DESIGNING OF MODEL AND STRUCTURE ON CALCULUS MATERIAL USING AN ADAPTIVE LEARNING APPROACH IN DISTANCE LEARNING

Elin Herlinawati[1], Heru Widiatmo[2], Hendra Gunawan[3], Wahyu Hidayat[4], Asmara Iriani Tarigan[5]

[1, 4, 5]*Universitas Terbuka (INDONESIA)*
[2]*Measurement Incorporated (USA)*
[3]*Bandung Institute of Technology (INDONESIA)*

elin@ecampus.ut.ac.id

Abstract

Distance learning has revolutionized education, including the availability of open sources, cloud-based web technologies (e.g., Wikipedia, blogs, and social networks), and online learning, e.g., e-learning (e.g., Coursera, Udemy, and edX). However, one of the challenges of most e-learning today is the application of traditional learning models to e-learning. All participants follow the presentation of learning materials with the same difficulty and speed, although the speed of student understanding varies. Therefore, 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 design an adaptive learning model that is 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 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 a model and structure of the learning of calculus material consisting of ten modules with five levels that must be studied.

Keywords: Adaptive Learning, calculus, distance learning, model and structure

1 INTRODUCTION

Distance learning has revolutionized education, including the availability of open sources, cloud-based web technologies (e.g., Wikipedia, blogs, and social networks), and online learning, e.g., e-learning (e.g., Coursera, Udemy, and edX). Numerous studies have shown that e-learning has improved the quality of teaching and learning, accommodated learning

styles/habits, increased access to learning opportunities, collaborated virtually across regions and even countries, developed skills or competencies needed in the 21st century, and made education cost-effective (Swan, 2010; Means et al., 2013; Shirky, 2015; Allen & Seaman, 2017; Stehle & Peters-Burton, 2019; Yang, 2020).

At the higher education level, this model is expected to provide wider opportunities for prospective individuals to continue to a higher level at an affordable cost and can achieve the same or better learning outcomes than face-to-face classes. E-learning with its flexible and virtual nature, demands for evidence of quality, credibility, and accountability are higher than traditional learning models (Protopsaltis & Baumi, 2019). E-learning is considered the most appropriate solution for future government efforts.

However, online learning also has limitations (Smaldino, 2011). The first limitation is that in online learning, students often unknowingly enter topics that are not in accordance with the material, even to sites that are not safe for students to consume. Second, information is very easy to access, it provides a great opportunity for students to create assignments by copying and pasting. Third, the large number of sites on the internet sometimes makes it difficult for students to find information that is relevant to their needs. Fourth, this requires good technical support and management. An internet network that is often disrupted will complicate online learning. Fifth, the problem in accessing information that often occurs is the slowness of obtaining information. The weaker the signal, the less likely students are to be able to send and receive data. Sixth, access speed is often influenced by the size of the web page. The more complex the web page, the greater the access speed required. Seventh, the lack of quality control because on the internet anyone can write, sometimes scientific information, sometimes unimportant, wrong, or unreliable.

The current e-learning system generally presents the same learning material for each student because it assumes that the characteristics of all students are the same. Thus, there needs to be an e-learning system that is able to accommodate the problem of differences in student characteristics, which can understand student preferences and strive to provide/deliver content and use methods that are appropriate to the characteristics of students.

All participants follow the presentation of learning materials with the same difficulty and speed, although the speed of student understanding varies. Therefore, Adaptive Learning (AL) can be an alternative e-learning model that can personalize the methods and habits of each student. *Adaptive learning* (AL) can be an alternative to the traditional e-learning model *one-size-fits-*

all and can personalize the methods and habits of each individual learning participant. In this case, 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 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.

Adaptive learning systems can be applied on the internet for use in distance learning and group collaboration. Adaptive learning systems are able to provide learning materials whose level of difficulty is in accordance with the abilities of students, and how to present learning materials according to the learning style of students. 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). Kurniawan (2019) also shows that student learning outcomes during learning using Adaptive learning have increased, this is indicated by the difference between the pretest and posttest results. Adaptive learning is also able to facilitate students' learning styles so that they can adjust to the needs of its users. Adaptive learning can be designed in the form of an Adaptive e-learning system (AES) which is useful for identifying 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 this paper, we design an adaptive learning model applied to calculus. This course was chosen because Calculus is a general basic course in college and most first-year students take it, especially students with a science background. This study aims to identify learning competencies in calculus material and design a model and structure of AL Calculus.

2 METHODOLOGY

This research begins with a literature study related to the concept of adaptive learning, especially when applied to distance learning in Indonesia. Continued with the identification of learning materials including competencies that must be achieved by students in the calculus course. then analyzing the relationship between competencies between materials, whether some materials can be studied simultaneously (not dependent on each other), or must be sequential

for certain materials (there are requirements for certain materials to be mastered first to continue to other materials). In general, the stages in this research are explained in the diagram in Figure 1.

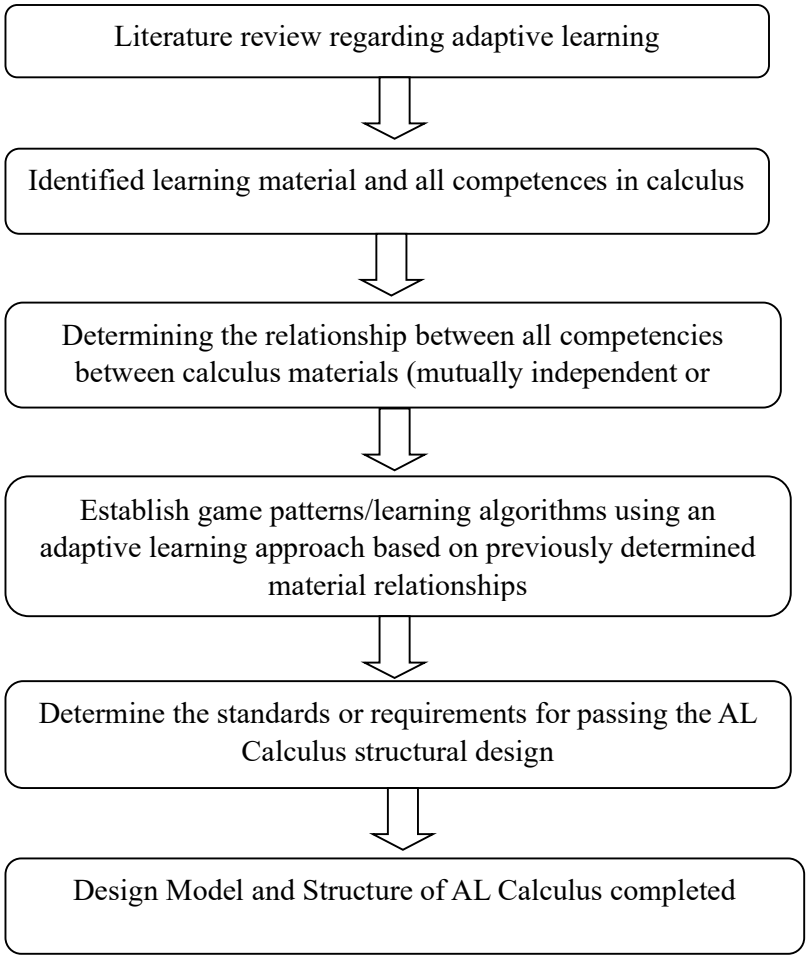

Figure 1. Research stages

3 FINDINGS AND DISCUSSION

The adaptive learning (AL) model is a model where the process and progress of student learning adapts according to the competence and learning speed of each student. In other words, the adaptive learning system 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.

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

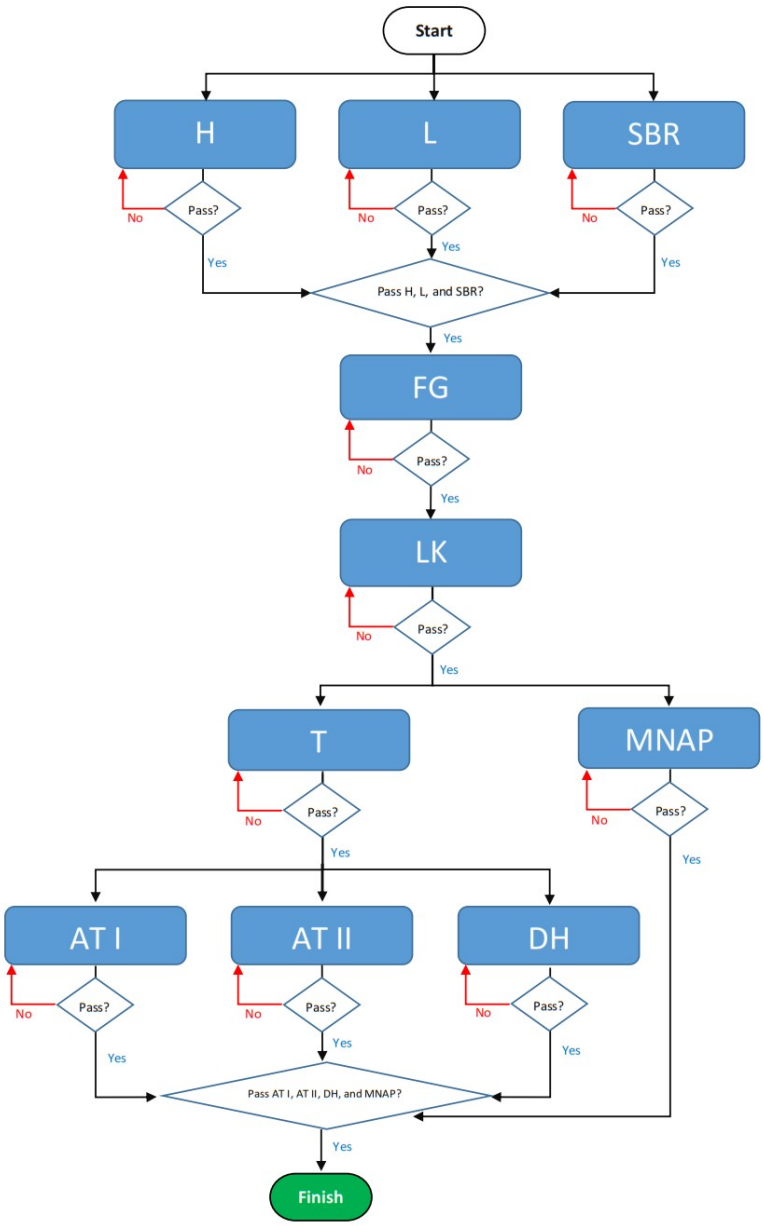

Figure 2. Design for adaptive learning model in Calculus.

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 Adaptive Learning 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. For example, suppose Student 1 after completing material A and does not need to study material B (because Student 1 already understands material B), but can go directly to material C. Conversely, Student 2 is required to study material B before studying material C.

Students are free to choose the order of modules in the modules at one level. For example, at the beginning level consisting of Modules H, L, and SBR, students can choose any of the three modules to start learning. After successfully completing the three modules, students are allowed to continue choosing modules at the next level, FG, LK, T, DH, AT1, AT2, and MNAP. However, to be able to access the modules at the next level, students must pass a minimum competency in all modules at the previous level. If a student does not achieve the minimum score, they are required to repeat the learning in the relevant module before being able to continue to the next level. Thus, this learning flow provides flexibility for students to choose their initial modules, but also applies a minimum standard that must be achieved before continuing to the next level.

Each module includes a number of learning competencies to be achieved. The organization of learning competencies in each module is arranged based on the complexity of the material, learning progress, and integration of interrelated concepts. The first Module, i.e Sets, for example, has six learning competencies. For the first learning competency, students are asked to show or determine examples of objects or examples of non-objects that are included in a set. This is a basic learning competency that students must have to understand the concept of a set. The following competencies require students to understand more complex set concepts.

Five practice questions appear after one learning competency is studied. Students are expected to complete these questions. After all questions are completed, feedback is given. Constructive feedback is given for both wrong and correct answers. At the stage of working on the practice

questions, the final score is not used to determine the level of competency being studied; test questions appear after students have studied all learning competencies in one module. Test questions cover all learning competencies in one module, the number of which represents each competency proportionally.

To continue learning to the next level module, students are required to achieve a minimum score or cut-score. The minimum competency is determined based on the cut-score of 60% of the assessment value given at the end of learning in each module. This means that students are considered to have achieved the minimum competency in the module if they obtain at least 60% in the assessment value. The assessment is in the form of a number of multiple-choice questions and short answers. While the final AL Calculus score is determined based on the average score of 10 learning modules. This model will be the basis for developing a web-based AL Calculus application.

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.

ACKNOWLEDGEMENTS

This research was funded by a grant from the Institute for Research and Community Service (LPPM), Universitas Terbuka, Indonesia.

REFERENCES

Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). *The Effectiveness of Online and* Blended Learning: A Meta-Analysis of the Empirical Literature. Teachers College Record, 115(3), 1–47

Shirky, C. (2015). Cognitive Surplus: Creativity and Generosity in a Connected Age. Penguin Press, New York and London.

Allen, I. E., & Seaman, J. (2017). *Digital Learning Compass: Distance Education Enrollment Report 2017*. Babson Survey Research Group.

Stehle, S.M., Peters-Burton, E.E. (2019). Developing student 21st Century skills in selected exemplary inclusive STEM high schools. IJ STEM Ed 6, 39. https://doi.org/10.1186/s40594-019-0192-1

Yang, N. (2020). E-Learning for Quality Teaching in Higher Education: Teachers' Perception, *Practice, and Interventions*. Springer Nature

Swan, K. (2010). Learning Effectiveness Online: What the Research Tells Us. In: J. Bourne & J. C. Moore (Eds.), Elements of Quality Online Education: Practice and Direction. Sloan Consortium

Protosaltis, S. and Baum, S. (2019). Does Online Education Live Up to Its Promise? A Look at the Evidence and Implications for Federal Policy.

Smaldino, S.E., Deborah, LL., James, D.R. (2011). Instructional Technology & Media for Learning: Teknologi Pembelajaran dan Media untuk Belajar. Terjemahan Arif Rahman. Jakarta: Kencana

Cavanagh, T., Chen, B., Ait, R., Lahcen, M., & James, R. (2020). International Review of Research in Open and Distributed Learning Constructing a Design Framework and Pedagogical Approach for Adaptive learning in Higher Education : A Practitioner ' s Perspective Constructing a Design Framework and Pedagogical Approach. International Review of Research in Open and Distributed Learning, 21(1), 173–197.

Andreas Kaplan (2021). Higher Education at the Crossroads of Disruption, The University of the 21st century. Emeral Publishers. ISBN 9781800715042

Putra, I. G. J. A., Dantes, G. R., & Ernanda, K. Y. (2019). Adaptive learning : Mengidentifikasi Gaya Belajar Peserta Didik Dalam Rangka Optimalisasi Sistem E-learning Dengan Menggunakan Bayesian Network 1). Jurnal Ilmu Komputer Indonesia (JIKI), 4(2), 21–30. https://ejournal-pasca.undiksha.ac.id/index.php/jik/article/view/2773

Kurniawan, C. (2019). Strategi Pembelajaran Adaptive learning dengan Pendekatan Visual-Verbal Preferences untuk Meningkatkan Kemampuan Pemecahan Masalah. Pascasarjana Universitas Negeri Malang.

Kusworo, N., Soepriyanto, Y., & Husna, A. (2021). Pengembangan Adaptive E-learning Sistem Berbasis Vark Learning Style Pada Materi IP Address. JKTP: Jurnal Kajian Teknologi Pendidikan, 4(1), 70–79. https://doi.org/10.17977/um038v4i12021p070