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Conceptual model proposal for integration of consortium e-learning using SOA architecture: A literature-based approach

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Abstract

The increasing demand for online learning (e-learning) is critical to supporting modern education, which faces the challenge of providing relevant, flexible, and affordable education. In addition, one of the innovations in organizing learning programs is Collaboration between universities in a consortium that raises the need for support for technology integration. Service-Oriented Architecture (SOA) supports interoperability, flexibility, and scalability in integrating this consortium's e-learning system. However, differences in technology standards, data management, and service sustainability are challenges. Comprehensive research is needed to design an integration model that can be adopted and become a practical guide in creating an integrated, adaptive, and forward-looking learning ecosystem. The research method will use two steps. The first starts with a literature study using scientific articles related to e-learning, SOA, and Collaboration. The second is the model's design, preceded by identifying the consortium's needs, the leading SOA services, and a simple architecture diagram to visualize integration. The results are in the form of conceptual and exploratory models in the form of new model designs, identification of trends, existing needs and problems, and theoretical contributions that can be used by researchers and practitioners that can be developed into another research.

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Keywords

E-learning integration, SOA, Consortium

Introduction

Higher education's challenge is providing relevant, flexible, and affordable learning services. One of the innovations is the development of a consortium between universities that allows for collaboration in organizing learning programs. The key to the success of this collaboration is integrating technology in the consortium, especially with the improvement of online learning (e-learning).

The integration of learning systems in e-learning systems has been developed as an integrated system architecture based on Service Oriented Architecture (SOA) [1]. This study makes SOA a connector for various components in the education system, including students, lecturers, universities, financial institutions and industry. This encourages the development of e-learning systems integrated with other applications and services and supports accessibility, flexibility and interoperability between various education platforms.

SOA-based service modelling and Business Process Management (BPM) highlights the lack of mechanisms to identify services related to information system development, so it becomes a challenge [2]. As a solution, a proposed service model can respond to changing user needs and be applied in various contexts and business processes.

Integration is also discussed in the microlearning content integration framework (Díaz Redondo et al., 2021), which describes three roles: students, teachers, and administrators. Two standards are used for integration: Learning Information Service (LIS) and Learning Tools Interoperability (LTI), which allow data exchange.

Collaboration between universities is a challenge in research that discusses doctoral program collaboration to overcome resource constraints [3]. The solution offered is the establishment of an Inter-University Consortium for doctoral courses as a collaborative project. Other research highlights digital partnerships between European higher education institutions to support sustainable education policies [4]. The findings of this study state three dimensions of digital learning collaboration: organizational, pedagogical, and technological. In addition, this study highlights stakeholder involvement and makes policy recommendations.

The Government of the Republic of Indonesia encourages cooperation between higher education institutions; this is stated in the regulation of the Ministry of Education, namely Permendikbud Number 3 of 2020, concerning National Standards for Higher Education, articles 15 and 18 [5] concerning cooperation between higher education institutions in the framework of the Merdeika Belajar Kampus Dekat (MBKM) program. The real form of this cooperation is a consortium, which aims to increase efficiency and collaboration [6][7]. In e-learning, this collaboration requires the support of technological infrastructure.

Referring to the description above, the implementation of SOA in the e-learning consortium has illustrated the internal and external interconnect between systems. Technologically, LSI and LTI standards are used to support data exchange. However, challenges include differences in technology standards, data security management, and the need to ensure service sustainability. Therefore, comprehensive research is needed to design an integration model that meets the university's needs and remains flexible in facing technological changes in the future.

This article provides a solution by proposing an SOA-based integration model as an initial design that can be used as material for future research with more complete stages. This

research is conceptual and exploratory, focusing on three things: first, a new model that refers to the understanding of the theory and practice of existing systems; second, identifying trends, needs or problems based on literature analysis; and third, providing theoretical contributions that form the basis for further research.

Method

To produce the concept of an integrated consortium e-learning system model based on SOA, two stages of systematic approach are carried out, namely the literature study stage and the model design stage, each of which has specific stages and objectives to support the development of the conceptual framework. The following is an explanation of the method in the picture seen in Figure 1.

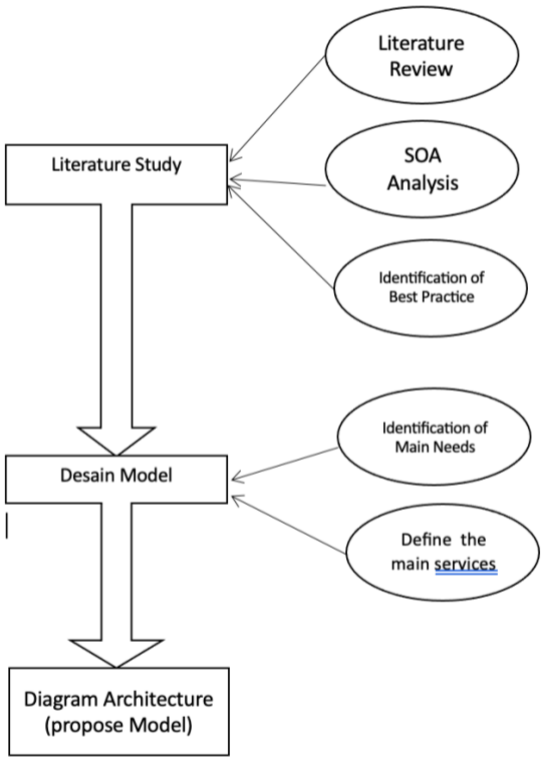

Figure 1. Research method

Literature Study

In the literature study stage, there are three aspects: Literature Review, SOA Analysis and Identification of Best Practices. Next, each aspect will be explained in more depth.

1. Literature Review

In this section, we will explain the literature related to and supporting the development of the proposed concept of an SOA-based consortium e-learning system integration model. The literature presented is about SOA, integration systems and frameworks, some of which have been presented as an introduction.

Service-oriented architecture (SOA) can be an approach to computer program development that uses computer program components called services to create

business applications [8]. Each service can interact in various platforms and languages. Literature review research on SOA [9] obtained forty-one articles published between 2006 and 2023. The results state that SOA is an established architectural style for building effective Information Systems (IS). However, new methods are needed to provide organizations with an easy-to-use and comprehensive process to ensure the quality of SOA models from business models.

A study that discusses the integration and interoperability of e-learning systems using the SOA architectural model approach has provided a mechanism for sharing resources and data, connecting systems in one institution and between institutions [1]. The use of SOA is expected to create a higher education ecosystem that is interconnected and enables collaboration. The study also explains the Enterprise Service Bus (ESB), which functions as a mediator connecting various services in SOA, providing interoperability even though it has a different format. SOA provides a framework for service development, while ESB functions as an infrastructure that supports communication and integration between services.

SOA and BPM-based modelling services are proposed to overcome the lack of service identification mechanisms related to information systems and limitations in capturing user needs [2]. The result is a framework consisting of software components that are integrated, flexible and can be customized to user needs. The framework consists of SOA and BPM layers to handle general and specific applications in a university environment.

The SOA architecture-based framework integrates micro-teaching flexibility in more formal distance learning [10]. The modular approach supports the integration of micro-learning into traditional LMS, using the Learning Tool Interoperability (LTI) standard as support for content to be accessed directly from the LMS platform without technical barriers. The Learning Information System (LIS) standard exchanges data between micro-learning and LMS.

An experiment to identify challenges in inter-university collaboration [4] was conducted in seven European universities using an evidence-based approach to understand and solve problems in digital collaboration. The results show three main challenge perspectives: Organizational domain, Pedagogical perspective, and Technological dimension.

The Organizational Domain creates an atmosphere of trust between students and the university regarding technology use. The Pedagogical Perspective explains that digital tools must be open source and free to ensure user accessibility. The Technology Dimension identifies technology needs that vary according to role and learning model.

In addition to the three perspectives, the study also discusses the involvement of stakeholders, namely students, teachers and other non-academic actors who support digital collaboration. Continued with policy recommendations, namely, that policies must be evidence-based to avoid tensions between decision-makers and institutions.

The initiation, formation, and operationalization of the consortium for doctoral courses [3] explains the challenges in its implementation, namely differences in standards, data security management and the need to ensure sustainability. The method of analyzing surveys conducted with students, professors, and school leaders shows that the consortium has great potential to increase collaboration between universities and meet doctoral education needs. In addition, it was also found that the problems faced were generic and could be found in other fields.

From the literature description above, we can identify the gaps that occur. First is the difference in implementation standards between universities, and to overcome this, the SOA approach is used. Second is the data security problem, so it is necessary to adapt the security protocol on the ESB, which is a reference from SOA and supports Interpretability. However, the next thing that appears is that it has not been standardized across institutions, so the next need is scalability and flexibility between institutions.

It is necessary to integrate the three main perspectives (domain organization, perspective pedagogy, and technology dimension) in inter-university collaboration to support the interoperability of e-learning systems. The opportunity is proposing a model that includes elements from each domain. While in the doctoral course consortium, one thing that needs to be considered is the program's sustainability. With SOA, this gap can be overcome by designing an adaptive solution that can be developed according to future needs.

2. SOA Analysis

The discussion of SOA for modern interconnected higher education [1] proposes the concept of an adaptive and customizable Enterprise Service Bus (ESB)-based reference system by facilitating integration between platforms and service providers. The proposed SOA architecture is divided into six layers (see in Figure 2), each with a role in the integration service.

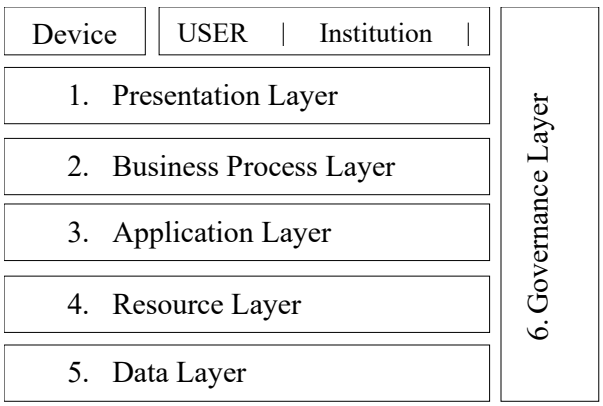

Figure 2. SOA System Architecture [1]

SOA architecture support in integration is found at every layer, namely interoperability support, which allows users to access various content and resources without technological limitations. Furthermore, along with the development of e-learning

systems, the architecture also supports flexibility in development, namely by adding and changing services as needed.

Next is a detailed guide to implementing SOA architecture as depicted in Figure 2, namely the SOA reference system that adds Enterprise Service Bus (ESB) seen in Figure 3.

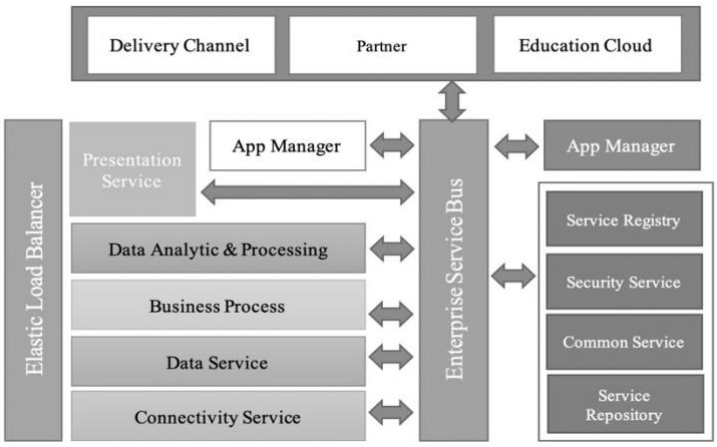

Figure 3. SOA System Reference

The SOA system reference above explains the important components that must be integrated, namely digital libraries, virus content, course information, and learning management systems (LMS). The presence of ESB is designed as a pattern to separate the complexity of service integration. ESB is a mediator connecting various services and systems in the architecture.

Viewed from the policy aspect, SOA encourages collaboration in collaboration but has not yet explained the intended policy in depth. At the same time, the organizational aspect emphasizes a clear governance structure in collaboration. For the SOA technology aspect in this study, the problem is the infrastructure gap.

The SOA approach is synergized with Business Process Management (BPM) to develop service modelling [2], identifying the importance of flexibility for diverse and heterogeneous users by utilizing the Learning Management System (LMS), namely sharing core services such as assessment systems, student registration and reporting while still allowing for personalization at the local level. This approach allows LMS to become a cross-institutional collaboration platform that supports learning, resource sharing and joint academic program management.

The proposed framework combines SOA and BPM layers that accommodate the LMS Academic Enterprise System (L-EAS) needs. Before the proposed framework, a Venn diagram is prepared to illustrate the intersection of business processes, namely how general policies apply along with specific policies in the university consortium.

Venn diagram depicts general policies coexisting with specific policies in a university consortium (Figure 4). This allows for the sharing of business processes among different units, encouraging collaboration and efficiency. Based on the Venn diagram, the

proposed framework is explained, namely one that integrates SOA and BPM architectures (Figure 5).

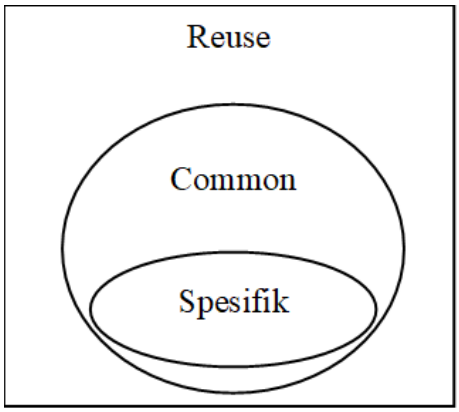

Figure 4. Venn Diagram Business Process

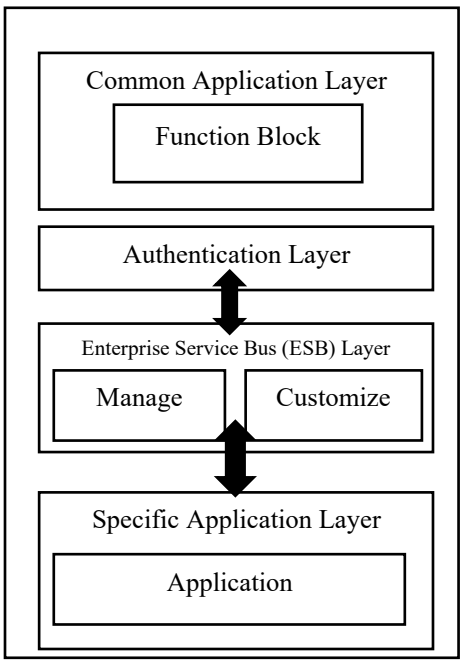

Figure 5. Sinergy SOA and BPM

From the Venn diagram, this study proposes a framework that integrates SOA and BPM and integrates systems by accommodating collaboration needs. The goal is to combine and synergize services to increase flexibility and improve information systems.

A systematic literature review of SOA Service Identification and Design Methods [9] explains the relationship between SOA and business model alignment, which emphasizes integration from technical and business perspectives. The findings indicate that a universal method is needed to address the heterogeneity of organizational needs. This review suggests various methods to identify and determine quality services from business models. Combining SOA principles and a business model-based approach can develop an efficient, scalable, and adaptable integrated e-learning system for inter-institutional collaboration.

3. Best Practices

Identify best practices for SOA implementation in education and non-education sectors so that they can be adapted to meet the needs of cross-institutional e-learning. The concept of ESB as a reference SOA system is an application in higher education in Indonesia [1] with the adaptation of six layers in the cloud computing environment (CCE) system. The presentation layer is a layer that combines connections between internal and external institutional systems in the learning process, both synchronous and asynchronous models. The Business Process Layer is responsible for software, including learning support software in the application layer. Furthermore, the resource layer manages storage and its Integration with the LMS and internal and external resources. This layer is a form of capability in interoperability and portability of the e-learning system. With ESB, the implementation of SOA in higher education can integrate internally and externally with other institutions and educational service providers called third parties. Technologically, there is Application Programming Interface (API) management, which is a protocol that supports the Integration

Khan's framework for online learning discusses a systematic approach to the design, evaluation and management of online learning with eight dimensions: institutions, pedagogical, interface design, evaluation, management, resource support and ethical. This framework addresses the challenges of Massive Open Online Courses (MOOC) in the gap between students, teachers, technology and ineffective measurement. With this framework, the system has great potential to support collaboration between universities because it can be accessed by students from various institutions, including the blended learning approach, which complements online learning with face-to-face lectures. Collaboration between universities can be developed through joint lecture materials, evacuation standardization, and utilization of shared infrastructure (MOOC and LMS).

The SOA architecture-based framework integrates micro-teaching flexibility in more formal distance learning [10]. The modular approach supports the integration of micro-learning into traditional LMS, using the Learning Tool Interoperability (LTI) standard as support for content to be accessed directly from the LMS platform without technical barriers. The Learning Information System (LIS) standard exchanges data between micro-learning and LMS.

Collaboration between universities is also discussed to overcome the limitations of experts [3]. Organizational governance and its structure are needed for sustainability. Technology as the backbone needs to consider infrastructure and communication features, both synchronously and asynchronously. Meanwhile, from the policy side, it includes material accreditation and credit recognition between institutions.

Integration is also explained in a study that developed a framework for the efficiency of online learning transformation [11]. Focusing on the challenges in developing countries, namely, the lack of technology, support, and digital learning materials and challenges

during the pandemic. The result is a proposed framework consisting of five main components: Infrastructure, e-learning delivery, LMS, E-content and user portal. In terms of collaboration between institutions, this framework supports infrastructure collaboration by sharing resources between institutions. Next is collaboration in E-content, formed by forming a collaborative team between institutions in developing content.

In Indonesia, there is a potential for collaboration between universities, namely under the Muhammadiyah community organization, where there is an affiliated course that is a standard, namely Al-Islam Kemuhammadiyahan (AIK) [12][13]. In the future, this course can be used as a case study for the university collaboration model.

Design Model

After getting an overview of the best practices combined with the growing trend of collaboration between universities and the need for an e-learning system consortium model, the next step is to submit a model design. As the purpose of the research, the intended model is a conceptual model expected to provide theoretical contributions that serve as a basis for further research. Each review will refer to the research problem to answer three challenges, which will be arranged in three levels: policy, organization and technology.

From the best practices in the SOA architecture, the policy level can be explained as the main part, namely providing standards and security and Intellectual property rights guidelines. At the same time, the organizational level is needed in the Composition of services between LMS, Synchronization of schedules and materials, Communication across the organization and Monitoring of work processes. The last level is technology, which contains interconnection technology between data and between systems.

The collaboration framework is conceptually identified in seven main domains [14], which serve as a means of connecting with industry partners and fellow educational institutions. The first is Social Behavior, emphasizing the importance of social behavior in creating a collaborative environment. Second, people are a key element in the framework that contributes significantly to collaboration success. Third, process refers to the mechanisms or steps applied in collaboration. Fourth, Organization, organizational structure, policies, and culture that support collaboration. Fifth, the Environment involves external contexts such as government policies, support from industry partners, and global technology trends. Sixth, Technology is one of the important pillars in supporting open innovation. Utilization of digital platforms, blockchain technology, and technology transfer. Finally, the seventh is Performance, measuring the results of collaboration, both in the form of innovation produced and its impact.

1. The Need for an E-learning Consortium Model

A comprehensive framework is needed to support collaborative learning in universities in collaboration with internal and external systems. The recommendation is learning

based on digital blockchain technology [14]. In addition, e-learning consortiums are also needed with the government's policy included in the Merdeka Belajar Kampus Merdeka (MBKM) program [6][7]. The collaboration includes curriculum, credit recognition, and joint evaluation systems.

2. Main Service of Model

Proposal A conceptual model must consider the Analysis of literature study results, best practices and SOA Analysis. This section is divided into two parts: identifying main needs and defining main services. Three main needs can be identified: functional, non-functional, and stakeholder needs.

Functional needs include services to support cross-institutional learning, such as learning content management, user collaboration, and an integrated assessment system. Furthermore, non-functional needs include scalability requirements, interoperability between systems, data security and efficiency of access time. Stakeholder needs are determined by the needs of the various parties involved: students, lecturers, educational institutions, and system administration.

Definition of the main services core of the SOA-based conceptual model. The scope of this definition concerns the function and role of each system service, namely content management services, Authentication and Authorization services, data interoperability services and Reporting and Analysis services.

Content Management Services are digital learning material managers that include uploading, content organization, and distribution to consortium members. Furthermore, authentication and authorization services manage access with the single sign (SSO) mechanism. At the same time, Data Interoperability Services connects e-learning systems from various institutions to exchange data in standard formats. Finally, Reporting and Analysis Services provide data-based information for decision-making and academic evaluation.

This stage produces a conceptual framework covering the main needs and designed services. Furthermore, it can be used as a guide to develop an effective and efficient consortium-based e-learning system. The model submission will be explained in the results and discussion section.

Propose Model

Compiling a conceptual model for the integration of the consortium e-learning system is based on three main challenges in collaboration: domains, namely, organizational domain, pedagogical perspective, and technology dimension. In addition, the model will also be integrated with the main services in the SOA architecture system, namely Content Management, Authentication and Authorization, data interoperability and reporting, so that the proposed model will focus on the standardization of protocols between systems, Cross-institutional data security management, integration of

organizational domains, pedagogy and technology. These three domains then become layers in the proposed model (Figure 6).

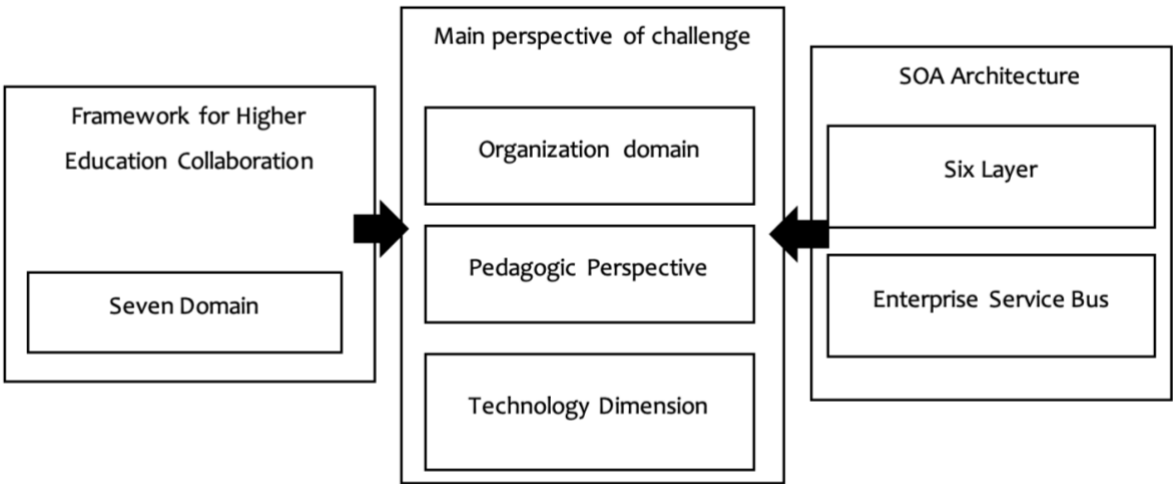

Figure 6. Design of Model

The first stage is to analyze three main challenge perspectives and compare them with the seven domains of e-learning system collaboration (Table 1).

Table 1. Three perspectives and Seven Domain

Three perspectives of the main challenges	Seven Domains	Information
Organization Domain	Process	Dealing with the workings and procedures involved in collaboration.
	Organization	Focus on organizational structures and cultures that support collaboration
	Performance	Covers the results of collaboration, including intellectual property rights and patents.
Pedagogic Perspective	Behavior Social	Emphasizes communication, trust, and commitment between individuals in a collaborative context. It covers the interpersonal aspects that are important in education and learning.
	People	Refers to collaboration between universities and industry partners, and the development of students and researchers in a collaborative context.
Technology Dimension	Technology	Covering technology transfer and digital platforms that facilitate collaboration and open innovation.
	Environment	Covers external factors that may influence the use of technology and innovation in a collaborative context.

Reviewing the six SOA layers with three perspectives on the main challenges. Namely, it will review the three perspectives that are the main challenges in collaboration with the layers of the SOA architecture.

These three perspectives—organization, pedagogy, and technology—provide a comprehensive framework for building conceptual models in the context of SOA architecture (Table 2). Models designed with the interactions and relationships between these three aspects in mind are expected to enhance digital collaboration between universities and strengthen the overall learning experience.

Table 2. Three perspectives and SOA Architecture

Three perspectives	SOA architecture system analysis	
Organization	Collaboration Between Departments	SOA allows the integration of various services that can facilitate collaboration between different faculties and departments.
	Flexibility and Adaptability	SOA supports designs that can be easily changed and improved.
	Building Trust	SOA can enable transparency in how digital services are managed and accessed by all stakeholders.
Pedagogic	Personalization	SOA can support the development of educational services tailored to the individual needs of students.
	Collaboration	SOA can integrate collaborative learning services that allow students from different universities to work together.
	Feedback based on Data	SOA enables better collection and analysis of data regarding learning processes.
Technology	Interoperability	SOA ensures that the various systems and applications used in education can interoperate with each other.
	Scalability	Service-based architecture allows for more scalable development
	Security and Accessibility	ensure that sensitive information is protected and can only be accessed by authorized users

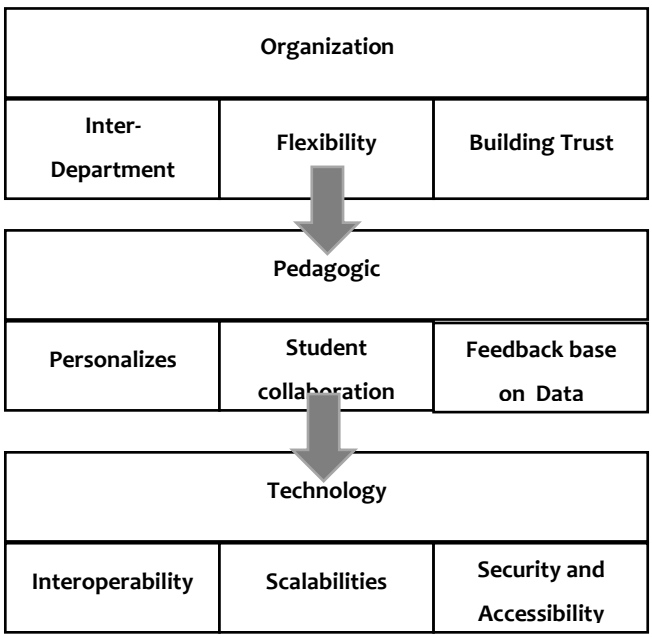

Figure 7. Propose Model of Integration Consortium E-learning Service (ICELS)

The relationship between the above perspectives and SOA architecture can be developed into a hierarchical relationship; the highest position is the Organizational Domain, which focuses on the structure, culture, and processes of inter-agency collaboration. It includes policies, rules, and governance that support departmental interactions and integration with external stakeholders. The second is pedagogy, which emphasizes the learning and teaching approaches that can be implemented within the SOA framework. It deals with how students and teachers interact with the educational services provided. Finally, technology serves as the foundation for implementing organizational and pedagogical perspectives. It includes the technical infrastructure, software, and protocols for integration and communication between services.

Based on the description above, this research proposes an integrated e-learning service system model for a university consortium called ICELS (Integration Consortium E-learning Service) (Figure 7).

Result and Discussion

Each perspective plays an important role in this hierarchy and supports each other to build a strong framework for implementing SOA architecture in educational environments. Understanding this relationship helps design effective and integrated strategies to improve collaboration and learning experiences in educational institutions.

As the top layer, the organizational domain focuses on the structure, culture, and collaboration processes between institutions. Its scope includes policies, rules, and governance supporting department interactions and integration with external stakeholders. Its main function is to build trust, create strong cooperation, and ensure organizational adaptability.

The pedagogical perspective in the middle layer emphasizes the learning and teaching approaches that can be applied within the SOA framework. Relates to how students and teachers interact with the educational services available. Its main function is to enhance the personalized learning experience, support student collaboration, and utilize data for relevant feedback.

The technology dimension is the lowest level and is a basis for the organizational domain and pedagogical perspective. Includes the technical infrastructure, software, and protocols for integration and communication between services. This dimension provides interoperability, scalability, security, and accessibility, supporting the two layers above.

The first advantage of this consortium model is flexibility, namely that existing systems can be integrated without major changes. The second is efficiency, namely reducing duplication of services and increasing collaboration between organizations. The third is high and modern security using blockchain and OAuth protocols. The fourth advantage is the model's scalability, making adding services or models easy.

Conclusion

The conclusion of this study emphasizes that the conceptual model of integration in e-learning system services must consider three important components: policy, organization, and technology. These three components can be arranged in a hierarchy: policy is at the highest level as the main foundation, followed by organization, and technology is at the lowest level supporting implementation. By referring to the SOA (Service-Oriented Architecture) architecture, each level in this model can be explained in terms of function and integrated working mechanisms. This conceptual model offers an initial framework that can be used as material for more in-depth discussion in future research to improve implementation and its benefits.

For future work, this proposed model (ICELS) must be continued to the validation stage by involving respondents and validators. Respondents have three types referring to e-learning system actors: students, lecturers, and administration. As validators, managers and developers of e-learning service systems are proposed.

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