Implementation of Software as a Service to Increase the Scalability of the Merdeka Belajar Policy in Indonesia

Daniel Soesanto[1], Liliana[2(*)], Maya Hilda Lestari Louk[3], Felix Handani[4]

[1,2,3,4]Universitas Surabaya, Surabaya, Indonesia

	Abstract
Received : February 14, 2023 Revised : May 1, 2023 Accepted : May 19, 2023	Merdeka Learning is one of the breakthroughs in education carried out by the Government of Indonesia. One form of activity from Merdeka Learning is student exchange. However, not all universities in Indonesia have implemented e-learning properly due to the high cost of developing and implementing this system. Software as a Service (SaaS) is a fork of Cloud Computing that can create configurable systems for use by multiple users, especially for multi-scheme SaaS. This research develops a multi-scheme SaaS-based e-learning system with an iterative method for nine months to increase the scalability of this e-learning. Trials using the black box testing method were conducted on 15 officers and 36 students from 10 tertiary institutions. Respondents were asked to use various features of the system. The results of interviews after the trial stated that the system could assist in dealing with the online learning process at their universities. From this study, it can be concluded that multi-tenancy can be used in the development of e-learning to support the independent campus program on a website basis.
Keywords:	data management; e-learning; multischema; software as a service; saas; education technology
(*) Corresponding Author:	lili@staff.ubaya.ac.id

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INTRODUCTION

The Merdeka Belajar program is one of the Indonesian Government's efforts for equal education distribution (PDDikti, 2020a). This includes online learning using the e-learning platform (Almaiah et al., 2022) and a program where students can attend lectures not only in the student center but also in other majors and universities.

E-learning is experiencing rapid development due to the COVID-19 pandemic (Alhumaid et al., 2020). As a result, people in developing countries who previously used physical classes as a place to study (Bizzo, 2022) is forced to learn to use various technologies for learning, such as zoom, email, Moodle, classroom, and other forms of Learning Management Systems (LMS). Getting used to this technology is no longer an option but an action that must be taken to survive.

E-learning platforms can assist institutions in managing, planning, delivering, and tracking learning and teaching processes (Almaiah et al., 2022). LMS brings a change in many ways. The most positive impact felt by the community is that e-learning media can reduce the cost of education and provide various benefits for its users, such as ease of use and unlimited access to time and place (Bizzo, 2022). However, adapting to the use of LMS cannot just happen. Various factors affect the

acceptance of e-learning from the student's perspective, such as self-efficacy (Bettayeb et al., 2020), motivation (Badali et al., 2022), infrastructure (Al-Fraihat et al., 2020), and the quality of e-learning itself (Min et al., 2019; Zhang et al., 2021).

In Indonesia, the unstable condition of infrastructure causes various problems. For example, in higher education, students who want quality lectures must go to a big city or outside the island (Mardiana et al., 2018). In addition to the high tuition fees, they have to provide additional costs for living support. This causes unequal quality obtained by various levels of society.

Currently, the Government has been trying to make infrastructure, even in various regions (Budianta, 2020), to improve the quality of the economy, education, health, and other fields, through the Merdeka Belajar program. With this equitable distribution of infrastructure, including internet access, every institution in Indonesia has the same opportunity to implement online education.

In Indonesia, there are 4,591 universities with 39,000 study programs (PDDikti, 2020b). However, the problem that arises next is that most institutions in Indonesia do not have good e-learning (Fahmi, 2020), especially to support the Merdeka Belajar program. This is due to the lack of support from expert staff in the development of e-learning that suits the needs of the institution (Bizzo, 2022), the high cost of developing e-learning (Fahmi, 2020), the need for a long e-learning development time, and the maintenance process that is not easy (Azouzi et al., 2018).

The multi-tenancy system can be an alternative solution, namely by creating e-learning that can accommodate many universities (Pallavi & Jayarekha, 2022). Thus, each university's e-learning can be integrated, and students can access cross-university e-learning on one platform only. This multi-tenancy uses a multischema model (Shroff, 2010), because each joining university will have its database, with configurations that can be done up to the entity level and attributes of the database builder. Furthermore, using this multi-tenancy e-learning system, each university does not need to provide its infrastructure, such as server installation and hosting (Azouzi et al., 2018). So universities that do not yet have their e-learning facilities can also take advantage of this multi-tenancy e-learning system to assist in teaching and learning.

Data diversity and its management is one of the most challenging issues to research (Lu & Holubová, 2020). Database technology with multischema impacts data processing so that the system's scalability can be increased. From the end-user side, multi-tenancy systems allow users to use the system more efficiently, with better data integration with different techniques (Liu et al., 2019). Splitting the tenant database structure with the Software as a Service Multischema method allows the system to build a configurable model on demand without disturbing other tenants, with flexible application deployment and enabling reuse (Azouzi et al., 2018). With a multischema database for e-learning, the efficiency of hardware and software infrastructure resources among many users is possible, which also increases the scalability of the developed e-learning system.

The research question used in this study is "how to help institutions that do not yet have e-learning be able to provide adequate online education facilities without spending large resources while at the same time supporting the Merdeka

Belajar program?". For this reason, an analysis of the institutional needs for e-learning is carried out, which will then be used to develop an e-learning system that can be configured according to the institution's needs.

Several studies have been previously developed regarding the implementation of e-learning for the Merdeka Belajar program in Indonesia, but all of them still use conventional e-learning which is only intended to share information online. In 2020, Wulandari et al proved through their research that online learning can still implement the concept of Merdeka Belajar (Wulandari et al., 2020). Another research conducted by Elihami in 2021 seeks to implement the new Merdeka Belajar paradigm in two different types of schools (Elihami, 2021). Ahid and Sufirmansyah also conducted research related to the implementation of Merdeka Belajar in East Java using e-learning, and found that the implementation of e-learning in East Java was also constrained by costs that had to be incurred during implementation (Ahid & Sufirmansyah, 2022). The latest research on Merdeka Belajar with the concept of e-learning, tries to see the level of technology use from teachers who are direct users of the e-learning system in the Merdeka Belajar program, where it is found that the level of technological understanding of e-learning actors on research subjects is still low (Sri Restu Ningsih et al., 2022). Previous studies have only tried to implement ordinary e-learning, no one has tried to combine the concept of software as a service as an alternative solution for ease of implementation of e-learning for the Merdeka Belajar program. The contribution of this research is to combine the concept of Merdeka Belajar with Multitenancy techniques in Software as a Service which is able to provide an online learning system for all those who need it more easily. This research aims to provide e-learning facilities for various institutions without the need to develop their system from scratch. The advantages of this system are that the system can be adjusted according to institutional needs to the entity level and database attributes, independent database ownership with minimal infrastructure, and accommodates the need for an independent curriculum to study in Indonesia while still being able to communicate easily between e-learning systems belonging to other universities.

The article will be divided into four parts, namely supporting theories of research, research methodology, discussion related to research results, and at the end, the conclusions of the study will be given.

METHODS

This research was conducted using iteration methods (Heeagera & Nielsen, 2018) and agile (Alejandro et al., 2019). Both of these methods were used because of limited time and resources, and agile collaboration between team members was required so that research could be completed quickly with minimal resources (Heeagera & Nielsen, 2018).

Multischema is one of the software-as-a-service-based cloud computing methods used in this study, where in this method, each tenant will have a different database. However, each tenant database will still be connected to the master database, which is the parent of all databases that are formed. While for the development of the system as a whole, the iteration method is used where each

feature developed consists of 3 stages, namely alpha, beta, and release. Development will start at the alpha stage, where all features will be completed with minimum functionality, and then continue with the refinement of each feature in stage 2, namely beta, and end with the final stage, namely the release stage.

In the process of analysis and validation, this study used primary data from 49 respondents at 10 different universities, both public and private in Surabaya. The composition of the respondents in this study is the first consisting of 2 university admins, where these admins are the people who manage e-learning at the university. While the rest consisted of 11 lecturers and 36 students from 10 different universities.

The instrument used for validation in this study was in the form of a questionnaire, which used a 4-point Likert scale. The use of a Likert scale without a midpoint was carried out because most of the respondents were students who most likely could use the midpoint as a safe answer to the questionnaire given. Therefore, based on research conducted by Chyung et al in 2017, to avoid biased responses, the midpoints on the Likert scale can be removed (Youn Chyung et al., 2017).

The research begins with an analysis process of several universities with different e-learning concepts. For example, there are universities that use Moodle as an LMS; there are also universities that use Google Classroom as an LMS tool. The analysis process is focused on the process of user identification, distribution of teaching materials, collection of assignments, examinations, and assessments, as well as the process of class discussion. To support the analysis of universities, the research team also analyzed by benchmarking against the Moodle, Classroom, and SPADA systems, without looking at the flow requirements of a particular university. From this process, the identification of the problems faced by several different universities was obtained. And then, the process of identifying system requirements that can answer the issues is carried out.

The following process is to design the data (Dybka, 2020), both in a multischema manner and for the e-learning process and design process flow (Von Rosing et al., 2014). If the design process finds facts that do not match, then the research team will quickly re-analyze the user or comparison system so that the design process can be carried out as well as possible.

The implementation of the system is carried out using the Laravel framework with the PHP or Hypertext Preprocessor programming language. Some program implementations also use the Javascript programming language. Furthermore, trials were conducted in 10 universities, involving users from the department staff, lecturers, and students.

Multi-tenancy is a software architecture designed to provide services to many customers or tenants and is hosted in one resource with one application code and isolated user data. Multitenancy is also designed to be able to customize instances according to the needs of each customer/tenant (Bezemer et al., 2010; Jia et al., 2021). According to Shoff, two scheme models can be applied in multi-tenancy, namely multi-entity/single-schema and multischema (Shroff, 2010). Single-schema uses a single database to store all tenant data to increase the application's functionality. However, single-schema has a disadvantage in complex applications because the layout of the application code needs to be adjusted, and the query for filtering becomes more complicated.

Multi-schema is used to make application modifications easier and this model is also supported by most Database Management Systems (DBMS). Figure 1 illustrates a multischema with a different database for each customer/tenant. The logged-in user will be redirected to the database according to the user's OU. Implementing custom fields in the multi schema is different from single schema. In multischema, custom fields are stored in the Meta-data table and do not store values because values already exist in each table. Thus, the application design is more straightforward, and modifications will be more accessible. The implementation of Edit_Customer_Screen is based on the Meta-data table, so each query executed must be on the database that matches the user's OU.
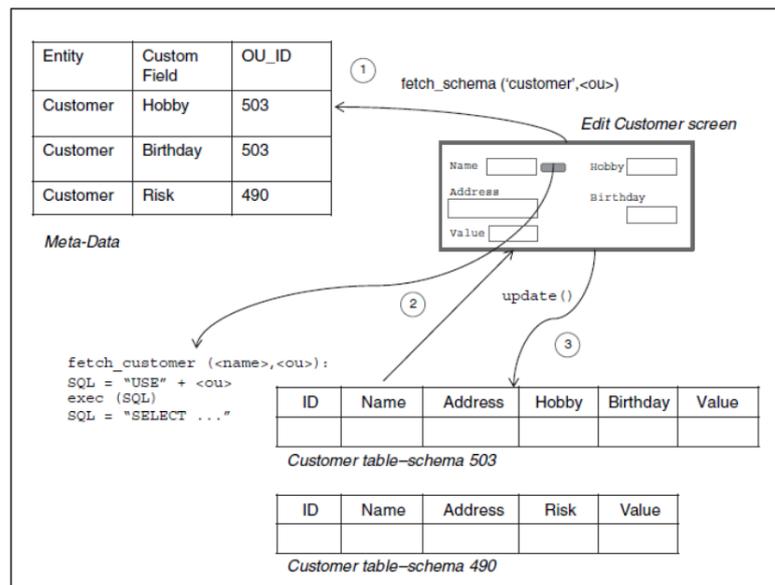
Figure 1. Multi-Schema Concept

The Merdeka Belajar's curriculum is a policy of the Indonesian Minister of Education and Culture to help students master various scientific fields that are of interest or valuable in the world of work (Tohir, 2020). In addition, it can help students improve their hard or soft skills to suit the demands of the times. The general requirements for students to follow the Merdeka Belajar curriculum are students from accredited study programs and active students who are registered with PDDikti (*Pangkalan Data Pendidikan Tinggi*).

The Merdeka Belajar curriculum has 8 learning activities: student exchanges, internships or work practices, teaching assistance, research or research, humanitarian projects, entrepreneurial activities, independent studies or projects, and building villages or thematic actual work lectures. Currently, there are few student exchanges with a credit transfer system between partner universities in the country. Therefore, student exchanges are held to help increase Bhinneka Tunggal Ika (Unity in Diversity), establish friendship between regions, ethnicities, cultures, and religions, and cover disparities in higher education.

Students can take courses at different universities and be registered as participants in courses in the intended study program at other universities. This learning activity can be done face-to-face or online. This research will focus on the form of student exchange activities.

RESULTS & DISCUSSION

Various previous studies have been carried out related to implementing cloud computing in the field of e-learning. However, the application of cloud computing concepts also varies, ranging from infrastructure as a Services (IaaS), Platform as a Services (PaaS), to Software as a Services (SaaS).

In a study conducted by Mohuti et al., it was found that problems in the implementation of e-learning, such as the high cost and complexity of providing hardware, can be overcome with cloud computing, so of course, the scalability of this e-learning will increase (El Mhouti et al., 2018). However, in addition, Mhouti also found that the level of security and internet speed is still a problem in implementing cloud computing in this e-learning.

Shiddiqui in 2019 also stated that cloud computing is a technology that is very helpful in increasing e-learning scalability by making it easier for users to implement this system (Siddiqui et al., 2019). By using cloud computing, every institution that wants to implement an e-learning system, simply provides an internet connection as its initial capital.

In 2022, a study analyzes the security level of e-learning based on cloud computing. The study found that potential cyber-attacks can be classified into two: those that target end users, including teachers and students, and those that target the cloud server provider itself (Najm et al., 2022). Therefore, the responsibility for securing cloud-based e-learning lies with the end user and the cloud provider itself.

In addition to general e-learning research that has been done, there is also research in the field of e-learning that has focused on the policy of the Indonesian Ministry of Education, namely Merdeka Belajar. In 2020 Wulandari et al., conducted research on implementing the Merdeka Learning policy on online e-learning in Indonesia (Wulandari et al., 2020). The results of this study indicate that the independent learning policy that is applied online can work well, even though it only uses a simple online learning media, namely WhatsApp. This can be proven from the results of interviews and observations, where each student can have a good experience developing their potential in real projects. However, information transfer limitations still exist because the media is only for sending simple messages. The use of this media in the schools studied was due to the limited funds owned by the schools to provide adequate online learning facilities. Another research conducted by Elihami in 2021 seeks to implement the new paradigm of Merdeka Belajar in two different types of schools, namely Al-Islam and Muhammadiyah.

The paradigm developed is named RADECE (Reading, Answer, Discuss, Create and Evaluation), where this paradigm is used by teachers to be able to teach better about the concept of Merdeka Belajar in these two types of schools (Elihami, 2021). Ahid and Sufirmansyah also conducted research related to the implementation of Merdeka Belajar in East Java using e-learning, and found that the implementation of e-learning in East Java was also constrained by costs that had to be incurred during its implementation. These implementation constraints have prevented many schools from adopting e-learning as a tool to facilitate the implementation of the Merdeka Belajar program (Ahid & Sufirmansyah, 2022). Recent research on Independent Learning with the concept of e-learning, tries to

see the level of technology utilization of teachers who are direct users of the e-learning system in the Merdeka Belajar program, where it was found that the level of understanding of the technology of e-learning actors on research subjects is still low. This low understanding of technology can be overcome by routine training given to teachers, so that in the end understanding of technology can increase.

In the analysis process, several problems were found that were faced by almost all respondents at the university level. The problems are:

1. According to data from PDDikti (PDDikti, 2020a) (2018), currently there are approximately 4,600 tertiary institutions in Indonesia. Each tertiary institution has its own media to support the teaching and learning process, such as having its own e-learning facilities or using third party media assistance.
2. Identifying users who are logged in varies, such as using a username or email. This causes the data between universities cannot be adequately integrated.
3. Providing access to assignments and exams is not uniform, with different levels of data detail. For example, with Google Classroom, participant identification is only based on information submitted by participants themselves because participants can use personal Gmail. Meanwhile, with Moodle, the participant identification process can be carried out more validly because only registered users can access the system.
4. This non-optimal data integration process will have an impact on the smooth implementation of the Merdeka Belajar.

Apart from the results of the respondent's analysis which is primary data, other problems from previous research were also found, namely related to the lack of funds at certain educational institutions. The lack of financial support causes the lack of facilities owned by these institutions so that they cannot use good e-learning and have an impact on the distribution of less than optimal information. In other studies, e-learning has been implemented based on Cloud Computing, which can reduce operational costs and increase the system's flexibility.

Based on the analysis of university e-learning, e-learning systems in general, and cloud computing-based e-learning, it can be concluded that the data integration process can be completed by building a system with a multischema concept. In addition, this concept can also increase the flexibility of the system that will be used and implemented in each university because each university can determine its e-learning model needed, with independent database ownership. On the financing side, this e-learning system with the Cloud Computing – Software as a Service model can reduce hardware usage to a minimum, but still be able to use various e-learning facilities to the fullest, including communicating with e-learning systems belonging to other universities easily.

The data design is divided into two for the multischema system and e-learning itself. This is done to separate the core system (e-learning) from the operational system (multischema). Multi-schema System Entity Relationship Diagram (ERD) stores data related to the Merdeka Belajar system and courses. Multi-schema System ERD can be seen as in [https://tinyurl.com/mrxx2ce8] (Margojoyo et al., 2022). ERD E-learning system is used by the system to store data related to learning activities in e-learning for each university. ERD E-learning system as a whole can be seen in [https://tinyurl.com/2rpma64x].

Design of the new university account registration process, as can be seen in

Figure 2. The university admin starts the process on the registration page. First, admin needs to enter registration data related to university identity and university admin account to manage university e-learning. After that, the admin can wait for the verification process by the Government super admin. If the university data is valid, the government super admin will verify the data, as can be seen in Figure 3. Verification status will be sent via email to the registered college admin.
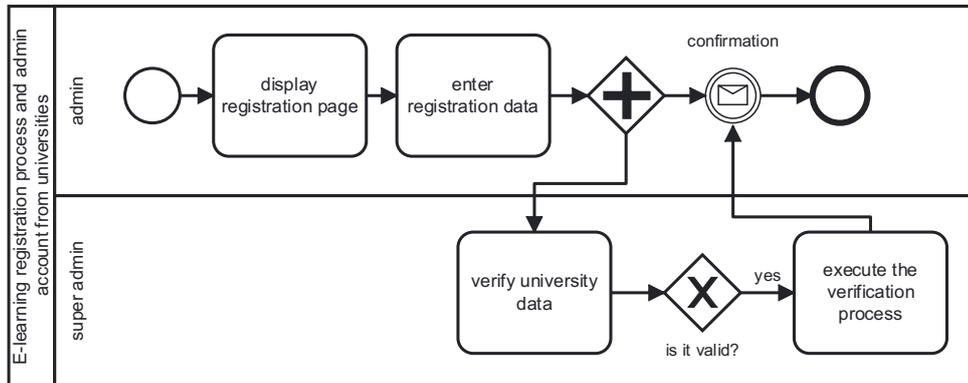

Figure 2. Registration Process Design
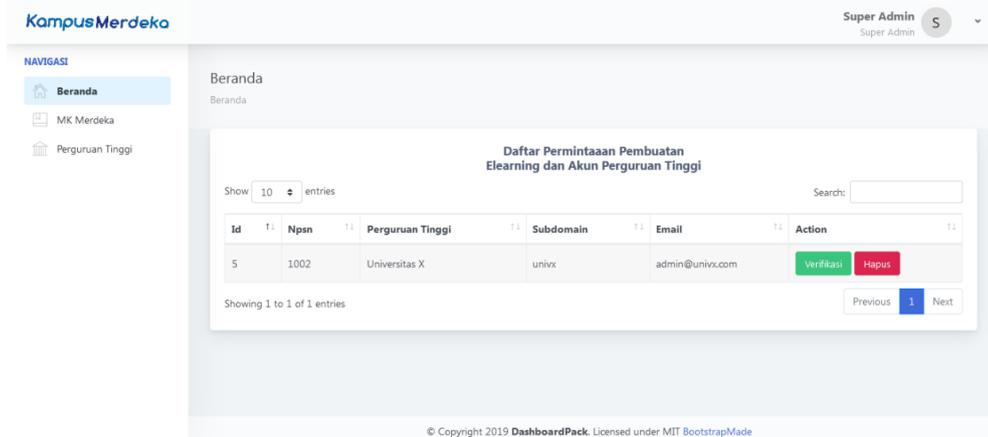
Figure 3. Verification Page by Government Super Admin

In the super admin process from the Government to verify the university, the back-end system will automatically create a new database with the basic schema for the verified university. Figure 4 is an illustration of a multi-tenancy process with a multischema model. There will be many databases on the server, such as the primary database and the database of each university (db_tenant). The university database has links to the primary database to identify database ownership. So the university will have its database to accommodate higher education e-learning. Figure 5 is the result of implementing a multischema database, where the new university database is in the format of the multi-tenancy system database name and id in the university table.
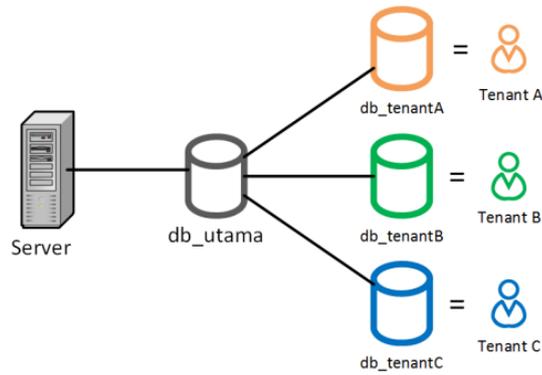
Figure 4. Multi-Schema Illustration
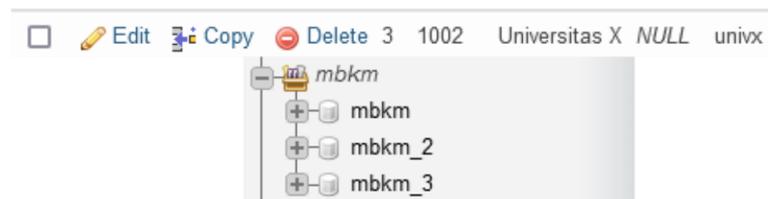
Figure 5. Multi-Schema Results

The custom data creation feature is used to create custom storage areas in the database according to the needs of each university to increase the scalability of this system. In this section, custom data will be verified with examples of cases of creating attendance data storage for the first to the third week of lectures. The attendance data storage attribute structure consists of participant data, courses, and attendance for the first to the third week. The custom data presence ERD display can be seen as shown in Figure 6. This custom data feature can be accessed via the "Custom Data" button on the left panel. The display of the custom data list can be seen in Figure 7, and the form for adding custom data can be seen in Figure 8.
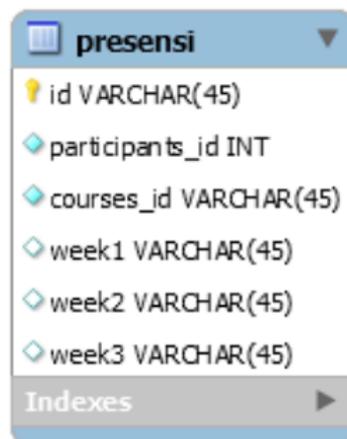
Figure 6. ERD of Custom Data
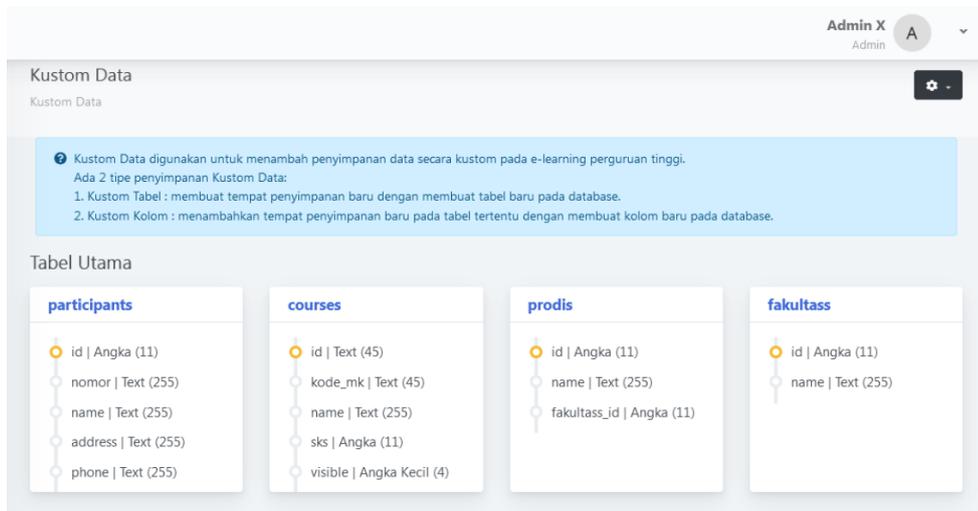
Figure 7. Custom Data Page
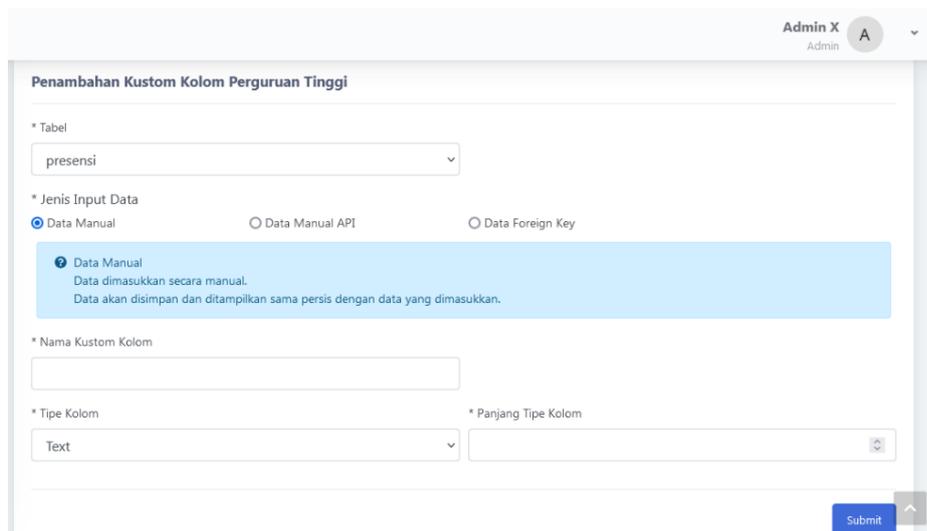
Figure 8. Custom Data Addition Form

The home page or start page of each website formed during tenant verification can also be configured to increase the scalability of this e-learning system. The configuration process on the e-learning home page can be seen in Figure 9. This form is used to display information for university participants according to their individual needs. The e-learning homepage feature is used for course participants (students and lecturers) to view participant data information created by each university. It appears on the first page after logging in. If the college does not require this e-learning homepage feature, the participant's home page will be used to display the participant's course list page. E-learning participants use the participant course list page to view a list of courses that are followed or taught. For example, for Merdeka Belajar's courses attended by students, the name of the university in the course will be colored red to indicate the courses being followed are Merdeka Belajar's courses, as can be seen in Figure 10.
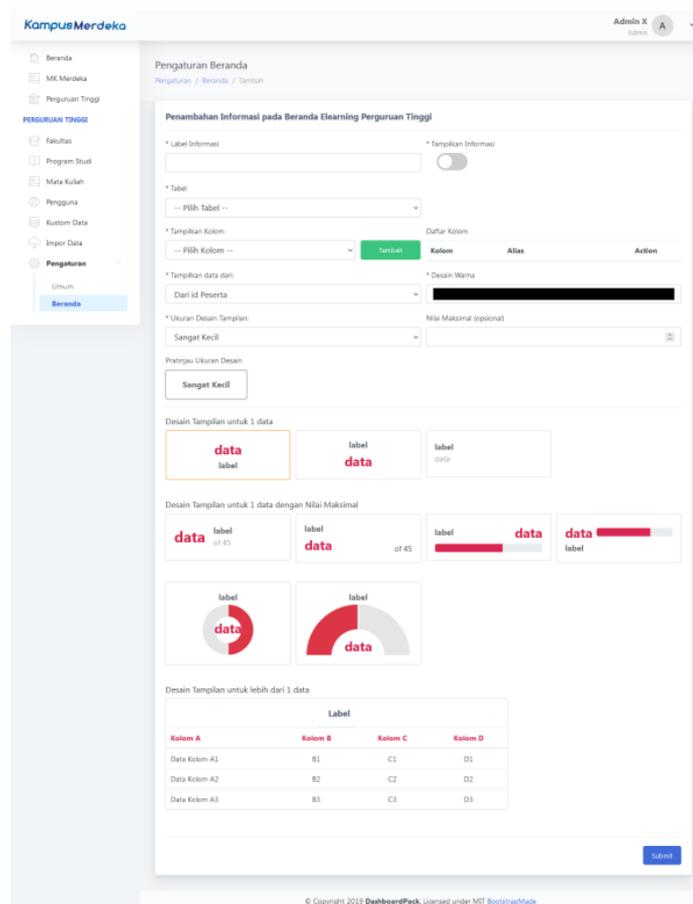
Figure 9. Information Setting Form Home E-Learning
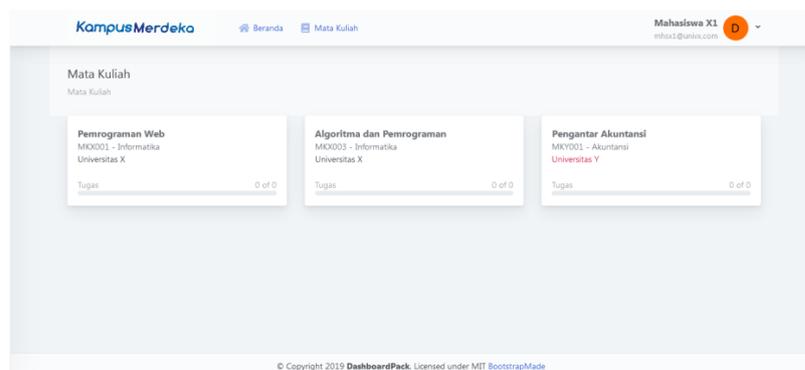
Figure 10. Course List Form from the Student Point of View

In making Merdeka Belajar's multi-tenancy e-learning system in general, there are several obstacles, namely obstacles in implementing the multi-tenancy system and using plugins. Meanwhile, the initial difficulty encountered was adjusting the query to retrieve data from many databases, for example, when displaying a list of college courses themselves and Merdeka Belajar's courses. Furthermore, there are also difficulties in creating custom data features because custom entities and custom attributes need to be flexible and easy to understand for ordinary users. In addition, in the custom data feature, there are difficulties in data

storage, especially for foreign key data storage types that have relationships with other tables. Furthermore, there are difficulties in implementing the e-learning homepage feature because the displayed data must be flexible, such as showing one or more data and getting data from custom data features.

Implementing plugins involves several difficulties, such as dragging and dropping multiple files, pusher, select2, sweetalert, and chartjs plugins. The drag and drop various files plugin, on average, directly uploads files to the server one by one, while the system needs to select the file first then, when submitting, all data and files will be sent as 1 to the server. The pusher plugin that is applied to the real-time chat feature has difficulties in synchronizing sending and receiving messages. The system must distinguish whether the messages sent or received are messages to start a new chat or continue an existing conversation. Furthermore, the difficulty of implementing the select2 plugin occurs in select2 with an ajax request because the data received must be adjusted to the data format and appearance. For example, in the previous e-learning homepage creation feature, selecting more than 1 column using the select2 plugin with multi-select. Difficulties occur when changing the data because the selected column data must be displayed in order. Furthermore, the sweetalert plugin difficulty occurred during the Merdeka Belajar's student verification process because it was necessary to display and select a study program for the student at the time of new student verification. The application of the chartjs plugin has difficulties when creating a ½ donut chart and placing a label in the middle of the donut chart.

The trial was conducted on 10 universities involving admins, lecturers and students. System testing is also differentiated based on the type of user and the menu that the user can access. Based on the system acceptance test in the account registration process for creating university e-learning, changing courses that are part of the Merdeka Belajar, student registration for Merdeka Belajar's courses, and the data configuration process, all university admins answered that the system could be used properly and assist with the necessary administrative processes. For the type of lecturer user, system acceptance trials are carried out on the menu for providing teaching materials, administering exams, collecting assignments, and discussion forums. As a result, 92% of respondents stated that the system provided could help lecturers' assignments and the system is easy to use. Meanwhile, of student respondents, 97% said that the system could help them, according to the menu provided, namely information related to each course taken, examinations, assignment collection, and discussion forums.

CONCLUSION

From the researcher's point of view, databases with multischema are something new, so there are still many problems encountered, especially in the integration process with various programming languages and features that exist today. In this study, a multischema database can support the provision of e-learning facilities that can be configured for various universities in need. In addition, using a multischema database, data integration of multiple e-learning systems can be carried out well. Therefore, the scalability of the e-learning system is increasing.

Several limitations have not been resolved in this study. The research team could not analyze the Government's needs in terms of Merdeka Belajar. So, the data recorded for government super admins is still an estimate. With the collaboration with PDDikti, this research can be developed to be more complex, taking into account the data needs of the Government side.

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