their perspectives on the learning design model that has been validated by an expert in learning design. External validation focuses on confirming the components and processes of a learning model that combines the Ethno-STEM Learning Model's qualities.

The view of learning design practitioners will be given to learning design practitioners who meet several criteria. The determination of learning design practitioners is based on: 1) Having a learning design educational background / having studied learning design at the master's level (S2); 2) Have expertise in learning design and understand learning design in educational institutions; 3) As a teacher of science subjects at the high school / general level or equivalent.

3.6.4. Model use

The steps taken in the implementation of the Ethno-STEM learning model are:

a) Set the class that the experiment will perform.
b) Did a pretest.
c) Create a small group in the class.
d) Carry out treatment using ethno-stem learning model.
e) The Ethno-STEM cycle is performed on 3 separate themes. The three themes were successively carried out with the first theme of eco-friendly boats, the second theme of drying fish, and the third theme of transforming dirty water into scientifically clean water.
f) Did a posttest.
g) Testing the significance of gain scores in experimental classes with statistical methods to determine the effectiveness of their influence.

Model testing is carried out in the context of model validation, namely to determine the effectiveness and advantages of the Ethno-STEM learning model.

Model testing was carried out using quasi-experimental research methods of the Pre-test Post-test Control Group Design (Peffers et al., 2007) . The quasi-experimental research method was chosen because in this experiment, researcher could not take samples for groups in full random, but using existing (non-random) class samples.

3.7. Instrumental Validation

The data analysis technique used in the study begins with instrument validation until the data analysis results of the research implementation.

3.6.1. Instrument Validation by Experts

The instrument validation used in this study is validation of content and empirical validation. Content validation requires a rational analysis of someone who is an expert in a field related to the instrument being developed, this is called professional judgment. The results of the evaluations carried out by experts were then analyzed using qualitative and quantitative data analysis techniques. Qualitative data analysis is done by summarizing the input of experts and encoding it, reducing data and concluding input from experts which will then be used as a basis for revising the instrument. Quantitative data analysis was carried out using the Content Validity Ratio (CVR). CVR is a content validity approach to determine the suitability of items with domains that are measured by the judgment of experts. Expert validation data is analyzed by the following steps:

a. Criteria for evaluating validator responses

The validator gives a response to the instrument that has been made, then the criteria are reported with the following conditions:

Table 3.7 Criteria for valuating validator response

Criteria	Score
Yes	1
No	0

b. Giving scores on the answers to items by using CVR Scores that have been given by expert appraisers are then processed using the formula:

$$CVR = \frac{n_e - (\frac{N}{2})}{\frac{N}{2}}$$

Description:

n_e = Number of responses stated "yes"

N= Number of experts

c. Calculating CVI value (content validity index)

After identifying sub-questions on the instrument using CVR, then calculating CVI for the total number of sub-questions. In simple terms CVI is the average of the CVR values for the sub questions answered yes.

$$CVI = \frac{CVR}{The\ amount\ of\ questions}$$

d. Categories of the results of CVR and CVI calculations

The results of CVR and CVI calculations are in the form 0-1 number ratio. Whether or not a validated unit depends on achieving a CVR critical value. Following is the Lawshe critical CVR price table (critical CVR) for a number of different experts.

Tabel 3.8 The value of CVR Lawshe from the validator

The amount of expert	Minimal score of CVR
5	0.736
6	0.672
7	0.622
8	0.582
9	0.548
10	0.520
11	0.496

(Wilson et al., 2012)

The results of the CVI calculation are in the form of a 0-1 number ratio. This number can be categorized as follows.

Table 3.9 Category the result of CVI

Range scale	Category

0-0.33	Not suitable
0.34-0.67	Suitable
0.68-1	Very suitable

3.6.2. Validation Instruments of Test for Pre-service Teachers' Sustainability Literacy.

a. Validity is a measure that shows the validity of an instrument. A valid instrument means that the measuring instrument used to obtain the data (measure) is valid. Valid means that the instrument can be used to measure what should be measured. The overall validity of the question is influenced by the validity of the item. If the score of each item has a large support for the total score, then the test questions have high/strong validity. Interpretation of the correlation figures for the items listed in Table 10.

Table 3.10. Category of validation

Range	Category
$0,00 < r_{xy} < 0,20$	Strongly weak
$0,21 < r_{xy} < 0,40$	Weak
$0,41 < r_{xy} < 0,60$	Medium
$0,61 < r_{xy} < 0,80$	Strong
$0,81 < r_{xy} < 1.00$	Strongly strong

b. Reliability test aims to test the level of permanence of the instrument used or the extent to which the instrument can produce a steady/consistent score. Test reliability categories are presented in Table 11.

Table 3.11. Category of reliability

Range	Category
$0,00 < r_{xy} < 0,20$	Strongly low
$0,21 < r_{xy} < 0,40$	low
$0,41 < r_{xy} < 0,60$	Medium
$0,61 < r_{xy} < 0,80$	High
$0,81 < r_{xy} < 1.00$	Strongly high

Table 3.12. Result of CVR and CVI

NO	A	B	C	D	E	F	Ne	N	N/2	Ne-N/2	(Ne-N/2)/N/2	Interpretation of CVR	CVI	Interpretation of CVI
1	0	1	1	1	1	1	5	6	3	2	0.67	Remained		
2	1	0	1	1	1	1	5	6	3	2	0.67	Remained		
3	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
4	1	1	1	0	1	1	5	6	3	2	0.67	Remained		
5	1	0	1	1	1	1	5	6	3	2	0.67	Remained		
6	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
7	1	1	1	1	0	1	5	6	3	2	0.67	Remained		
8	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
9	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
10	1	1	0	1	1	1	5	6	3	2	0.67	Remained		
11	1	1	1	1	0	1	5	6	3	2	0.67	Remained		
12	1	0	1	1	1	1	5	6	3	2	0.67	Remained		
13	1	1	1	1	0	1	5	6	3	2	0.67	Remained		
14	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
15	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
16	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
17	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
18	0	1	1	1	1	1	5	6	3	2	0.67	Remained	0.8	Very suitable
19	1	1	1	0	1	1	5	6	3	2	0.67	Remained		
20	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
21	1	0	1	1	1	1	5	6	3	2	0.67	Remained		
22	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
23	1	1	0	1	1	1	5	6	3	2	0.67	Remained		
24	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
25	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
26	0	1	1	1	1	1	5	6	3	2	0.67	Remained		
27	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
28	0	1	1	1	1	1	5	6	3	2	0.67	Remained		
29	0	1	1	1	1	1	5	6	3	2	0.67	Remained		
30	1	1	0	1	1	1	5	6	3	2	0.67	Remained		
31	1	0	1	1	1	1	5	6	3	2	0.67	Remained		
32	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
33	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
34	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
35	1	1	1	1	1	1	6	6	3	3	1.00	Remained		

NO	A	B	C	D	E	F	Ne	N	N/2	Ne-N/2	(Ne-N/2)/N/2	Interpretation of CVR	CVI	Interpretation of CVI
36	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
37	1	1	0	1	1	1	5	6	3	2	0.67	Remained		
38	1	0	1	1	1	1	5	6	3	2	0.67	Remained		
39	1	1	1	1	1	1	6	6	3	3	1.00	Remained		
40	1	1	1	1	1	1	6	6	3	3	1.00	Remained		

According to table 3.12, the instrument for measuring sustainability literacy is very acceptable for use in research.

3.7. Data Analysis

3.7.1. Implementation of Environmental Education Course Based on STEM

Data on the implementation of course program from the observations of the activities of lecturers and pre-service teachers uses a rating scale. Data from the observations of course program and pre-service teachers' activities are processed using the formula for the percentage of learning implementation as follows:

$$KP\% = \frac{J}{JP} x\,100\%$$

Information:

KP%= Percentage of implementation activities

J= Number of implementation carried out

JP= Total number of implementation

Table 3.13 Interpretation of implementation score

No	Implementation (%)	Category
1	1-20	Very bad
2	21-40	Bad
3	41-60	Enough
4	61-80	Good
5	81-100	Very good

3.7.2. Measuring the Efectiveness of Environmental Education Course Based STEM to Enhance Pre-service Teacher Sustainability Literacy and Concept Comprehension.

To determine whether there is an average improvement on students' initial and final concept comprehension regarding the material of environmental issues after STEM-based project with local wisdom, data obtained from the pretest and posttest were analyzed quantitatively using parametric statistics. The analysis will be done if the data is normally distributed. If the data from normality test is normal then the test will use in this study is the Shapiro-Wilk test with a significance level (α) of 0.05.

To determine the significance of improvement in pre-service teachers' concept comprehension of environmental issues, the scores obtained were analyzed by the McNemar test. This test is used to assess the significance of the difference between correlated proportions, for example testing the significance of individual responses before and after certain treatments or testing the significance of the significance of group responses to two opinions. The formula is as follows.

$$X^2 = \frac{(D-A)^2}{D+A}$$

Information:

A = Frequency of pre-service teachers who experience not increased in concept comprehension

D = Frequency of pre-service teachers who experience increased in concept comprehension

To find out whether there is an increase in the average of concept comprehension of pre-service teachers after the course program is calculated by the normalized gain average (N-gain). The normalized gain average is defined as the ratio of the actual gain to the average maximum possible increase for pre-service. The equation to calculate the average gain normalized <g> is as follows.

$$\langle g \rangle = \frac{\%\langle G \rangle}{\%\langle G \rangle_{max}} = \frac{(\%\langle Sf \rangle - \%\langle Si \rangle)}{(100 - \%\langle Si \rangle)}$$

Information:

$\langle g \rangle$= average of gain

$\langle G \rangle$= average of actual gain

$\langle G \rangle_{max}$= average of gain maximum

$\langle Sf \rangle$= average of posttest score

$\langle Si \rangle$= average of pretest score

Table 3.14. The result of N-gain criteria

Results of gain $\langle g \rangle$	Category
g ≥ 0,7	High
0,7 > g ≥ 0,3	Medium
g < 0,3	Low

Statistical Test

1) Normality Test

Testing the normality of sustainability literacy aspect data is done to find out whether the sustainability literacy aspect data is on normal distribution or not. Normality test calculations are performed using the **kolmogorov smirnov-z** and **shapiro-Wilk tests** with the help of Predictive Analytics software (PASW Statistics 22) or IBM SPSS version 22.0. The normality test calculation step is as follows.

a) Formulation of hypotheses

H_0 : The samples came from normal distributed populations.

H_1 : The samples came from an abnormally distributed population.

b) Dasar pengambilan keputusan

- If sig ≤ 0,05 then H_0 is rejected
- If sig ≥ 0,05 then H_0 accepted

c) Normality Test Results

2) Effectivity Test

The effectiveness of learning model of environmental education course based on Ethno-STEM learning model in enhancing preservice teachers' sustainability literacy is done using the wilcoxon signed rank test. This test is used to see the average difference of two paired samples (test the difference in pretest and posttest data). The stages of this test are as follows.

a) Hypotheses

H_0 : There is no significant improvement in every aspect of sustainability literacy before and after the implementation of the model of environmental education course based on Ethno-STEM learning model.

H_1 : There is a significant improvement in every aspect of sustainability literacy before and after the implementation of the model of environmental education courses based on Ethno-STEM learning model.

b) Critical Value

For a 95% confidence level or $\alpha = 0.05$ and a two tailed test then the value of z of the table is $\pm$ 1.96.

c) Calculating Z value

d) Decision making

Decision making is done in two ways, namely comparing the value Z calculate with Z table or by comparing the value of probability obtained with $\alpha = 0.05$.

If the decision is based on the value of Z calculated, then the criteria is to accept H0 if - Z table < Z calculate < + Z table, For other Z prices H0 is rejected.

If the decision is based on the probability number (value p), then the criteria are:

- If the p value $\leq$ 0.05, then H0 is rejected
- If the p value $\geq$0.05, then H0 is accepted

If this effectiveness test is carried out on every indicator of sustainability literacy, the following results are obtained.

a) Hypotheses

H_0 : There is no significant improvement in any indicator of sustainability literacy before and after the implementation of the model of environmental education course based on ethno-STEM learning model.

H_1 : There is a significant improvement in every indicator of sustainability literacy before and after the implementation of the model of environmental education course based on ethno-STEM learning mode.

b) Critical Value

For a 95% confidence level or $\alpha = 0.05$ and a two tailed test then the value of z of the table is ± 1.96.

c) Calculating Z value for each indicators

By using SPSS version 22.0

d) Decision Making

Decision making is done in two ways, namely comparing the value Z calculate with Z table or by comparing the value of probability obtained with $\alpha = 0.05$.

If the decision is based on the value of Z calculated, then the criteria is to accept H0 if - Z table < Z calculate < + Z table, For other Z prices H0 is rejected.

If the decision is based on the probability number (value p), then the criteria are:

- If p value ≤ 0,05, then H_0 is rejected
- If p value ≥ 0,05, then H_0 is accepted

3.7.3. Pre-service Teachers' Perception After Taking the Course Program.

Pre-service teachers' responses to each statement are expressed in five categories, namely Strongly Agree, Agree, Less agree, Disagree and Strongly Disagree. The analysis is done by calculating the percentage of

each answer for each statement in the Survey Instrument. Scoring for positive statements and negative statements is presented in Table 15.

Table 3.15. Scoring

Score explanation	Positive statement	Negative statement
Strongly agree	5	1
Agree	4	2
Less agree	3	3
Disagree	2	4
Strongly disagree	1	5

The scores of each statement for all pre-service teachers' responses are averaged and expressed in the form of percentage achievements using the following formula.

$$Percentage = \frac{\sum average\ score}{\sum maximum\ score} x\,100\%$$