WEB-BASED APPLICATION OF CALCULUS DISTANCE LEARNING USING AN ADAPTIVE LEARNING APPROACH

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Abstract

In this digital era, distance learning has become a trend in the world of education. It can be seen from the number of e-learning platforms such as Coursera, Udemy, and edX and is also supported by the many open learning resources, both written such as Wikipedia and blogs, as well as in the form of videos on YouTube. One of the challenges of e-learning is how to achieve optimal learning outcomes or even better than traditional learning models. With the varying the speed of student understanding, Adaptive Learning (AL) can be an alternative e-learning model that can personalize the methods and habits of each student. The adaptive learning model is a model in which the process and progress of student learning are adjusted to each student's competence and learning speed so that it has high learning effectiveness. In this paper, we present a web-based application based on the design of an adaptive learning model applied to calculus learning through an online platform by developing the structure and flow of calculus materials and assessment procedures that will be applied to the platform. This study aims to develop a web-based application by identify calculus materials and design a model and structure of AL Calculus, including the assessment process to measure student learning achievement. The learning flow can allow students to choose the modules they will study according to their level of competence in each material but still apply the minimum standards that must be achieved before proceeding to the next level. The result is an adaptive and comprehensive calculus learning application consisting of ten modules with five levels that must be studied.

Keywords: Adaptive Learning, calculus, distance learning, model and structure, web-based application.

1 INTRODUCTION

Distance learning has revolutionized education through the use of open sources, cloud-based web technologies such as Wikipedia, blogs, and social networks, and online platforms like Coursera, Udemy, and edX. Researches have highlighted that e-learning enhanced teaching and learning quality, supported learning styles and preferences, increased access to educational opportunities, enabled virtual collaboration across regions and even countries, developed skills and competencies needed in the 21st century, and provided education cost-effective (Swan,

2010; Means et al., 2013; Shirky, 2015; Allen & Seaman, 2017; Stehle & Peters-Burton, 2019; Yang, 2020).

E-learning is regarded as the most suitable solution for future government efforts. Due to its flexible and virtual characteristics, demands for evidence of quality, credibility, and accountability are higher than traditional learning models (Protopsaltis & Baumi, 2019). However, online learning also has limitations (Smaldino, 2011). The first, students often unintentionally access topics that are not in accordance with the material, including to sites that are not safe for students to consume. Second, the ease of accessing information provides significant opportunity for students to create assignments through copying and pasting. Third, the large number of sites on the internet challenges students to find information that is relevant to their needs. Fourth, an internet connectivity that often disrupted will reduce effectiveness online learning process. Fifth, the weaker the signal, the less likely students are able to send and receive data. Sixth, access speed is often affected by the size and complexity of a web page. Lastly, the lack of quality control on the internet allows anyone can write, sometimes scientific information, sometimes irrelevant, inaccurate, or unreliable.

There needs to be an e-learning system that able to accommodate differences in student characteristics especially the pace of student understanding. Adaptive Learning (AL) offers an alternative e-learning model to the traditional e-learning model one-size-fits-all and can personalize the methods and habits of each individual learning participant. Learning content and assessment can be adjusted with the aim of creating a personalized learning path for each learner according to the knowledge, skills and learning needs of the learner concerned (Cavanagh et al., 2020). Adaptive learning is an educational method that uses computer algorithms and artificial intelligence to organize interactions with learners and provide learning resources and activities that are tailored to meet the unique needs of each learner (Andreas Kaplan, 2021). The AL model is an approach when the process and progress of student learning are adjusted with student's competence and learning pace so that has high effectiveness on learning.

AL systems can be implemented on the internet to support distance learning and group collaboration. These systems are able to provide learning materials at appropriate levels of difficulty and how to present learning materials according to the students learning style. In other words, adaptive learning systems can adapt their appearance to suit the characteristics of students, so that they have high learning effectiveness and appreciation for the achievements of

each student's ability level (Putra et al., 2019). As in Kurniawan (2019), the difference between the pretest and posttest results indicated that the student learning outcomes during learning using AL have increased. AL accommodates student's learning styles so that they can adjust to their needs. It can be designed through an Adaptive e-learning system (AES) which designed to identify students' learning styles and presenting materials that suit their learning styles. AES can be accessed online so that students are expected to be able to use it outside of class hours (Kusworo et al., 2021).

In the previous paper, as in Herlinawati et al. (2024), we have designed an adaptive learning model applied to calculus. The learning flow created can allow students to choose the modules they will study according to their level of competence in each material but still apply the minimum standards that must be achieved before continuing to the next level. In this paper, we introduce a web-based application that built based on the model and structure from that paper. The goal is to provide a clear overview about AL model that we developed.

2 METHODOLOGY

This research begins with a literature study on the concept of adaptive learning applied to distance learning in Indonesia, continued with forming a model and structure for AL calculus by identifying learning materials including competencies that must be achieved by students in the calculus course and analyzing the relationship between competencies of each materials, whether some materials can be studied simultaneously or must be sequential for certain materials. Finally, creating the web-based application based on model and structure that has been built. In general, the stages in this research are explained in the diagram in Fig. 1.

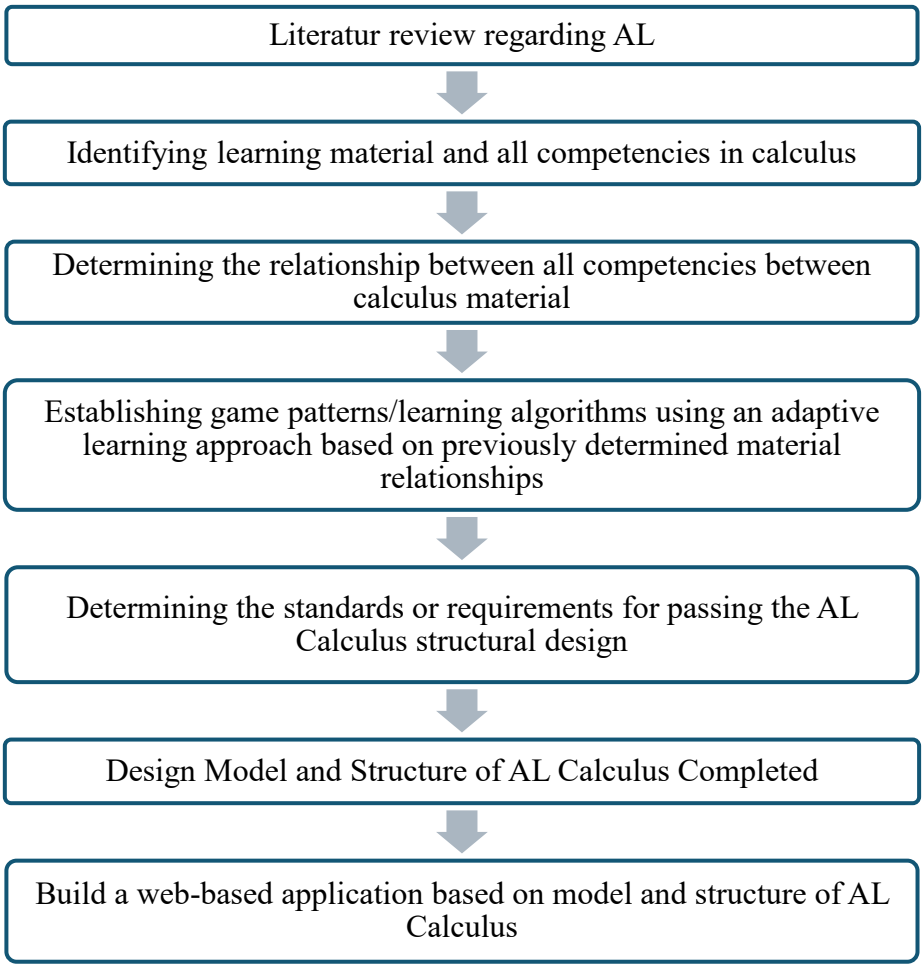

Figure 1. Research Stages.

3 FINDINGS AND DISCUSSION

As discussed in the introduction, the adaptive learning (AL) model can adapt its appearance to suit the characteristics of students, so that it has high learning effectiveness and appreciation for the achievement of each student's ability level. This model is beneficial for students who want to master the material quickly or for those who need more time to master the material.

3.1 Model and Structure of Adaptive Learning Calculus

In this study, the representation of the learning idea based on AL is applied in Calculus material and designed in a web-based online learning in the form of AL Calculus Structure and Model. The developed AL Calculus model is designed in the form of structure and material as in Fig. 2.

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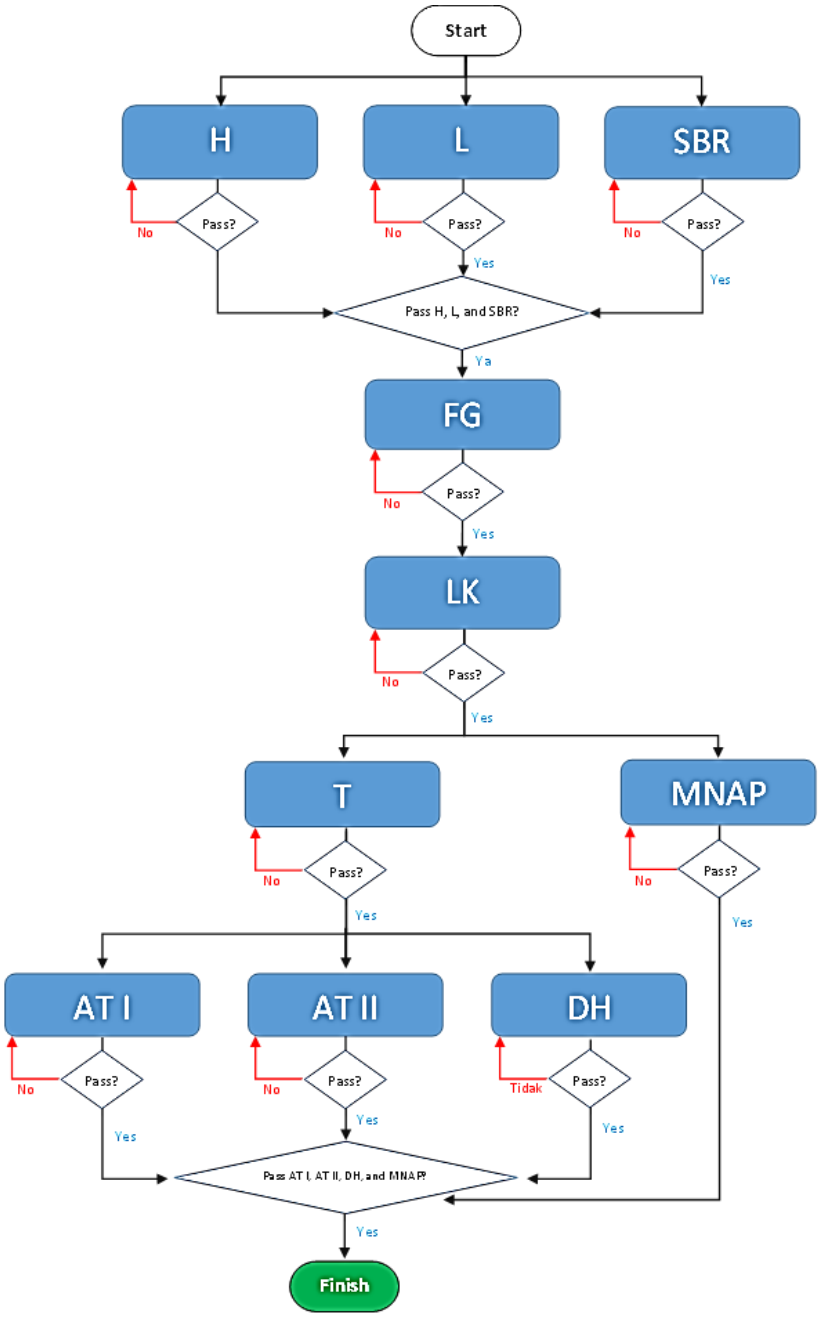

Figure 2. Design for adaptive learning model in Calculus.

There are ten modules in AL Calculus with five levels or stages that must be mastered. These modules are Sets (H), Logic (L), Real Number System (RNS), Functions and Graphs (FG), Limits and Continuity (LK), Derivatives (T), Differentials and Approximations (DH),

Applications of Derivatives from Graphs and Functions (AT1), Applications of Derivatives from Modeling (AT2), and Numerical Methods of Root Equations (MNAP).

In the AL Model, all information and learning activities are recorded, stored, and analyzed, including all correct and incorrect answers in quizzes or tests, the amount of time to complete assignments, learning patterns, and learning strategies. The presentation of learning materials is not linear, but can jump from one material to another.

Students are free to choose the sequence in which they complete the modules within the same level. For instance, at the beginning level, which consist of Modules H, L, and SBR, they can begin with any of the three. Once they have completed all three modules, they may proceed to the next level and select from the following modules: FG, LK, T, DH, AT1, AT2, and MNAP. To move on to the next level, students must meet the minimum competency requirements for every module in the previous level. If they fall short of the required score, they must retake the corresponding module before progressing. Thus, this learning flow provides students the freedom to choose which modules to start with, while still enforcing a minimum standard that must be met before advancing.

Each module contains several learning competencies to be achieved. These competencies are arranged according to the complexity of the material, the progression of learning, and the integration of interrelated concepts. For example, the first module i.e. Sets, has six learning competencies. In the first competency, students are required to identify or provide examples of objects or non-objects that belong to a set. This is a basic learning competency that essential for students to understand the concept of a set.

The following competencies guide students to understand more advanced concepts of sets. After completing each competency, students are given five practice questions to work through. Once they finish these questions, they receive feedback, both correct and incorrect responses are accompanied by constructive explanations. The results of these practice questions do not determine students competency levels; instead, assessment takes place after all competencies in the module have been learned. At that point, students complete test questions that cover every competency within the module, with the number of questions distributed proportionally across the competencies.

To continue to the next module level, students must meet a minimum score, or cut-score. This minimum competency is set at 60% of the total assessment score given at the end of learning in each module. In other words, students are considered to have achieved the required minimum

competency if they score at least 60% on the module assessment value. The assessment consists of multiple-choice. Meanwhile, the final AL Calculus score is determined based on the average of the scores from all 10 learning modules. This model will be the foundation for developing a web-based AL Calculus application.

3.2 Web-Based Application of AL Calculus

Based on model dan structure of AL Calculus above, here is the result of its web-based application.

3.2.1 Login page

Before start the application, user must create account first by clicking *Buat Akun* as in Fig. 3. Then login by entering the e-mail and password that has been created.

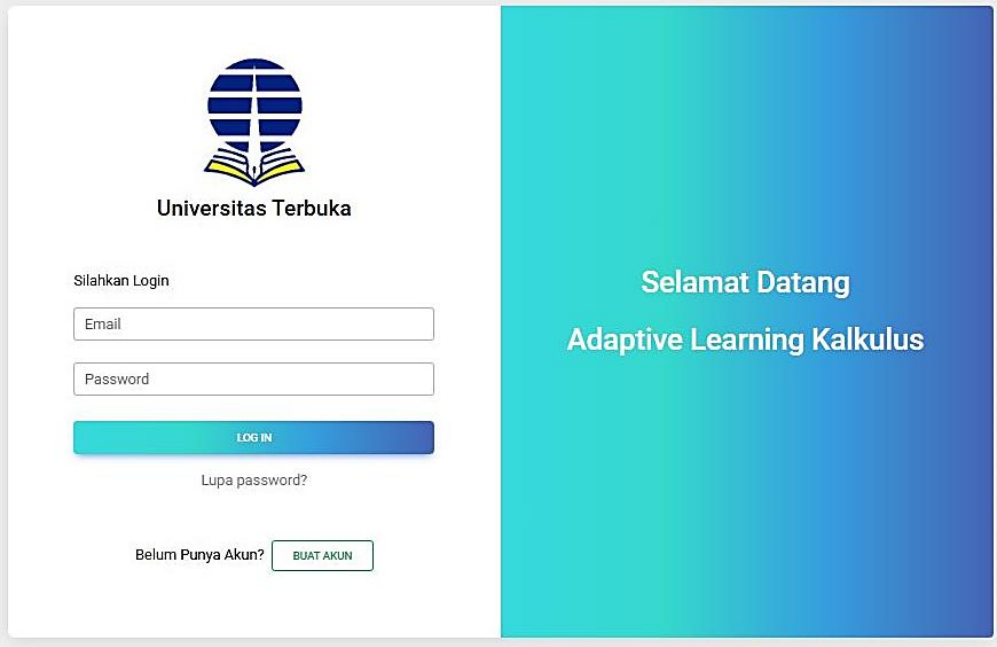

Figure 3. Login Page.

3.2.2 Home page

After Login, there is a home page (*Beranda*) which consists of several component. As in Fig. 4, on the left side displays the levels that need to complete, each consists the modules to study. To start learning, click the *Mulai Belajar* button located in the middle side. On the right side, we can also see how many times we have visited the website and the progress of the material that has been achieved.

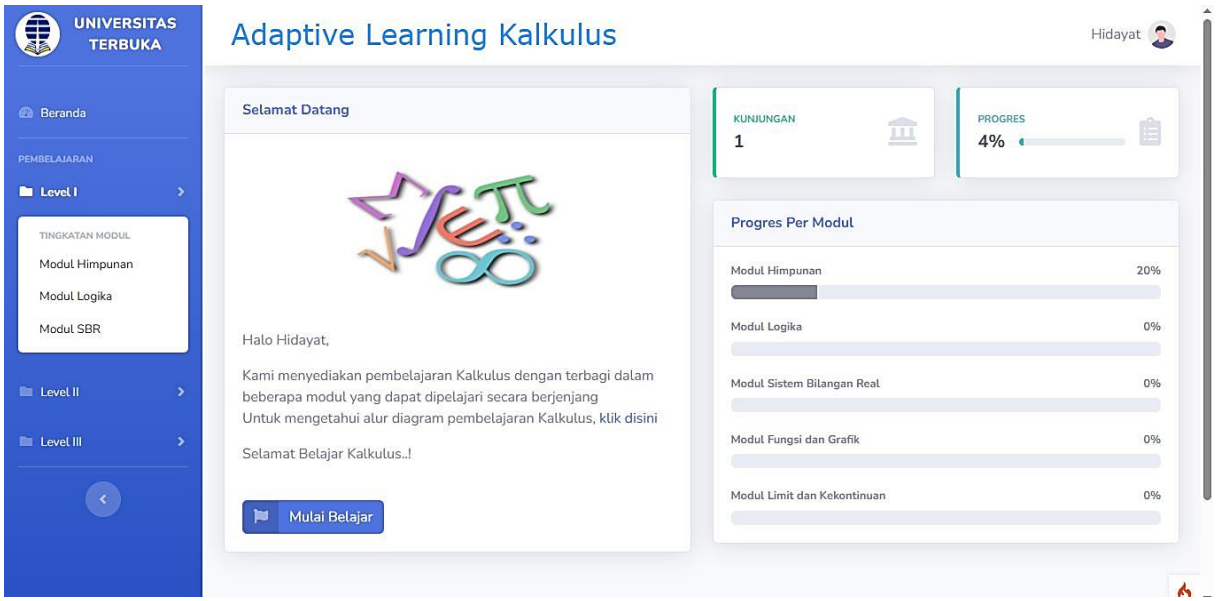

Figure 4. Home Page.

3.2.3 Modul page

Immediately after clicking *Mulai Belajar* button as we want to start the study, we will be given a choice of modules to study. Based on the structure above, there are several independent modules, so we can choose which one to study first without completing the others. This is indicated by the blue color on each module button, as shown in Figure 5.

Figure 5. Modul Choice.

After choosing one of module, as in Fig. 6a and 6b, brief material related to that module will appear, along with the competencies that need to be achieved to be said to have understood the entire module material and also some related references.

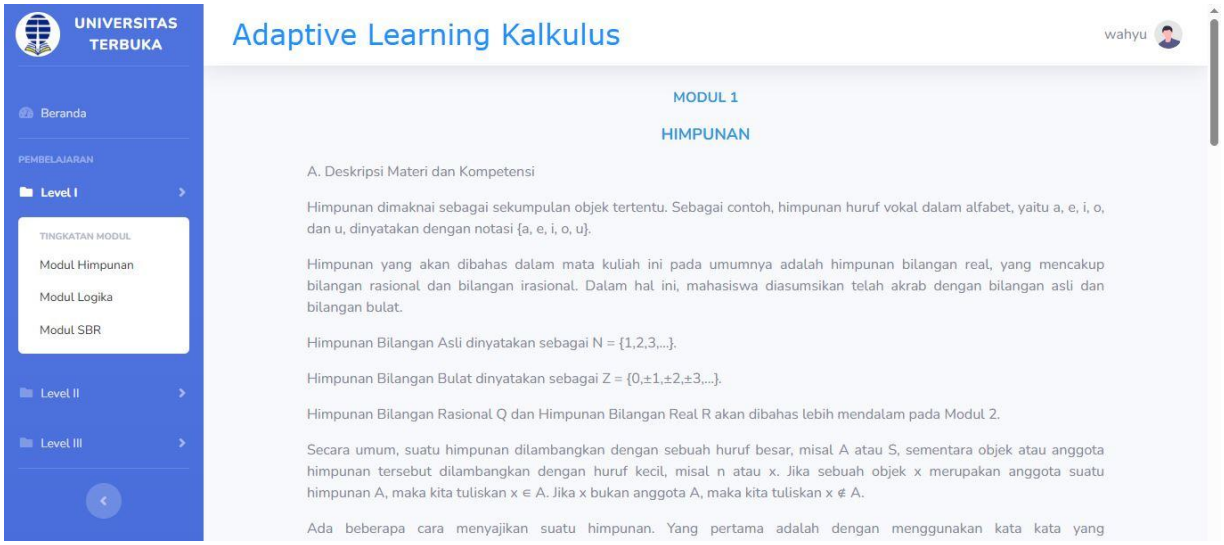

Figure 6a. Modul Page.

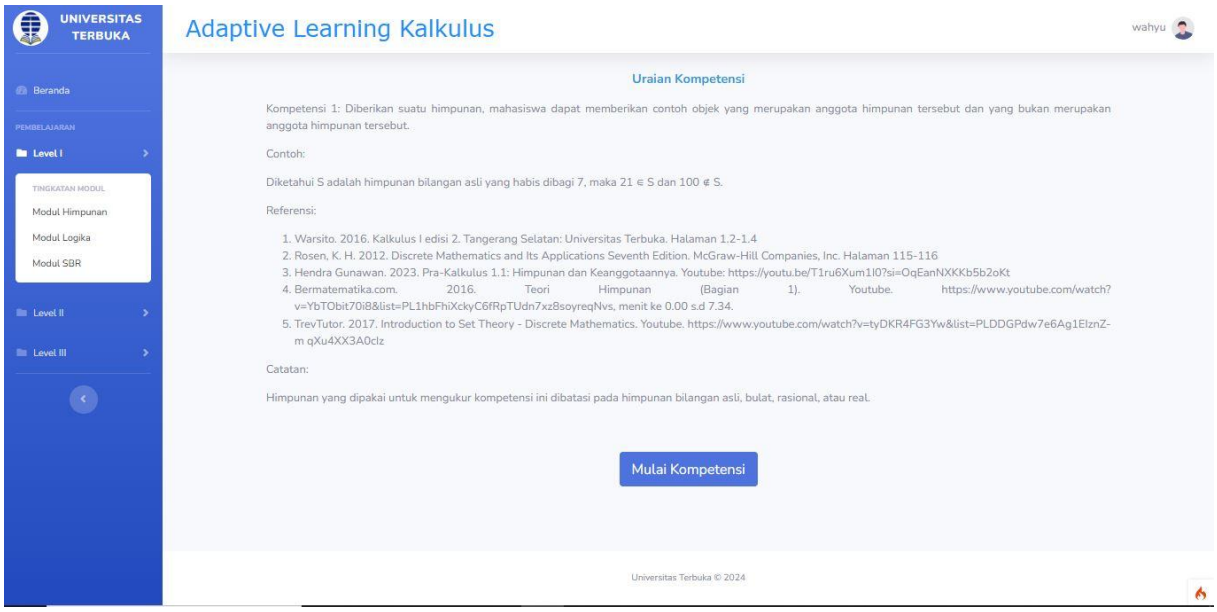

Figure 6b. Competencies Page.

In Figure 6b, there is a *Mulai Kompetensi* button to start the assessment. This assessment will determine whether students have complete the module so that they can continue to other module.

3.2.4 Competencies page

After clicking Mulai Kompetensi button above, students must complete all the competencies of the module starting from Kompetensi 1. The other competencies can not be started if the student hasn't completed previous competency. The competency that can be clicked to start are those in blue as in Fig. 7a and 7b. On Fig. 7b, if we have completed the competency, so the color change to be green.

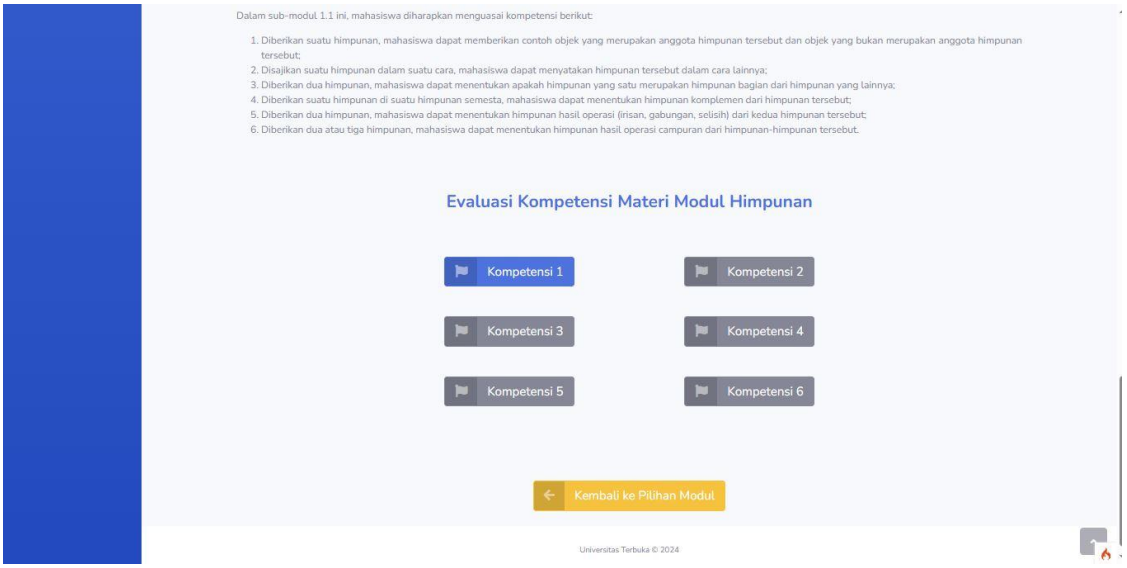

Figure 7a. Competencies Page.

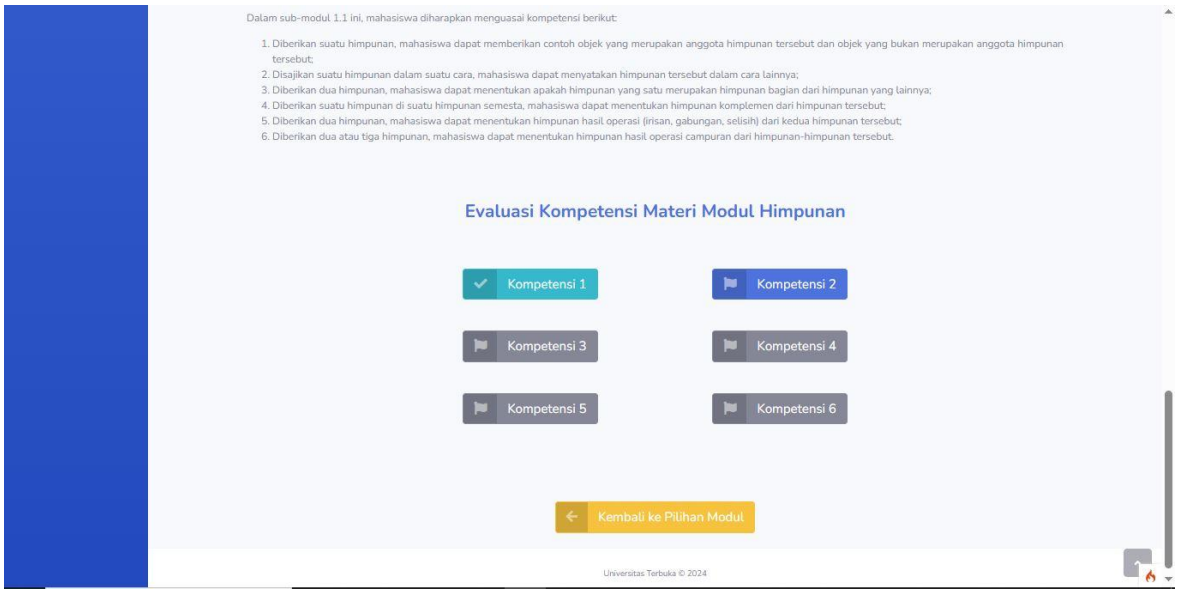

Figure 7b. Completed Competencies Page.

3.2.5 *Assesment page*

For every competency, there are five questions that user must complete. There is only one question that appear on the screen. The other question will appear if the user click the other number of question, but the previous question will disappear as in Fig. 7 below.

Figure 7. Assesment Page.

If the user has completed all the questions and passed the cut-off calue, then a display will appear as in Figure 8.

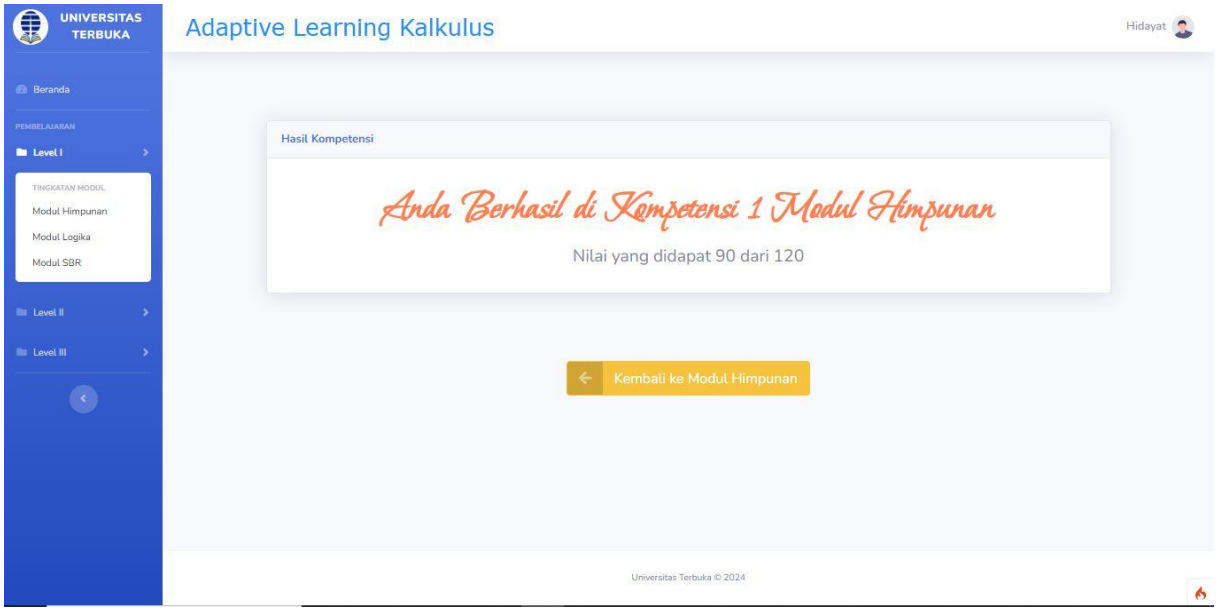

Figure 8. Success on Assesment.

4 CONCLUSION

Adaptive learning design for calculus courses, as basic courses at undergraduate level for science courses, has been explained. The learning flow created can allow students to choose the modules they will study according to their level of competence in each material but still apply the minimum standards that must be achieved before continuing to the next level. The result is a model and structure of calculus material learning consisting of ten modules with five levels that must be studied. This web-based application has not been tested, it will be tested further to get a better application.

ACKNOWLEDGEMENTS

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