



Book of Insects' Immune System: Development and Implementation with PBL in Increasing Students' Learning Outcome

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ABSTRACT

The purpose of this research was to develop a research-based reference book and applied through the PBL by means of reference books in learning activities. The method for the reference book used the ADDIE development models. The effectiveness test results of the reference book was conducted using a purposive sampling technique, with a total sample of 55 students and analysed by T-test. The results of the research showed that the reference books of the development results were declared valid by media experts and material experts. The integration of the development of reference books in learning activities has an impact on increasing student understanding as demonstrated through the pre-test and post-test scores that differ significantly with $t_{\text{value}} > t_{\text{table}}$ ($4.149 > 2.045$) at $p \leq 0.05$. Therefore, the development of insect's immune system book with PBL model increasing the student learning outcomes significantly. In addition, this research has been able to improve students' ability and competence in solving problems in insect immune system subject matter.

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INTRODUCTION

Educational problems that are developing nowadays include the complex educational issues (Lewis, 2015). The root of the educational issues is also not far from the problem of student awareness in learning, understanding the importance of the concepts being learned, and how the learning process is taught by educators in the right way (Harlen, 2002; Sudarisman, 2015). The development of various models and methods of learning, learning media, evaluation techniques, and curriculum improvements continue to be made in an effort to deal with learning problems (Taufik et al., 2010).



This is done to achieve learning outcomes for students following the objectives of education especially in Indonesia.

Contextual learning could be achieved through a learning process that is adapted to the demands of the ability to solve problems in the realm of expertise (Park, et al., 2012). The problem of education is often encountered in the learning process. In the classroom of science learning, especially how the educators can contextualize learning material into learning content that is easy to understand (Maulina, 2016). Learning science, especially biology, the truth lies in empirical evidence. Therefore, observation becomes one of the alternatives to understand, prove, and uncover biological facts. Learning through observation does not only come from references, but students are trained to observe any changes in their surroundings. The learning process will determine the learning outcomes (Tauhid et al., 2014). One of the factors causing the low learning outcomes and student understanding occurs because, during the learning process, it is not developing the appropriate learning characteristics (Ostrow, et al., 2017) Science, especially biology as a life-science of learning, is carried out by contextualizing material content (Amin, 2016).

Animal physiology as a branch of biology that studies the physiology process in organisms gradually and continuously requires a process of contextualization in learning activities (Rubiah, 2016). The insect immune system is part of the topic of study in the Animal Physiology group. Insect immune system learning material is a complex learning material with the scope of the field of study in the area of basic scientific groups in biology learning. Insects have a particular form of self-defense that is different from other animals. The body of an insect has unique and special properties, and its metabolism is different from other types of animals. The body's defense against various threats from pathogens and other foreign bodies has different characteristics and regulations.

The previous observations of the problem, which is the low student learning outcomes in the Animal Physiology course at the Faculty of Teacher Training and Education (FTTE), Lampung University. The data shows that in 2015/2016, the even semester showed that the results of studying Animal Physiology. The results showed that only 45% of students understood animal physiology material thoroughly with completeness standard more than 66. It showed that during the learning process in the Animal Physiology course in Biology Education Faculty of Teacher Training and Education (FTTE), Lampung University was not able to contextualize the material learning with real life, as many as 72% of students have difficulty in finding learning resources that have an impact on poor understanding of students (Maulina, et al., 2016).

The previous results of data through a limited survey showed that 82.7% of the immune system material in insects is the most difficult subject matter to student's understanding (Maulina, 2019). The effort to realize to increase students' understanding of the topic of insect immune system studies in Animal Physiology courses was carried out by conducting research experiments in the laboratory. However, adequate infrastructure and high costs are needed. The problem encountered was the comparison of the number of students and available facilities that were not balanced. Therefore, books become one of the media in learning activities (Johnson, et al., 2014).

Referring to the efforts of scientific development and integration in education, the development of research-based reference books needs to be done as a tool to understand contextual phenomena in learning activities (Barroh, et al., 2012; Amin, 2010). Textbooks as a source of learning for the development of the academic culture of the academic community (Law No. 12 of 2012 Higher Education). The reference book is a book that contains a real material presentation about research results that specifically can provide insight, understanding, knowledge for students about the concepts and solutions of various phenomena in the application of life (Muhlisin & Prajoko, 2019). The function and purpose of textbooks other than as a reference by students, as well as evaluation materials, teaching aids in implementing the curriculum, one of the determinants of teaching methods or techniques that will be used by educators (Imran, 2014). One way to contextualize learning that requires a thorough understanding so that it takes a form of learning and learning experiences for students in real life.

Books about defense mechanisms in insects that are currently available are limited to the scope of knowledge without being accompanied by facts and observational evidence. The results of research and data acquisition techniques regarding the immune system in insects need to be used as a basis as a reference source of reference. Therefore, the solution to the use of learning media in the form of research-based reference books is essential for building knowledge. Another fact which is still related to the need for teaching materials in learning activities that 73.73% of respondents stated; teaching materials in the form of reference books are needed to support student learning and understanding. As much as 53.33% of students reveal that the reference books used so far have not represented the results of the latest research results related to lecture material (Maulina & Amin, 2015). Supporting the results of other studies shows that the results of the implementation of the development of innovative reference books can improve the character and student learning outcomes (Situmorang, 2013). Finally, the need for research-based reference books becomes an essential part of achieving meaningful learning outcomes (Park, et al., 2014).

In line with the results of the integration of scientific fields in learning, Minister of Research and Technology Regulation number 44 of 2015 in article 8, explains that the results of the research must be referred to in the learning material. Thus, research products provide significant benefits in the educational aspect through the development of teaching materials based on research results. In order to be effective, the development of teaching materials is referenced to the needs of students (Astuti, et al., 2016). In this case, the course in Animal Physiology with consideration of the facts of teaching material needs that have been revealed previously. Integration of scientific content in learning activities is contained in the subject of the insect immune system.

The integration of learning is carried out with models and learning methods that are appropriate to the development of the world of education (Kusumatuty, et al., 2018). The educational paradigm currently applied refers to the development of the 21st century learning era (Major, & Mulvihill, 2018; Kumar & Refaei, 2017). Hence encourages students to be able to think critically in choosing valid and relevant information, and able to innovate creatively, competent to work independently and in groups, be able to solve problems of daily life and have knowledge base and deep understanding to become lifelong learners (Afandi & Sajidan, 2018). In Indonesia, this formulation is contained in the Law on National Education System No. 20 of 2003 article 3.

The 21st-century educational challenge of the digital 4.0 era explains that the approach to organizing learning from various perspectives of science through multi-disciplinary science becomes crucial that is needed right now (Hosnan, 2014; Amin, 2017). Application of everyday life problems that are dilemmatic or paradoxical problems, research challenges that have not been solved, simulations of real-world events are several examples of material that can be easily digested by students (Merrit, et al., 2017).

The immediate benefits of the multi-disciplinary learning model are the acquisition of scientific concepts in daily application and mastery of several alternative solutions to problems that can be implemented in real life (Afandi & Sajidan, 2018). Thus, this research clearly has an impact on the role of education as a basis for knowledge in multidisciplinary science to build knowledge and awareness of students about scientific content and education (Arends, 2008).

Problem Based Learning (PBL) is a learning approach that uses real-world problems as a context for students to learn about critical thinking and problem-solving skills, as well as to obtain essential knowledge and concepts from the subject matter (Barrett, 2017). Problem-based learning is used to stimulate high-level thinking in problem-oriented situations, including learning how to learn (Chiang & Lee, 2016). Problem-based learning makes students become independent learners, meaning that when they learn, they can choose appropriate learning strategies (Babich, & Stankunas, 2016). Skillfully use these strategies for learning and be able to control their learning processes, and motivated to complete their learning (Department of National Education, 2003).

The main purpose of problem-based learning was to explore students' creativity in thinking and motivating students to continue learning (Asyari, et al., 2016). Problem-based learning is not designed to help teachers provide as much information as possible to students, but it is developed to help

students expand their thinking skills, problem solving, and intellectual skills. Also, learn various adult roles through their involvement in real or simulated experiences and become an independent learner (Cullen & Jackson, 2018; Ibrahim, 2000). Therefore, problem-based learning is focused on student learning development, not to help teachers gather the information that will later be given to students during the learning process (Cindy, 2004; Cindy, 2007).

The integration of the reference books as one of the literacies in learning activities using the PBL model is expected to increase student understanding (Park, et al., 2012; Hou, 2014). Accordingly, based on the background, this study aims to develop research-based reference books on insect immune systems and improve students' learning outcome through Problem Based Learning.

METHOD

This research consists of two stages of activities, namely the development and experimental research. Development research was conducted to develop a research-based reference book which was then used as a reference book for learning activities in experimental research. Following was on staged of the research study (Figure 1).

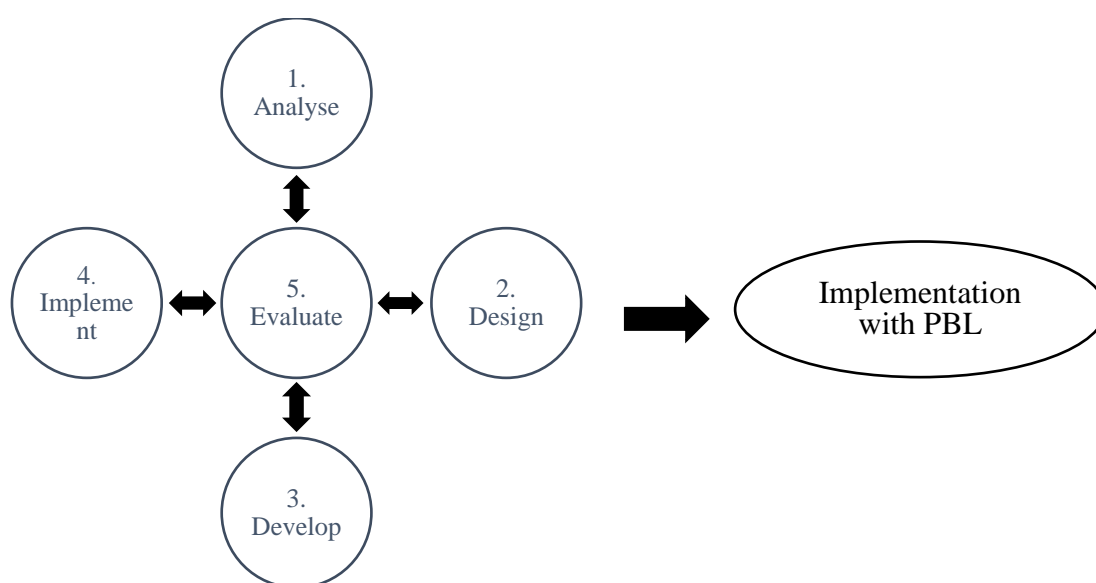


Figure 1. The Stage of Research Study

Development of Research-Based Reference Books

The book development stage uses the ADDIE development model (Branch, 2009). The steps for ADDIE development are carried out in the following stages:

The need analysis (*Analysis*)

This stage will be carried out an analysis of the needs of Biology Education students at Lampung University who have taken Animal Physiology courses on the use of reference books in the learning process and the weaknesses or strengths of reference books that have been used so far. Through identification of the need for reference books in learning activities through the process of learning analysis through testing the ability of students to insect immune system material, interviewing lecturers and students and providing feedback responses regarding the use of reference books in lecture activities through questionnaires.

The study was conducted at the University of Lampung in March 2018, with Biology Education students from the Faculty of Teacher Training and Education (FTTE), Lampung University who have taken Animal Physiology courses in the academic year 2016/2017 as a sample in the study. This research is survey research on the analysis of the need for reference books as learning media in Animal Physiology courses.

Qualitative data were obtained from a survey of teaching material needs for students through

observation during learning with a questionnaire for lecturers and students. The student response data obtained through questionnaires.

The results of the student questionnaire sheet applied with a *Likert* scale calculation with indicators that have been developed regarding the availability of teaching materials in the form of reference books that have been used in learning activities and their needs for students during the learning process. The data obtained are analysed descriptively as percentages so that the percentage of the class as a whole can be calculated using:

$$\text{Percentage (\%)} = \frac{\text{Total Score Acquired}}{\text{Maximum Score}} \times 100\%$$

The lecturer questionnaire has an open questionnaire that contains the development of learning and the use of reference books during the learning process in Animal Physiology courses.

Book development design based on research findings (*Design*)

This stage created draft model of research-based reference book. From the research results, research materials will be developed into a reference book form. The design of the reference book design refers to the *Directorate General of Research and Development Strengthening Ministry of Research, Technology and Higher Education* where the reference books must have the following elements: (1) Foreword, (2) Table of Contents, (3) the body which divided into chapters (4) bibliography and (5) glossary. The manuscript would be typed using the specific font.

Preparation of research-based reference books (*Develop*)

The development phase was carried out by undergoing the process of compiling and typing thoroughly the material and design in accordance with the draft. During the development phase of the reference book, a revision is made. Either from the author or from the supervisor.

Reference books that have been revised and declared appropriate based on the validation of media experts and material experts. The book evaluation component is carried out using an assessment instrument by the media expert. Specifications for the assessment in the form of the appropriateness of display and legibility of the book were developed from the National Education Standards Agency (2014) and modified according to the research objectives.

Quantitative data were analysed in the form of a questionnaire assessment score from the validator. While qualitative data are in the form of responses and suggestions provided by the validator. The compiled book is declared to be suitable for use if the questionnaire scores were either good or very good. The data analysis technique used in analysing quantitative data in the form of an assessment questionnaire score is to calculate the answer value using the following formula:

$$\text{Final Score} = \frac{\text{Total Score Acquired}}{\text{Maximum Score}} \times 100$$

The results of the assessment score will be determined the eligibility criteria of the reference book, which can be reviewed from the assessment in Table 1.

Table 1

Criteria of validity data of validator questionnaire assessment

Score	Qualification	Note
80 – 100	Excellent	No need to revise
70 – 79	Good	No need to revise
60-69	Fair	Revision needed
50-59	Deficient	Revision needed
<50	Fail	Revision needed

(source: assessment category aspect from NESAs, 2014)

Implement

This stage will test the effectiveness and practicality of reference book products in a small group

of product users. The practicality and feasibility tests for books were obtained through questionnaire sheets. The implementation stage was carried out in the Animal Physiology course at the University of Lampung in May 2018 with samples of correspondence of 30 students.

Evaluate product results (*Evaluate*)

The development of ADDIE at the evaluate stage is cyclic, which means that evaluating can be done at the end of each of the previous stages; thus evaluating is flexible. Evaluate is in charge of improving and reviewing success at each stage to produce reference book products in this Animal Physiology course.

The evaluation stage has a role to evaluate the reference books that have been developed, the evaluation of reference books includes the feasibility of books based on the evaluation of the validation of reference books by the validator of material experts and media experts, the results of the assessment of reference books by supporting lecturers, the results of questionnaire responses of reference books by students by filling out questionnaire sheets.

Implementation of book-product to the target users with PBL

The effectiveness test results of the reference book were analysed for the cognitive value of pre-test and post-test using paired t-test using SPSS 20.0 statistical test. At this stage, a qualitative calculation is used, which aims to analyse the effect of the use of reference books based on student research through learning Problem-Based Learning by using reference books as literature in learning activities.

This research was conducted in October 2018 with four face-to-face lessons. This research was conducted on the subject matter (material topic) of the insect immune system in the invertebrate class.

Implementation of Problem-based Learning in the experimental class was carried out with the stages of learning activities ((Barrows, 1986; Barrows 1998; Barret, 2005) through stages: (1) students are oriented towards the problem presentation (2) students formulate and analysed problems with hypotheses (3) students conduct a literature study (4) Organize ideas systematically and analysed (5) percentage of analytical results and synthesis of problems, and (6) evaluate the results of the presentation of the problem-solving process and reflection on learning outcomes.

In conventional classes learning activities was carried out through practical learning activities through the stages of explaining the purpose of learning, a description of the theory, tools, and work materials, work procedures and the percentage of practical results. Respondents in this study were biology education students who took the Animal Physiology course in sixth semester of the academic year 2017/2018 at the University of Lampung, Indonesia. The sample consisted of 55 students who were obtained through purposive sampling techniques. The research design used was a pre-experiment, pre-test & post-test design control group (Creswell, 2019) with the scoring technique obtained by measuring the N-Gain value.

The research instrument consisted of 20 items that had been validated by material experts and tested on students who were not research samples. The questions have given consist of multiple problem-based choice questions with answer choices consisting of 5 choices (A, B, C, D, and E). Validity and reliability tests were determined based on the results of the trials on 25 biology teacher candidates who were not research samples.

The reliability test results with Crocbachs Alpha showed a result of 0.847. The research data were tested statistically by using ANOVA which aims to explain the difference between more than two groups of samples with a significance level of 5% ($p < 0.05$) (Mertler, & Reinhart, 2016). The data obtained were first tested on the prerequisite of the analysis including the Kolmogorov-Smirnov normality test and homogeneity of variance using the Levenes-Test. All data testing is done by using the SPSS program version 22.0 for windows.

RESULT AND DISCUSSION

The analysis stage was a crucial part of the process of developing reference books. The student

needs for books and subject matter of development as a result of research form the basis of developing books. This stage was obtained through field observations in the Biology Education Study Program at FTTE-Lampung University in Animal Physiology lectures. The background to the development of books is based on the availability and use of existing learning resources. Besides, the subject matter of Animal Physiology lectures which are considered confusing is the primary key in making the reference books. Data collection was taken through questionnaire sheets and interviews with lecturers and students. The following is a representation of the results of the preliminary analysis presented in Table 2, Table 3, Figures 2 and Figures 3.

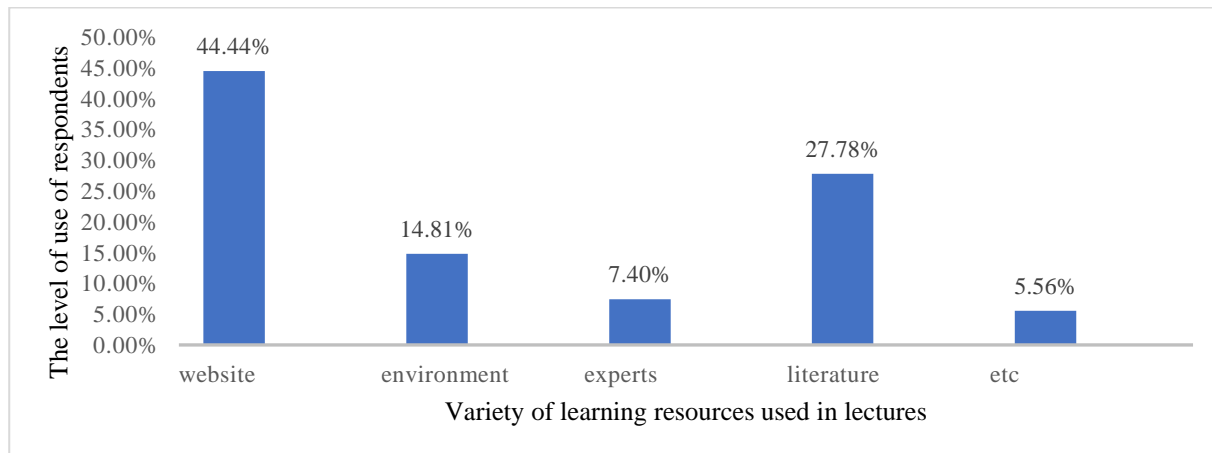


Figure 2. The Use of Learning Resources in Lectures

The needs analysis shows that the use of learning resources in lecture activities from 54 student correspondents shows that 44.44% of learning outcomes are taken from the website and 27.78% from various literature books (figure 2). The high use of websites as a learning reference has both positive and negative impacts. On the positive side, technological advances open up broad insights and make it easier for students to reach an understanding of various learning difficulties. However, in other cases, the use of the website needs attention from the source of truth. Technology makes learning activities easy and facilitated, but the important thing is the accuracy of the source of the website that is being referred to cannot be trusted yet.

The results show that the lecturer gives literature books to students who are the primary reference during animal physiology lectures and as many as 27.78% of students use books as learning resources. Unlike the website, students believe that books have a high degree of authenticity and originality. However, the presentation of reference books that so far used in the class has not been widely referred to the results of the latest research related to learning material. Therefore, so far, the use of books is not optimal to be able to meet learning needs.

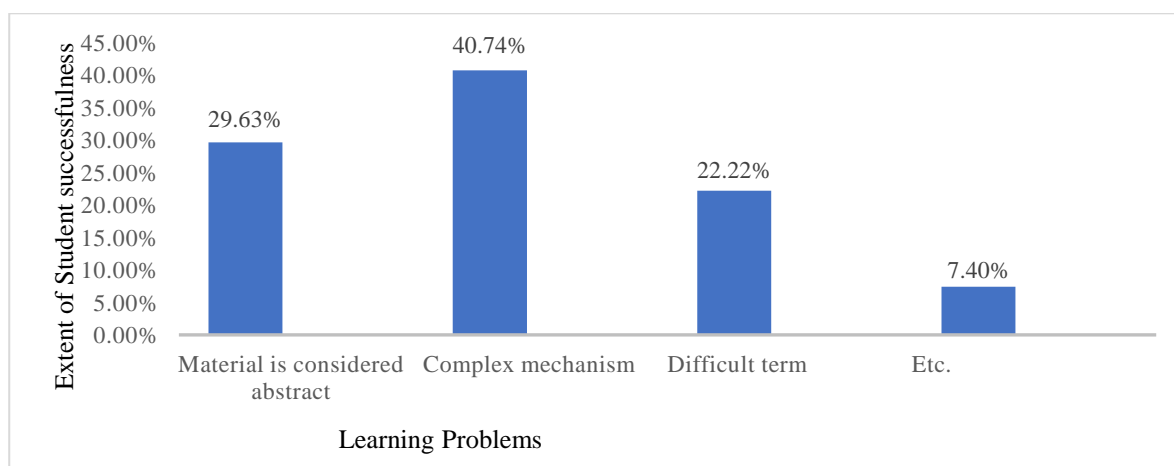


Figure 3. Criteria for the Difficulty of The Immune System's Primary Matter in Insects

The explanation of reasons students considers immune system material is complicated in Figure 3. This indicator is the criteria in the results of the answers 29.63% of student respondents who consider immunity in insects is considered abstract. Abstract, as explained, is the subject matter that cannot be seen and clearly described. Accordingly, 40.74% of respondents gave the reason that immunity in insects involves various processes of action and reactions from the body's systems so that the process is considered complex and challenging. Another related problem is the use of tricky terms that cause students to have difficulty in understanding the contents of the material. As many as 22.22% of student respondents expressed their difficulties in using terms that were not accompanied by image/visualization. Therefore it is necessary to provide a reference book as an ingredient for the enrichment of the immune system in low-level animals, in the class of insects in particular.

Table 2.

The need of reference books in lecture activities

No.	Indicator	Percentage
1	The need for reference books in the learning process	73,73%
2	Representation of current research results related to the material	53,33%
3	Reference books become the source of learning in overcoming difficulties in understanding material	30,23%

(source: assessment category aspect from NESAs, 2014)

Table 2 presented that the results of the benefits and needs of reference books for students in understanding the material. Animal Physiology Lectures 73.73% of students need a reference book as a reference and source of material. The reference book that will be created aims to facilitate students in understanding learning material and can be used to repeat lessons that have been learned or are intended to learn new material (Harlen, 2002).

Reference books are used as a reference for learning resources for students. However, the data shows that 53.33% of the correspondents said the existing reference books did not present various phenomena or research results related to the content of learning material. This suggests that the existing reference books have not linked learning with current issues. Thus, based on the results of the needs analysis above the development of reference books on the subject matter of the insect immune system.

The design of this research-based reference book showed in the Figure 4. The details of the book section consisting of fourth main chapters are as follows: Chapter I describes the insects in general and overall that begins with the morphology of insects and the life cycle that occurs. Insects for most people are known as destructive animals that have a negative impact on life. However, in chapter II, it is explained that insects have benefits and roles for the ecosystem and specifically for humans and other organisms on earth. It is explained that evolutionary development states that insects are the oldest group of animals that are still capable and survive. Therefore, insects have high adaptability. Insects are often used as objects in research in terms of regulation and metabolism that occurs in the body capable of quickly producing and compounds or substances to maintain itself a bag of foreign substances that are in his body.

Insect defense mechanisms are generally explained at the end of chapter II. The aim was that the reader's understanding can be focused on the immunity reactions that occur in the body of the insect. Therefore, the insect's defense mechanism was explained therein. This section has included colour pictures that support the written description to help the reader understand the context of the contents of the description. The end of chapter II explains how the immune system is divided into insects, therefore in the second chapter, it could be explained the mechanism of the immune system humoral directly.

The third part of the book was explain the cellular immune system. The role of cellular response in eliminating various pathogens with a large size when entering the body of an insect. How the coordination of hemocyte cells to be able to do self-defense so that the insect's body could be stay alive was explained therein. The fourth chapter of the book explains the humoral immune response

mechanism. In particular, insects obtain defenses derived from their parents (innate immunity) humoral and cellularly. That was conveyed in the second part of the chapter, and the humoral response is explained and supported by methods and data from the results of laboratory research.

This section also includes illustrations and tables to ease the readers understanding; image of tools and an explanation of how use of tools to test humoral defense reactions. The presentation of images from laboratory equipment and the procedures for their use enrich the insight for the readers. It presents results from laboratory studies that have been carried out. Therefore, attracts the reader curiosity about the contents of the book on immune system material that occurs in insects specifically.

The results of this research-based book development product are validated against the standard of visual and content feasibility by the validator of media experts and material experts. As stated in tables 3 and 4.

Table 3.

The results of the validation of media experts

No.	Assessment Category Aspects	Score	Category	Test Decision
1.	Book's size component	100	Very Valid	No need to revise
2.	Book's cover design	100	Very Valid	No need to revise
3.	Book's content design	95,54	Very Valid	Revise as necessary

(source: assessment category aspect from NESAS, 2014)

The results of the appraisal of the book's appropriateness subsequently serve as material for evaluation and improvement of the book's development. Based on the results of the assessment conducted by the validators, data obtained that the validity of the book visually obtained a feasibility assessment score of 74 out of the 80 maximum scores (92.50%). It means that the results of the development of the book obtained outstanding criteria. The forms of advice from media experts on the design of the contents of the book which includes: writing procedures, large letters, the distance between paragraphs and writing on the description of the picture. Besides, the results of the content validation gave a score of 47 out of 56 scores for the maximum value of the content assessment (83.92%), which meant obtaining excellent criteria.

Validation assessment scores from experts are listed in Tables 3 and 4. These results provide recommendations for improvement of the book, especially on the component presentation of the contents of the material. Several parts of the book, such as pictures and captions, need to be revised to be understood by the reader. And, some theoretical study results sourced from books, journal articles, or other scientific research results need to be adjusted and reviewed.

Table 4

Validation result from experts

No.	Assessment Category Aspects	Score	Category	Test Decision
1.	Appropriateness content component	90	Very Valid	Revise as necessary
2.	Presentation component	75,83	Valid	Revise
3.	Language component	100	Very Valid	No need to revise

(source: assessment category aspect from NESAS, 2014)

The book evaluation aspect of the user is reviewed in terms of practicality of the book, which includes language, readability, presentation, appearance and benefits. According thr Table 5, all aspects of the assessment of research-based insect immune system reference books are appropriate to use. The following is a representation of the assessment by book users. The linguistic aspect of the book product has a score of 91.83, which means the book can be understood and read by the reader.

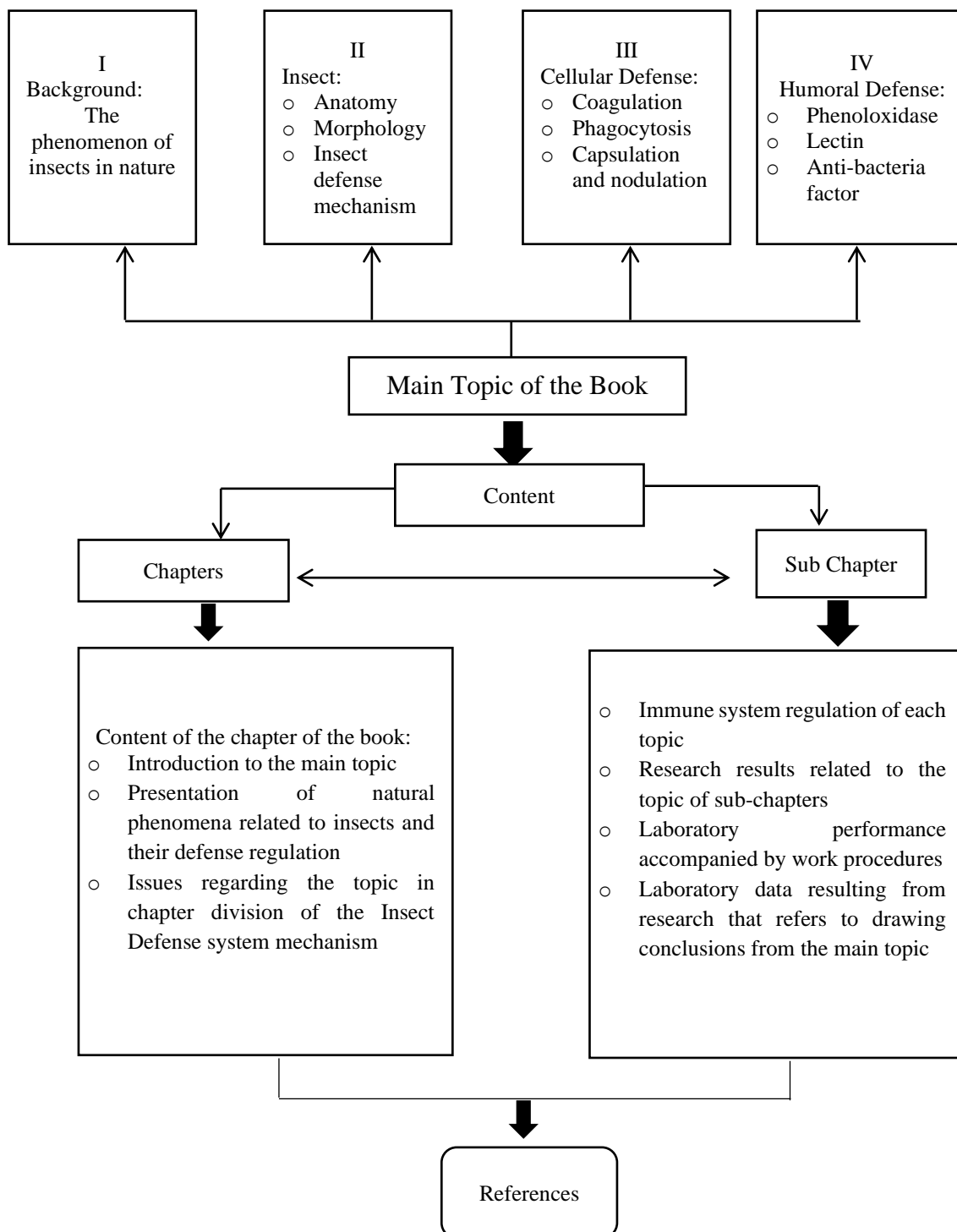


Figure 4. Material Mapping From Reference Books

Table 5.

Evaluation aspect of reference books by users

No.	Assessment Category Aspects	Score	Test Decision
1.	Language	91,83	Very reliable to use
2.	Readability	87,50	Very reliable to use
3.	Presentation	92,71	Very reliable to use
4.	Layout	87,83	Very reliable to use
5.	Benefits	96,04	Very reliable to use

(source: assessment category aspect from NESAs, 2014)

The results show that this reference book is interesting for students in terms of presentation and appearance. Present pictures and information on the subject matter of the immune system are contained therein. This reference book provides a benefit value of 96.04% of students saying this book provides use value as a source of learning on the subject matter of the insect's immune system.

This reference book was designed in accordance with the subject matter of the insect's immune system, which consists of four main sub-chapters; introduction, insect, humoral defense, and cellular defense. The fifth division of this chapter is based on a preliminary analysis of the subject matter of the immune system in insects in animal physiology courses. This reference book is declared worthy to use by providing information to readers regarding the regulations that occur in the body of insects to be able to survive and control the application of insect populations in the biological way. Book development with ADDIE models was the best design method (Peterson, 2003). The development of books that are made referring to the needs analysis of the students would result in impact to the suitability of achievement targets and this research was to the students' ability to solve problems (Wang & Hsu, 2009; Vaan-Rooij, 2010).

Representation of the effectiveness of the book can be seen in the results of the pre-test and post-test presented in Table 6. The reference book is able to increase cognitive understanding in students as much as 83.33. The learning process is carried out two times with the subject matter of invertebrate class animal defense systems, insects.

Table 6.

Representation of the significance value of pre-test and post-test in the group design class

Paired Differences								
Design sample	Mean	Std. Deviation	Std. Error	95% Confidence Interval of the Difference		T	df	Sig. (2-tailed)
				Lower	Upper			
Pair 1 Pretest - Posttest	16.50000	21.78065	3.97658	24.63303	8.36697	4.149	29	.000

Note: the increase in the value of pretest and posttest is indicated by the value $t_{val} > t_{table}$ ($4,149 > 2,045$).

The results of students' initial understanding are shown by the average results of student pretest scores of 41.67. Integration of the development of reference books in PBL-based learning activities results in increased student understanding, which is shown through the post-test score of 57.67. Representation of increased pretest and posttest values can be seen in Figure 4. These results point to a significant difference with the value of $t_{val} > t_{table}$ ($4.149 > 2.045$) at the level of $p < 0.05$ seen in Table 5. The data shows that PBL has a significant role in student understanding (Minner *et al.*, 2010). Learning holistically by observing and referencing appropriate learning resources helps improve learning outcomes (Timpany, 2009; Güneş & Kırmızı, 2014).

The integration of learning using research-based books and PBL produces a holistic form of learning that can enhance understanding and learning experiences (Usta & Güntepe, 2017;

Korthagen, 2013). PBL builds an understanding of concepts, understanding the relationships between material concepts and connecting concepts, procedures, and applications in student-learning (Gijbels, et al., 2005). Research-based reference books help students understand how to develop concepts, connect concepts, and understand the application of immune system material to insects with the environment and real life.

CONCLUSION

Development of the references books resulting from the development of research results contain scientific concepts about insects, causes of natural damage, and human efforts to restore the role of the proud as an organism in the ecosystem. Integration of the development of reference books in learning activities using the PBL model has an impact on increasing student understanding as indicated through significantly different pre-test and post-test scores with values of $t_{hit} > t_{table}$ ($4.149 > 2.045$) at $p < 0.05$. The research-based reference book that has been developed has been adapted to the needs of students by referring to learning achievements that contain scientific concepts about insects, causes of natural damage, and human efforts to restore the role of insects as organisms in the ecosystem. In addition, this research has been able to improve students' ability and competence in solving problems in insect immune system subject matter.

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