A conceptual model of inquiry laboratory-based ethnosocioecology

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Abstract. The article is a literature review to emerge as a conceptual model of inquiry-based instruction. It was a study of literature and an analysis of the necessary to integrate local environmental knowledge into the instructional model, also the excessiveness and weakness of the inquiry cycle and especially inquiry lab. According to the analysis, the authors consider to design inquiry laboratory cycle based on ethnosocioecology and add one stage of the previous cycle which is consist of only five steps. The content of ethnosocioecology is expected to cultivate pre-service teacher awareness toward the environment. The additional step is an investigation. In addition to bridge the differences between upper and lower intellectual skills of the pre-service teacher, the investigation facilitates pre-service teacher to enlarge their knowledge, experience, and understanding about local practices in nature conservation to be applied in solving the environmental crisis. Hence, a new model of inquiry laboratory-based ethnosocioecology consists of six phases that are observation, investigation, manipulation, generalization, verification, and application. That phase is grounded to ethnosocioecology as a guide to conduct each stage of inquiry laboratory cycle. The new instructional model is predicted as a model to empower the environmental literacy among university student, especially biology pre-service teachers.

1. Introduction

The increasing of environmental issues in the global, national and local scale leads to the needs of a citizen who more concern about the environment [1]–[3]. Education is expected to be able to integrate real issue to empower the creativity and critical thinking in solving the problem related to the current natural environment [4]. Environmental awareness needs to come with real action to analyze the crisis through the sequence of problem-solving strategy [5], one of them is an inquiry.

The teaching effectiveness could be measured from the links between teaching approaches and student achievement [6]. The inquiry as one of learning strategy that force student to actively engaged in the investigation, collect and analyze the data either qualitative or quantitative to be formulated into
a meaning conclusion, principles or law and play a role in increasing and improving the conceptual understanding, reasoning and thinking abilities [7]. Teacher, lecturer or instructor have to explain conceptual objectives clearly to be developed into a problem or question at the beginning of instruction. Both of them facilitates student in making the interrelationship of concepts and drive them into observation, investigation, and experimentation activities. The result of such events as evidence or the basis of concept explanation or conclusion [8].

Scientific inquiry activities train the skills of hypothetical formulation, design the experiment, analyze the data and evaluate the evidence [9]. This activity allows the student to understand that the complexity of social processes can emerge knowledge which is organized into various disciplines. Thus, the student interest and insight about the nature of science are obtained from a direct experience [10], [11].

2. Literature review

2.1. Social learning theory

According to social learning theory, there are two ways of interaction that is reciprocal determinism between personal, behavior and environment factors in inquiry-based teaching and learning. Personal factor such as cognitive, belief, attitude or perception affects individual behavior to interact with the environment (social or natural). The environmental condition also can be changed or altered by human action. An environment with various information and characteristics could influence human personal factor and transform individual behavior. The theory is explained by the Figure 1 as follow [12].

![Figure 1. Reciprocal Determinism.](image)

2.2. Ethnosocioecology

Ethnosocioecology refers to knowledge and perception of local society towards ecosystem management and conservation practices to adapt to any changing of ecology and social system. The term is a composite of ethnocology and socioecology. Ethnocology refers to the study of knowledge, perception, and practice of local people towards culture, economy, and ecology and resources management [13]–[15]. The integration of social and ecological system then emerge social-ecological system theory [16]. Socioecology as a discipline which considers behavior, ecology, and evolution of society to adapt towards the variety within a social system that includes societal group relationship to interact with nature and one each other [17].

Instruction with problem-solving strategy oriented to the local wisdom is an effort of sustainable education [18]. The developed curriculum with additional local knowledge is contributed to the preservation of cultural heritage diversity and development of an instructional strategy that more contextually [19]. Local knowledge plays a role in constructing a hypothesis and becomes the component of science contents, the basis of natural conservation project such as water management, utilization of land organisms to agriculture with the participation among local people [20]–[22].

2.3. Inquiry learning cycle

The previous study reveals that inquiry-based instruction is a strategy that forces a student into active engagement within an activity to build knowledge through scientific approaches as a scientist [23]. The students’ prior experience is fundamental to knowledge construction through discussion within collaborative work [24]. Scientific inquiry teaching full with scientific investigation. Investigation allows the student to dialogue and analyzes obtained information critically. Hence, student deepens their
prior knowledge and transforms into their attitude and behavior while interacting with the natural and social environment [25].

The inquiry has six levels based on intellectual experience, control, and develop skills. The more the highest inquiry level, it needs the more highest intellectual expertise and self-control. Additionally, there is a shift of control from teacher to the student. The more student knowledgeable, the more student ability to drive their activity to solve the issue or construct a principle of science [26]. The following Table 1 presents the inquiry level [27].

| Discovery Learning | Interactive demonstration | Inquiry lesson | Inquiry Lab | Real-world Application | Hypothetical study |
|--------------------|---------------------------|---------------|-------------|-----------------------|--------------------|
| Low                | Intellectual Sophistication | Locus of Control | Culminating skills | High Student |
| Rudimentary skills | Basic skills               | Intermediat skills | Integrated skills | Advanced skills |

Each inquiry level has a specific instructional objective. Discovery learning gives priority to knowledge construction through the essential learning experience. Interactive demonstration facilitates student to create the predictions and identify the prior knowledge. Inquiry lesson drives the student to cooperate within a workgroup to identify principles or links between concepts and improve the existing understanding. Inquiry lab allows active student role within the workgroup to formulate a new law or belief based on variable testing and measurement then result in a more detailed experience. The real-world application helps the student to involve in a project or problem-based approach to cover a real problem either individually or collaboratively. The hypothetical study encourages the student to analyze and create an explanation related to studied phenomena [28].

Inquiry-based instruction often becomes a frighten and challenge education for student or teacher. The understanding restrictiveness of teacher towards the inquiry especially as a significant factor to avoid its implementation [29]. Student anxiety to conduct the scientific approaches and result in the right answer leads to their resistance. An excellent achievement while traditional instruction cannot be a guarantee that the student will be a success in the inquiry. The less management of inquiry instruction can produce a student refuses to involve actively within that constructivist approach [30]. Furthermore, the teacher has to conceive the concepts and processes within physics and biology field, transfer of knowledge into real context, development, and application for science and technology, hold the scientific inquiry skills and its implementation within teaching and learning [31], [32].

There are the primary characteristics which need to take more consideration to design the inquiry-based instruction. The student is engaged in a project. The teacher has to develop another resource besides a textbook, Teacher-student collaborative to identify each role, responsibility, and role shifting clearly along inquiry instruction. A balance of chance between teacher and student to present the information verbally. The development of authentical assessment consists of content knowledge, intellectual skills and attitude, not limited to the evaluation of the final instruction [28], [33]. A balance for the teacher to give a scaffolding and student exploration [24].

3. Method
The development of the instructional model uses a quantitative method through applying questionnaire of inquiry level [26] for 116 biology pre-service teachers and a critical review of several articles. The questionnaire consist of the description of fifth stage for each inquiry cycle. Respondents need to select “Yes” if they have done the step or “No” if they have never done it. Only the 5 “Yes” responses at each level of inquiry were counted and averaged.
4. Result and discussion

4.1. Inquiry laboratory-based ethnosocioecology

All steps in the inquiry laboratory cycle based on ethnosocioecology context with a consideration that knowledge of ethnosocioecology will encourage the pre-service teacher to environmental problem solving upon the current local wisdom [34]. The developed inquiry level to be a new instructional model is determined based on inquiry level measurement with a questionnaire [28] that is categorized into high (>80%), moderate (>60%), adequate (>40%), low (>20%), and very low (≤20%). According to the measurement of 116 pre-service teachers from three universities, from six levels of inquiry, inquiry laboratory until the upper level still, need to improve. Pre-service teacher ability on inquiry laboratory is only 59%.

Integration of knowledge and values to the instruction allows the student to participate actively in the investigation at societal environment [35]. The investigation which is followed by an effort of problem-solving contributes to build or empower pre-service teacher capacity [18], [36]. That activity sequence creates a meaningful experience and learning. Environmental knowledge, attitude and environmentally friendly behavior can be cultivated through cultural history, knowledge system and local experiences [37].

Inquiry laboratory needs highly intellectual experience and self-control. Students drive scientific inquiry process by themselves. However, the student should have adequately intellectual sophistication [28], [38]. Hence, the teacher also has to arrange and develop inquiry instruction model that facilitate student in learning and bridge the intellectual gap between student [39]. Inquiry laboratory cycle with five steps that is observation, manipulation, generalization, verification, and application [28] then it is inserted by investigation step between observation and manipulation step. The following Figure 2 shows the inquiry lab cycle based on ethnosocioecology.

![Figure 2. A conceptual model of inquiry laboratory-based ethnosocioecology.](image)

4.1.1. Observation-based ethnosocioecology. This first step encourages the pre-service teacher to discuss the environmental crisis and natural resources management of local society. They identify the existing knowledge. Various experience related to the problem is communicated to a learning group [40]. Discussion process is followed by conceptualization (as subphase of observation) about problem definition, and identification variables definition included to the issue that will be further investigated [28], make a prediction or hypothesis towards the identified problem and conduct an argument exchange around the planning of problem-solving. The preparation consists of investigation, testing design and field data collecting [41]. Pre-service teacher conducts the observation activities collaboratively and present opinion, response others argument, and make a decision. Description, communication, respectful reasoning, awareness building start to develop [42], link the prior knowledge with experience to enrich the insight then it contributes to raising the willingness to learn the issues for further [43], [44], grow the self-efficacy, trained the self-regulation to suggest and response others opinion and decision making [33].
4.1.2. Investigation based ethnosocioecology. The prior planning is implemented through investigation [41]. This activity refers to ethnosocioecology. A pre-service teacher explores and gathers the evidence about social habits to preserve the ecosystem based on the formulated question or problem at the conceptualization step. Exploration uses interview and documentation method. Scientific investigation encourages pre-service teacher interest to learn and enrich the insight about science [45].

Obtained information around local environmental problem and practice of natural conservation along observation and investigation is organized through integration step as subphase of the investigation. That subphase assist pre-service teacher to formulate causal and effect relationship and make an explanation based on the evidence such as people act in satisfying the needs, technology development and utilization or policies to environmental management. Pre-service teacher stays work and learns collaboratively to improve the intellectual skill and enrich knowledge about ecology and social component and process. The more student knowledgeable, the more student to gain their self-efficacy and self-control to present an argument and create a decision [46], [47].

4.1.3. Manipulation based ethnosocioecology. According to the discussion and gathered data about ethnosocioecology and environmental issue, pre-service teacher design an objective and step of the experiment [41]. They examine and give evidence about the effect of a specific variable (independent variable) included to ethnosocioecology towards a conditional change of dependent variable (for example water pollution). Self-directed experiment trains a pre-service teacher in constructing and deepen science knowledge and its link to the studied problem. Empirical evidence is used to answer the questions or predictions and make the relation between variables [48]. Manipulation phase allows the pre-service teacher to achieve problem-solving skills as environmentally friendly behavior, collaborative, applying scientific attitude, and tolerance towards the variety of opinions [42].

4.1.4. Generalization. Pre-service teacher formulates empirical law or principle related to ethnosocioecology and environmental problem through consideration or sense-making appropriate to resulted data along hypothetical testing and data analysis, inquiry process controlling by making a decision or process management, arrange; evaluate and reflection of learned knowledge through the testing process (articulation and reflection) [49]. Such method still conducts in a workgroup and negotiation. Generalization facilitates pre-service teacher to self-regulation and reflection [42].

4.1.5. Verification. The result of generalization is communicated to other groups and discuss the possibility that causes a difference of the obtained result (for example error of pre-service teacher to do the procedure of experiment). Verification helps to give evidence of prediction validity at the previous phase (manipulation) [23], [50]. Pre-service teacher learns to reason based proof [41], understand the nature of science [45], reinforce the understanding of science concepts and empirical law which is constructed along the generalization step [51].

4.1.6. Application. The final step is an application that is a chance to the pre-service teacher in completing worksheet included an analysis of causal and effect of the independent variable changing towards dependent variable [28] and applied the new knowledge to practical problem solving [41], [52]. This phase allows the pre-service teacher to achieve conceptualization skills and enrich intellectual ability as well [42].

5. Conclusion
The development of an instructional model needs to be considered from the aspect of need analysis and development objectives [53]. Conceptual instructional model of inquiry laboratory-based ethnosocioecology is developed to facilitate pre-service teacher to be literate to their environment through scientific inquiry teaching and learning. Meaningful and contextual learning is mediated by the integration of local environmental knowledge into inquiry learning activities. The instructional model emphasizes pre-service teacher to navigate their scientific inquiry independently until they generate an
empiric law or principle based on variables testing that is grounded by local environmental knowledge. Hence, the pre-service teacher is trained to grow their motivation to learn, analyze and aware of the ecological problem then able to create a solution. The sequence of activities within inquiry laboratory-based ethnosocioecology expected to form environmental literate people.

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