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Letter of Acceptance

Dear Sir/Madam,
On the behalf of the committee of the 1st Annual Conference on Science Education and Technology (ACSET) 2020, we are pleased to inform that your paper with ID "**258**", entitled:

"**Framework for Personalized Learning with Smart E-Learning System using Macro and Micro Adaptive Approach**"

Written by **Widyat Nurcahyo & Yumniati Agustina**

has been **ACCEPTED** and will be proceeded to be **SUBMITTED** in **Journal of Physics: Conference Series** indexed by **Scopus**.

Related to your paper acceptance, you need to complete the payment of IDR 2,500,000 for the publication. Please transfer the publication fee to: 0895666356 (Percepatan Publikasi/BNI) no later than **January 25, 2021**

We congratulate for your achievement. Shall you have further questions, please contact us through WhatsApp: +6287878138831 (Dr.rer.nat. Lalu Rudyat Telly Savalas, M.Si.) or +6287738066422 (Dr. Saprizal Hadisaputra, M.Sc).

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Framework for Personalized Learning with Smart E-Learning System using Macro and Micro Adaptive Approach

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Abstrak
Pendidikan tradisional yang menyamaratakan seluruh peserta didik sudah semakin ditinggalkan. Kesadaran akan pentingnya personalisasi pembelajaran bagi setiap individu siswa ditambah dengan perkembangan teknologi yang memungkinkannya, menumbuhkan model pembelajaran cerdas. *Smart learning* menekankan pada pentingnya desain teknologi untuk membuat pembelajaran lebih baik melalui adaptasi dan personalisasi. Penelitian ini bertujuan untuk membangun kerangka kerja sistem e-learning cerdas untuk mendukung pembelajaran yang dipersonalisasi. Tinjauan literatur sistematis PRISMA yang digunakan dalam penelitian ini dilakukan dalam empat tahap, yaitu: Identifikasi, Penapisan, Kelayakan, dan Interpretasi temuan. Dari tiga tahap pertama, ada enam artikel yang layak untuk dibahas. Berdasarkan analisis literatur tersebut, kerangka kerja dibangun. Pendekatan *macro-adaptive* digunakan di awal kuliah dengan menentukan gaya belajar siswa melalui kuesioner Index of Learning Style dari Felder-Silverman. Personalisasi dilakukan dengan 3 cara, yaitu melalui *learning path*, *content*, dan *user interface*. Pendekatan *micro-adaptive* digunakan selama kuliah berlangsung secara *real-time*, berdasarkan *adaptive engine* yang dibangun menggunakan jaringan syaraf tiruan. Personalisasi juga bisa dilakukan secara manual oleh siswa dan pengajar. Dukungan konsultasi antara siswa dan pengajar juga diberikan.

Abstract
Traditional education that generalizes all students has been increasingly abandoned. Awareness of the importance of personalization of learning for each student, coupled with technological developments that enable it has fostered a smart learning model. Smart learning emphasizes the importance of technology design to make learning better through adaptation and personalization. This study aims to build a smart e-learning system framework to support personalized learning. PRISMA Statement systematic literature review used in this study was carried out in four phases, namely: Identification, Screening, Eligibility, and Interpreting the findings. From the first three phases, there were six articles that eligible to be used for discussion. Based on the analysis of these articles, the framework was built. The macro-adaptive approach at the beginning of the course by determining student learning styles through Felder-Silverman's Index of Learning Style questionnaire. Personalization is done in 3 ways, through learning paths, content, and user interface. The micro-adaptive approach used during the course takes place in real-time, based on adaptive engines built on artificial neural networks. Personalization can also be done manually by students and instructors. Consultation support between students and instructors is also provided.

Keywords: *Smart Learning, E-Learning, Macro-Adaptive, Micro-Adaptive, Felder-Silverman Learning Style.*

INTRODUCTION

Due to the rapid development of technology, facilitating learning based on

information technology and multimedia is increasingly being used. Teachers and students were moving towards e-learning applications. This mode of education is characterized by low costs, expansion of opportunities, and unlimited time and space. On the other hand, there is an increasing awareness of the importance of personalization in education. Basically, every human being is different. They have their own preferences. Likewise in learning, each student has different learning preferences. By learning according to their preferences, students will be able to learn more effectively. A fundamental shift in education is needed towards a more personal, social, open, dynamic, and knowledge-based model, to replace the one-size-fits-all, centralized, static, and top-down model of traditional learnings [1].

These two strong influences have led to a rapid increase in efforts to personalize e-learning in this decade by utilizing various technologies that were previously impossible. This has again gained a very strong driving factor in the last six months with the case of the Covid-19 pandemic. One of the sectors forced to change due to the pandemic is the education sector. According to UNESCO data, as of 7 July 2020, 1,067,590,512 students from 110 countries were affected by school closures [2]. With the closure of schools ranging from early childhood education to tertiary education, which is still being implemented today, the need for e-learning is increasingly urgent. In turn, the need for a change in the learning paradigm towards personalized learning will also increase.

One of the efforts to personalize learning in e-learning is in the form of smart-learning. The smart-learning concept emphasizes the importance of technology design to make learning better through adaptation and personalization, especially through the use of smart devices technology and intelligent technologies [3].

Because this kind of learning approach is still relatively new, a framework is needed so that the concept of smart learning can be used effectively in real learning. In this article, we propose a smart learning system framework using a hybrid micro and macro adaptation approach.

One of the concepts of smart learning in e-learning is manifested in the adaptive learning system (ALS). Adaptive learning refers to the process of creating learning experiences to achieve learning goals, unique for each student based on the student's character, interests, and performance [4].

Radwan in [5] argued that there are two levels of adaptation in ALS. The first is an adaptable system where the system allows the user to change certain system parameters and adapt behavior accordingly. The second is adaptive system where the system automatically adapts to the user based on the system's assumptions on the user's needs.

In [6] the adaptive e-learning approach is divided into four categories, namely:

a. Macro-Adaptive Approach
b. Aptitude–Treatment Interaction (ATI) Approach
c. Micro-Adaptive Approach
d. Constructivist–Collaborative Approach

In the macro-adaptive approach, sets of alternatives to learning objectives, content, and delivery could be selected based on student profiles and characteristics. These characteristics include: cognitive style or learning style, student learning objectives, delivery system, level of achievement, level of detail, etc. The adaptive e-learning system could be affected by these characteristics in multiple ways, such as identify students' individual needs then prepare particular learning for them, specify the prerequisites of learning contents, adjust to student learning styles, and achieve various learning goals relative to each student's necessity or aptitudes. Then the experts create adaptive e-learning strategies that are planned for various categories of students.

The ATI approach argues that for individual students there have to be different modes of learning and/or different designs of media. This is based on the concept that if learning

aptitudes were paired with suitable learning, learning outcomes could be predicted effectively. The goal is to discover the relationship between learning and competence. For this goal, a feature of the ATI approach relates to the control in the learning process. For example, limiting control to students with below-average starting knowledge will be more effective. Adaptation was done by identifying several things, including intellectual skills such as reasoning and mathematical abilities, cognitive or learning styles, and previous knowledge. Also, in the ATI approach, metacognitive abilities were deemed important, and researchers have studied their impact on various variables like feedback and control. Of late, cognitive processing capacity has been acknowledged as an affecting talent. Thus researchers were designing new adaptive e-learning systems consolidating the effects of cognitive load theory.

The micro-adaptive approach first identifies students' particular learning needs throughout learning, then determines instructional tactics suitable for those needs. That is, the adaptive micro-learning model relies heavily on task rather than pre-task action. The intelligent guidance system (ITS) is an instance of this approach. In the macro-adaptive approach, differentiation of learning activities was usually used over a greater segment. In contrast, the micro-adaptive approach uses the time-related quality of the skills and characteristics of learners, particularly those that change dynamically, such as affective dispositions, response errors, and response latency. User behavior and performance can be monitor to optimize instructional operations. The adaptive micro models generally customize learning content such as structure, presentation, and number throughout learning. This adjustment is base on the quantitative representation of the individual style.

As the name suggests, the constructivist–collaborative approach uses adaptive clustering to help constructivist and collaborative learning by integrating appropriate mechanisms of knowledge representation, reasoning, and decision making in the instructional design. Today technologies such as Web 2.0 tools and social media help computer-supported collaborative learning in adaptive e-learning.

According to the definition set by the USA Office of Educational Technology from the Department of Education, personalized learning refers to learning where the learning speed and learning approach are optimized according to the needs of each student. From this definition, there are two things that must be optimized according to the needs of each student, namely: learning speed and learning approach. Both are very closely related to the learning styles of students. In other words, the learning system must be able to adapt to the learning styles of each student.

Various models of learning styles have been known in the world of education, including: Felder-Silverman, VARK, Kolb, Myers-Briggs, Honey-Mumford, and others. In this study, the Felder-Silverman (FSLSM) learning style approach will be used. FSLSM is very appropriate to be used by engineering students [7] and the questionnaire to assess the Index of Learning Style (ILS) is very practical to measure the dominant learning style for each student and the results can be easily linked to the learning environment [8].

According to [7], there are four dimensions of learning in FSLSM, namely: Pre-processing, Perception, Input, and Understanding. Each dimension is defined by two opposing learning styles. So there are eight learning styles that can produce sixteen combinations [9]. The following is a brief description of eight learning styles from the four dimensions of FSLSM:

1. Pre-processing Dimension
   a. Active Learning Style
      Active students actively work and try out things to learn effectively.
   b. Reflective Learning Style
      Reflective learners favor reflecting on the learning content and think about it.

2. Dimensi Perception
   a. Sensing Learning Style
      Learners with this style prefer to learn facts and tangible learning materials using their sensory experiences.
   b. Intuitive Learning Style
      Intuitive learners learn best when studying general principles and conceptual materials, such as theories and their interpretation.
3. Input Dimension
   a. Visual Learning Style
      Visual learners are easy to learn what they have seen, such as flowcharts, diagrams, or pictures.
   b. Verbal Learning Style
      Verbal learners best learn from written or spoken textual representations.
4. Understanding
   a. Sequential Learning Style
      Sequential learners prefer step by step learning progress in small incremental steps.
   b. Global Learning Style
      Global learners learn best by overall comprehension using global and holistic perception.

METHOD

The methodology used in this study is a systematic literature review based on the PRISMA Statement [10]. The systematic literature review is carried out in four phases, namely: Identification, Screening, Eligibility, and Interpreting the findings.

The identification phase search for the literature through research databases with specific keywords in accordance with the research theme. The screening phase removes duplicates and unrelated articles by applying filters to the abstract with certain criteria. The eligibility phase determines the articles used in the analysis and discards the rest by reading the articles full-text. The last phase analyzes the eligible articles to build a complete understanding of the issues discussed.

FINDINGS AND DISCUSSION

Identification Phase

Literature searches were carried out using the National Library search facility (https://e-resources.perpusnas.go.id/), SCOPUS, ERIC, and Google Scholar. The keywords used for the search were a combination of the following words: "smart learning" OR "smart e-learning" OR "smart elearning" OR "smart education" OR "adaptive learning" OR "adaptive e-learning" OR "personalized learning" OR "personalized education" OR "personal learning" OR "personalized adaptive" OR "individualized learning" OR "individualized e-learning" OR "adaptive learning style". The search returned 64 articles from various journals.

Screening Phase

To get the appropriate literatures, several filter criteria were applied. The first criteria was the article publication year was limited to 2015 - 2019. The second criteria was the content of the article related to the smart e-learning system for personalized learning based on the Felder-Silverman learning style at the higher education level. The third criteria was that the article was not research duplication of the articles that have been selected. To apply the second and third criteria, the author filtered the abstract by reading them one by one. The filter results

based on these three criteria reduce the number of articles that match to 18 articles.

Eligibility Phase

The full text of the articles on the results of the screening phase was read one by one in detail to obtain suitable literature for discussion. Finally, there were six articles that eligible to be used, as follows:

1. Kolekar in [7] developed a Moodle-based ALS using the Felder-Silverman learning style. The approach used was macro adaptive. The adaptation type was navigation. The adaptive engine used the Fuzzy-C algorithm..
2. El Guabassi in [8] developed a prototype of ALS based on mobile technology. It used the ATI approach. The type of adaptation was content, which adapted based on the Felder-Silverman learning style. The adaptive engine used rule-based condition-action.
3. Bajaj & Sharma in [9] proposed an adaptive engine framework for recognizing learning styles based on two models (Felder-Silverman and Kolb) for ALS, using Neural Network and Decision Tree. The approach used was macro-adaptive.
4. Zhimin Qi in [11] developed an ALS model based on data mining techniques using the micro-adaptive approach. The adaptation type was content. The adaptive engine used a decision tree and the back-propagation Neural Network.
5. El Janati, Maach, and El Ghanami in [12] proposed the Dynamic Adaptive Hypermedia System (DAHS) framework for ALS using the ATI approach. The adaptation type was presentation. The adaptive engine was based on rule-based and optimization.
6. Arsovic & Stefanovic in [13] proposed an adaptive e-learning model for personalized learning experience. The Felder-Silverman learning style was used with static and dynamic adaptation. The adaptive engine used expert system.

Interpreting the Findings

The framework of e-learning portal in [7] is shown in Figure 1. This framework set Active Learning Style as the initial learning style. As the student accessed the learning materials, the information was captured and stored. These logs then analyzed and clustered using Fuzzy C means algorithm to determine the student actual learning style. Once the actual learning style was determined, the portal interface will change.

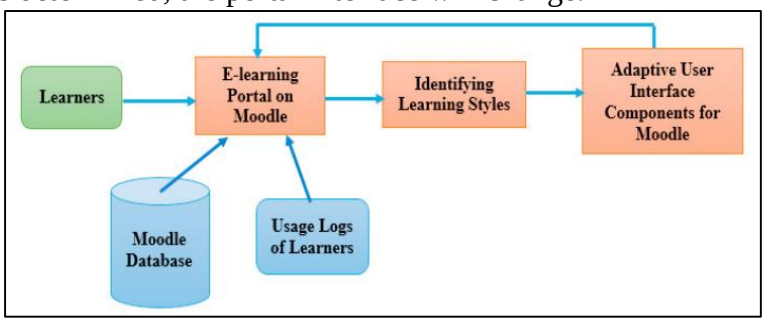

Figure 1. Framework of Moodle-based E-learning Portal
Source: [7]

In [8], the student set the initial learning style, then the system generated the course according to the learning style. The interface and content dynamically change based on the learning sytle and learning environment. The adaptation approach used rule-based with condition-action paradigm.

Framework for smart education in [9] is shown in Figure 2. The student attributes were identified from student's interaction with virtual teacher with sample content. Adaptation engine then determined the learning model from the attributes. The system then generated personalized content and learning path that suitable with the student.

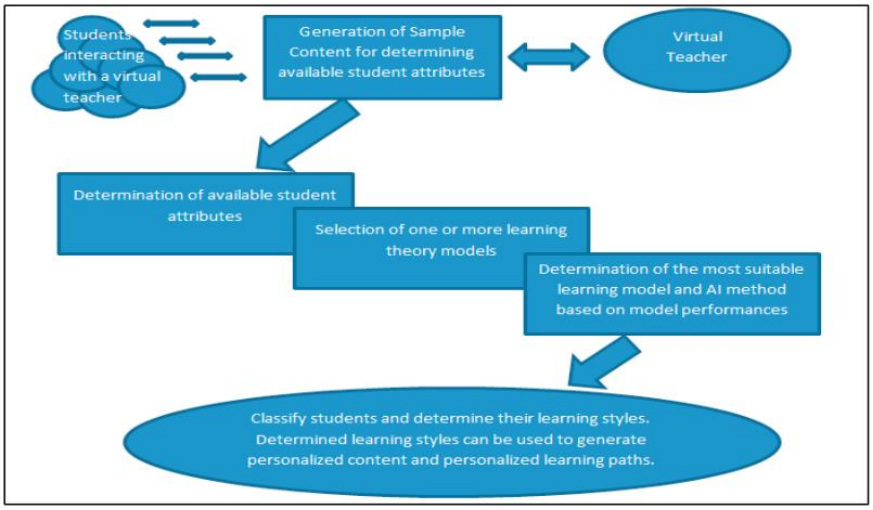

Figure 2. Framework for Smart Education
Source: [9]

In [11], student's usage of the Web was logged then analyzed online using Web mining technology. The user's action were divided into behaviors. The system helped student by sending the suitable web pages that student might browse in advance.

The architecture of the adaptive learning system in [12] is shown in Figure 3. This framework use four main engine for adaptation, namely: Learner Detector Engine (LDE), Learner Model Engine (LME), Transcoding Engine (TE), and Adaptation Presentation Engine (APE). LDE captured capabilities of the student and other contextual data using pedagogical test, then recorded the information in LME. LME update the Learner Model. Based on the learner model, APE analyzed, adapted, restructured, and delivered the adaptive presentation to the leaner. TE was used to covers learning object media to the requested media.

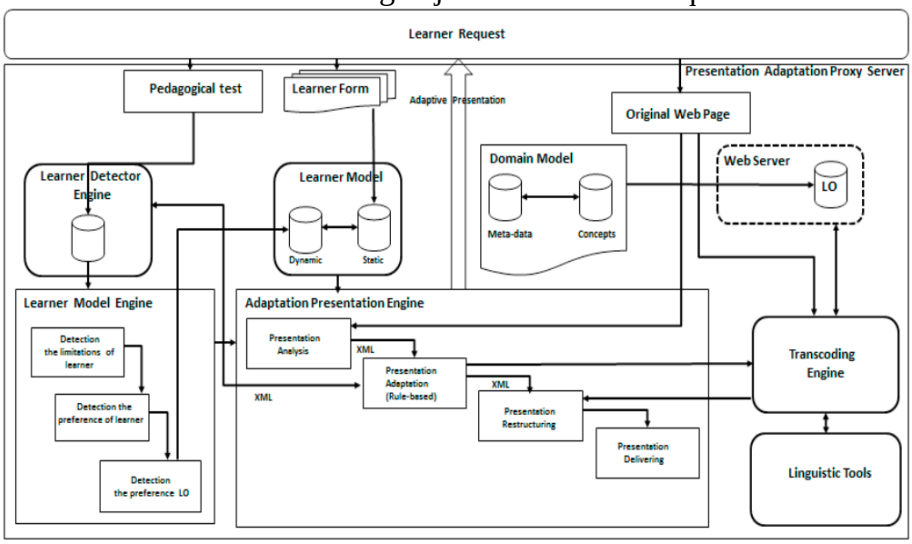

Figure 3. Architecture of the Dynamic Adaptive Hypermedia System for Adaptive Presentation
Source: [12]

The framework proposed in [13] is shown in Figure 4. This framework first used ILS questionnaire to adapt the LMS according to the student's learning style. The system continuously monitored the student's activities in real time. Data mining techniques then provided information that can be used to further personalize the learning process, teaching styles and materials.

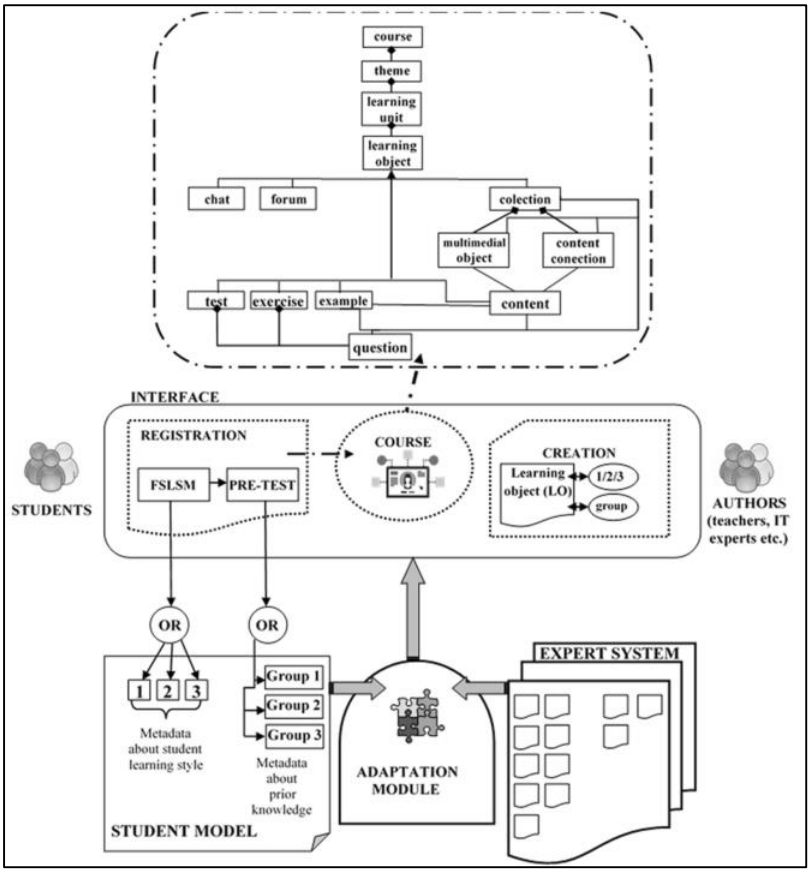

Figure 4. The Adaptive Learning Model
Source [13]

The sixth articles above provided a common structure of smart learning system framework. All of them have three distinct features, namely Initial Learning Style, Actual Learning Style, and Adaptive Engine. Initial Learning Style provides basic assumption for initial student's learning experience. Actual Learning Style is determined from the analysis of data that collected during learning activities. The adaptive engine then change the course based on the actual learning style.

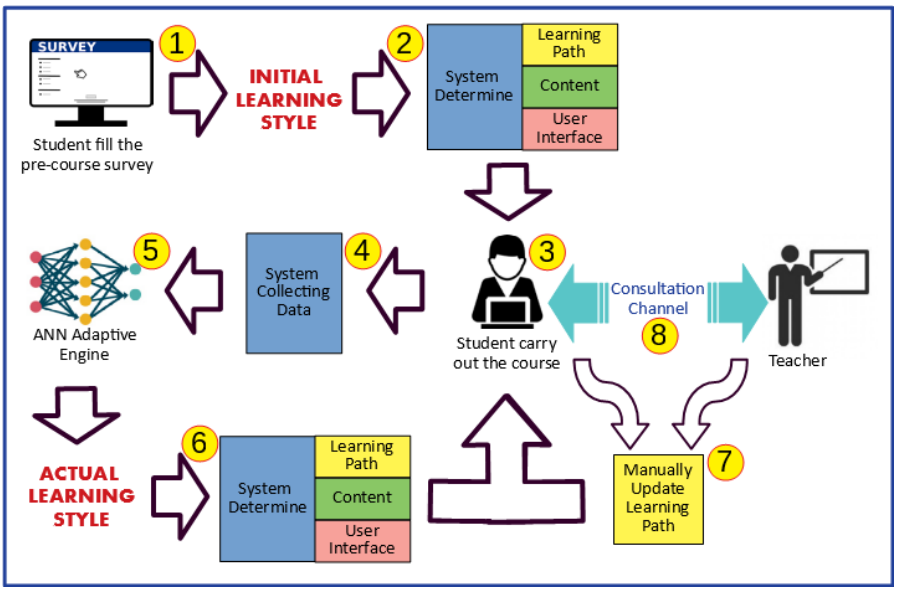

Figure 5. The Proposed Smart Learning System Framework

From the analysis above, a smart learning system framework is proposed using a micro and macro adaptation hybrid approach. By using this framework, it is hoped that an e-learning system can be built that can meet the learning needs of each student according to their respective learning styles so that the learning process can occur more effectively and efficiently. The proposed framework can be seen in Figure 5.

The course design allows all possible student learning styles to be accommodated by the e-learning system in 3 ways, namely: Learning Path, Content, and User Interface. Learning Path refers to the learning path that students take from the beginning to the end of the course. Content is the teaching material used. And the user interface is the interface in the e-learning system. With the 16 combinations of learning styles in FSLSM, the course design will have 16 combinations of learning paths, 16 combinations of content, and 16 combinations of user interfaces.

Before the course begins, the student first fills out the ILS questionnaire to define the students' initial learning styles. The system then determines the learning path, content, and user interface that the student will use in learning. So that when the student logs in to the system, the system will automatically display the user interface, and provide content in the learning path, according to the student's initial learning style.

Furthermore, the student will follow the learning process. During the learning process, the system will collect various data, such as the types of files accessed, when to access them, the time spent on content, the results and time of doing tests, and so on. These data will be the input for the adaptive engine to determine the student's actual learning styles. The adaptive engine will be built with an artificial neural network (ANN). ANN is a branch of artificial intelligence that originated from the idea of Parallel Distributed Processing (PDP) and mimics the work of biological neural networks with radical simplification [14]. ANN can be trained to learn. With this learning procedure, ANN will be able to generalize and associate data and have imperfect tolerance for input [15]. Corresponding with the student's actual learning style based on the adaptive engine classification, the system real-time adjusts the user interface and content presented to the student, including changing the learning path if necessary.

Does this provide a sufficient level of personalization for students? To improve it further, let's empower the student and the teacher with the ability to change the learning path manually. A channel of consultation between students and teachers will also support the learning process.

At the time of writing, the authors were developing an e-learning application using the smart learning framework with several other researchers. As a case for formative evaluation of this framework, a course with material that is easier to convert into online learning will be selected. According to [16], lecturers perceive that the types of material that are easier to convert into online learning are in the form of qualitative, understanding, rote, theoretical, general description, general concepts, emphasis on analysis, and having a lot of literature.

CONCLUSION

Learning problems related to the individual characteristics of students in higher education can be solved by utilizing technology in the form of a smart learning system. Smart learning systems that are needed are completely adaptable so that they can change the learning path, content, and user interface according to individual student learning characteristics. This paper presents a smart learning system framework that combines macro and micro adaptation to be used as a reference in designing a smart learning system. The framework provides the necessary steps that must be prepared and built in the smart learning system.

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