CHAPTER I
INTRODUCTION

1.1. Problem Background

A speaker at the Institut Pertanian Bogor (IPB) seminar in 2021 stated that "More or less, there are only one million insect species that have just identified from four to five million (Maryana, 2021). Considering Indonesia as a mega biodiversity in the world, one can affirm that there is still a lot of flora and fauna or wildlife, especially insects that have yet to be identified. This thing certainly offers an excellent opportunity and a challenge for young taxonomists. Unfortunately, Indonesia has a longstanding decline in taxonomy. Only a handful of students are interested in studying taxonomy because they think taxonomy is a tiresome and unnecessary science. This is shown by the diminishing number of students who choose to write articles in the field of taxonomy (Saptasari, 2012), although the richness of biodiversity to be treated and revealed is vast and complex. One of the crucial topics to discuss is insects. Although insects are the largest group of animals, research several years ago showed that more than 40 percent of insect species could become extinct in the next few decades (Sánchez-Bayo & Wyckhuys, 2019). Insects not only act as pests or vectors of infectious diseases but also play a significant role in our food chain as suppliers, facilitators, and decomposers (Dewan Guru Besar IPB, 2020) (Herlinda *et al*., 2021).

These challenges can be overcome through education in response to the community's needs. The community hopes the university will equip students with 21st-century skills that should be ready to be part of a changing era (Sandika & Fitrihidajati, 2018). This result is supported by a tracer study conducted on December 2, 2020, with biological graduates from FMIPA Unimed in the field. The alums hope that today's biology students should have competence or skills in understanding molecular approaches in taxonomy (DNA Barcoding, namely

starting from DNA isolation, determination of primers for PCR, use of PCR, electrophoresis), skills in processing and analyzing data in molecular fields such as MEGA software, the using of NCBI gene bank as well as analysis of the identification and diversity of organisms with a molecular approach.

Scientific research, scientific practices, and engineering practices are necessary to encourage students to adapt to new conditions and issues (Bybee, 2013). To equip students with 21st-century competencies, lecturers must create and apply student worksheets (*LKM*) using today's technology in the learning process. The use of student worksheets in a suitable situation can improve mastery of concepts (Ekantini & Wilujeng, 2018). The student worksheet must contain tasks that students must do, instructions, and steps for completing assignments that involve students asking to think more critically and be able to do projects. In particular, on the insect in the class of invertebrate taxonomy with the ability to analyze information/data.

Currently, two approaches have been carried out in studying the taxonomy of animals and plants: the conventional/classic approach through morphological with anatomical observations and the genetic approach. The genetic approach (DNA Barcoding) for animals has been used since the 2000s with *mitochondrial cytochrome oxidase sub unit I* (mt COI) as a marker for animals (D. A. Rahayu & Jannah, 2019). DNA barcoding has improved the accuracy and level of taxonomic classification and, as a result, has become a more critical approach to understanding biodiversity and species identification. Furthermore, DNA barcoding has facilitated the identification of many invertebrates, mainly insects, without entomologists (Erasmus, 2021).

In general, the implementation of DNA barcoding for educational taxonomy can be used for routine identification of specimens and to clarify or reinforce complete taxonomic research. Although DNA Barcoding is not a substitute for a comprehensive taxonomic analysis, it can be used as a starting point because it provides the first signal for population analysis divergence and facilitates comparative studies of population diversity across species. This lab exercise delivers a different context to introduce students to how to analyze DNA sequences and use DNA databases. (Erasmus, 2021; D. A. Rahayu & Jannah, 2019). This

means that through DNA Barcoding, students not only memorize the concept but rather how students understand the concepts of science and its application in life.

The expectation to achieve the DNA Barcoding competency for Biology students at the State University of Medan has been approved in the syllabus/semester learning plan, such as learning outcomes for number 2 (two) in Taxonomy of Invertebrates, namely having a sufficient understanding of applying dichotomous/determination keys to identify and classify animals based on morphological and molecular characteristics/DNA Barcoding (mt COI DNA genes) along with the use of NCBI gene bank data. Likewise, learning outcomes for number 3 (three) in Taxonomy of Invertebrates, namely having adequate knowledge and understanding of evolutionary and phylogenetic relationships (based on morphology and DNA mt COI) and the diversity of invertebrate animals.

Previously, the researcher interviewed biology students from the Class of 2019 and 2020 who had completed the Invertebrate Taxonomy course. The interview results showed that only few students know about the molecular approach in the application. A few students knew about this approach because several lecturers used it as a Critical Journal Review (CJR) task. However, in the practicum, just the conventional approach has been used. In order to support these results, the researcher conducted a preliminary study on biology students at the State University of Medan on September 23rd, 2022, with an online form. Based on that preliminary study, the result showed that 81% of students still need help understanding DNA barcoding, 94% have never used PCR, and 96% have never used MEGA XI. It means students do not comprehend DNA Barcoding and lack knowledge of how to use PCR, Mega Software, and NCBI bank gene. Furthermore, students were bothered by learning based solely on textbooks/presentations; there needed to be more of teaching materials in the form of practicum worksheets that could make learning more meaningful and provide special skills.

The above current problems must be solved through innovative efforts. Education today must lead to a learning process supported by technology to increase student achievement. The solution to overcome the above problems is using appropriate learning approaches and teaching materials. For example, this problem can be overcome by developing Biology student worksheets using insect-

based DNA Barcoding (In Indonesia, it is known as *Lembar Kerja Mahasiswa (LKM)*).

There are some methods or models that can be used in the development of student worksheets. The Research and Development (R&D) model, according to Thiagarajan (Trianto, 2014), with a 4D (define, design, develop, disseminate), is one of some models available. This model has been used to support various analyses to support student worksheet' development. It has also involved some expert assessments (material or content, learning approach), lecturer's response, and student's response so that it is proper for learning.

Based on the above problem background, a study was carried out with the title Development of DNA Barcoding Student Worksheet for Biology Undergraduate Students to increase student achievement in Invertebrate Taxonomy Course at the Universitas Negeri Medan.

1.2. Problem Identification

Based on the background above, problems that can be identified are:

1. Only a handful of students are interested in taxonomy, although the richness of biodiversity to be treated and revealed is vast and complex.
2. Students were bothered by learning based solely on textbooks/presentations, there needed to be more teaching materials like practicum worksheets that could make learning more meaningful and provide special skills.
3. Few students knew about the molecular approach, where students do not comprehend DNA Barcoding and lack knowledge of how to use PCR, Mega Software, and NCBI bank gene.
4. The student worksheet used in the Insect topic has yet to apply knowledge about DNA Barcoding even though already been approved in the syllabus/semester learning plan.

1.3. Problem Scoping

1. Student worksheet that develops is a student worksheet with DNA Barcoding on Insect topics for Invertebrate Taxonomy courses.
2. Student worksheets developed only based on content about amplification using PCR, blasting analysis with MEGA and NCBI, and how to make phylogeny using MEGA XI and NCBI gene bank.
3. Developing student worksheet product is developed using the Thiagarajan 4D model (Define, Design, Develop and Disseminate). Worksheet product assessment results from material expert validation, learning expert validation, subject lecturer's response, and student responses.
4. Worksheet product assessment results from material expert validation, learning expert validation, lecturer's response and student's response.

1.4. Research Question

Based on the identification and extent of the problem described above, the formulation of the problem that that was studied as follows:

1. How are the problems and learning objectives of the invertebrate animal taxonomy course based on DNA Barcoding at Unimed?
2. How is the design plan/ layout of the developed DNA Barcoding student worksheet?
3. How is the feasibility of student worksheets with DNA Barcoding on the Insect topics according to the validations of content or material expert?
4. How is the feasibility of student worksheets with DNA Barcoding on Insect topics according to the validation of learning approach expert?
5. How does the subject lecturer respond to student worksheets with DNA Barcoding on the topic of insects that be developed?
6. How do students respond to student worksheets with DNA Barcoding on the topic of insects that be developed?
7. How is the effectiveness of student achievement increasing by using student worksheets with DNA Barcoding on insect material in terms of the paired t-test and N-gain value?

1.5. Research Objectivities

Following the research question described above, the objectives of this research are:

1. To know the problems and learning objectives of the invertebrate animal taxonomy course based on DNA Barcoding at Unimed.
2. To know the design plan/ layout of the developed DNA Barcoding student worksheet.
3. To know the feasibility of student worksheets with DNA Barcoding on Insects according to the validation of content/material expert.
4. To know the feasibility of student worksheets with DNA Barcoding on Insects according to the validation of learning approach expert.
5. To know the lecturer's response to student worksheets with DNA Barcoding on Insects that be developed.
6. To know students' responses to student worksheets with DNA Barcoding on insects.
7. To know the effectiveness of increasing student achievement by using student worksheets with DNA Barcoding on insects from paired t-test and N-gain value.

1.6. Research Benefit Contribution

1. Student

   This student worksheet can be used as a learning resource to motivate students to be more active, creative, and efficient in the learning process with new experiences.
2. Educator

   The student worksheet produced from this development research can be used as a guide in teaching to apply knowledge about DNA Barcoding on the topic of Insects.
3. Researcher

The worksheets produced from this development research can be used as experience in implementing student worksheets to teach students and increase creativity to innovation.

4. Stakeholder, Campus or University

   The student worksheets from this development research can be used as examples to encourage the provision of teaching materials in the form of student worksheets using DNA Barcoding.

1.7. Operational Definition

Some of the terms used in this study are operationally defined as follows:

1. Development of student worksheets with DNA barcodes on insects is based on content and developed according to 4 D Thiagarajan (Define, Design, Develop, Disseminate).
2. Student worksheets is a teaching material containing summaries and implementation instructions that provide assignments that students must complete and refer to course learning outcomes.
3. The student worksheets (*LKM*) developed consisted of 3 activities consisted of 3 activities: Conventional PCR, Blast analysis with MEGA XI and NCBI gene bank, and how to make phylogeny using MEGA XI and NCBI gene bank.