Original Research Paper

Implementation of Information System Architecture Using TOGAF and Ward Peppard Analysis for High School

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Abstract: The development of IT has become a crucial and essential necessity for fostering innovation within companies. Recent technological advancements have resulted in Information Systems (IS) involving the processes of identification, evaluation, and decision-making related to a company's strategies. In its application, IS has been used not only within companies but has also extended into the realm of education. The significance of information systems in the education sector has become crucial for more modern education, especially in this era of education 4.0, where education tends toward digitalization. The high school is an educational organization located in Jakarta, Indonesia. These organizations have diverse business processes, ranging from the enrollment of new students, school data management such as student and teacher records, facility management, and the learning process, to routine divisional reporting, these high schools have not optimally and integratively implemented technology. They acknowledge the importance of integrating business processes with IS. Therefore, the design of enterprise architecture is needed to align business processes with information systems to ensure their mutual integration. The enterprise architecture undertaken in this study will assist in designing advancements in business processes, information systems, and organizational infrastructure, enabling high schools to better prepare for future challenges and move toward a more modern learning environment. This research employs The Open Group Architecture Framework (TOGAF ADM) combined with the application of the Ward Peppard method. TOGAF provides methods related to building, managing, and implementing enterprise architecture and information systems. The findings of this research consist of a blueprint recommendation comprising detailed proposals for integrated applications to enhance business processes and cater to the needs of the company. These recommendations can serve as a reference for designing information systems and making decisions in developing high school information systems.

Keywords: Technology Development, Information System, High School, Ward and Peppard, Enterprise Architecture, TOGAF, Blueprint

Introduction

The development of Information Technology (IT) has undergone many changes and resulted in various innovations in the current era of globalization (Kurnia *et al*., 2021). This has become a staple in the business world and is the key to achieving business value from technology (Santosa and Mulyana, 2023). One of the developments in IT results is Information Systems (IS) which involves the process of identification, evaluation, and decision making related to corporate strategy (Aziz *et al*., 2023). IS can

support business processes to improve work efficiency and form integrated business processes (Wichean and Sungsanit, 2022). The application of IS has been widely used by companies, associations, and even in the world of education which has undergone drastic changes in the last decade and is much focused on developing 21st-century capabilities in the use of technology (Alrakhawi *et al*., 2023). However, the problems experienced in each organization and their impact vary (Delly and Yurisca, 2021). They do not yet have the option to provide ideal support for further organizational performance

development, especially in the field of technology (Sardjono and Vijayanto, 2021).

Senior High School is one of the organizations engaged in education and is located in Jakarta, Indonesia. This school has several weaknesses that hinder the smooth running of business activities in high school, especially in the use of information system technology that is not optimal. During the COVID-19 pandemic, schools were forced to digitize many aspects of communication and business management (Deny *et al.,* 2021), these high schools admitted that they were not prepared to face the existing conditions, even though education has entered the era of education 4.0, where IS has been widely adopted in the field of education and allows schools to switch to a more modern approach. In organizational business processes, starting with the process of registering new students following traditional methods involving paper-based forms, it takes significant time to manually entangle data into Microsoft Excel (ME), which can potentially hamper the efficiency of student data input each year. Student data management is done through manual procedures, coupled with the use of ME applications to consolidate student information from different parts of the organization. This data includes student identity data, student grades, student achievement, attendance data, and others. High schools provide information services to students and parents that are still done through the WhatsApp application and often result in the loss of important information among other messages. Next is related to recording student attendance which is always recorded every day manually on paper, followed by monthly consolidation tasks carried out by the student department. This process often causes loss of attendance data or input errors related to permission or sick leave information. Senior high schools also have a vision of improving learning using IT in the learning process which until now has not been realized. Monthly evaluation reports are also needed for principals from various units as school performance evaluations that can be used as a reference in future decision-making, so an integrated system is needed so that interconnected data is transparent.

The application of SI for education must be planned and adjusted to the needs of the organization (Siswanto and Sumitra, 2020). Due to the mismatch between business processes and IS applications, as well as limited human resources in the IT field, researchers are expected to design Enterprise Architecture (EA) as an extension between business, IS, and IT (Karjadi *et al.*, 2022). This framework provides innovation and executive planning that will help organizations thrive by understanding organizational conditions according to a broad view and understanding the relationship between existing innovation assets, data flows, business cycles, and system direction (Lee *et al.*, 2020). A good configuration of business techniques can create a match between data

innovation and business needs for administrative activities in an association (Andry *et al.*, 2021). It also helps in the development of an organization's business activities, ranging from manual frameworks to coordinated and integrated frameworks (Gerber *et al.*, 2020).

Researchers designed EA using the TOGAF framework combined with an information system strategic plan using the Ward Peppard method (Setiyani and Effendy, 2021). EA is needed to provide detailed techniques on the most skilled methods to build, manage, and execute large businesses with EA and IS (Puspitasari and Kamisutara, 2021). Ward Peppard provides a theoretical framework to detail the relationship between the business sector, information systems, and information technology strategies (Mathrani, 2021). This approach consists of environmental analysis using a McFarlan strategic grid, SWOT, and value chain (Suhendra and Santiko, 2022). The result of this framework is in the form of mapping proposed information system applications needed to support the company's business operations and can be used as a guide in the application of information technology with the TOGAF ADM method (Fajrillah *et al.*, 2022). TOGAF ADM has a more comprehensive coverage compared to the method applied by Ward Peppard. Its use refers to the planning and technology of information systems as a whole (Crosley *et al.*, 2023). The framework also has an IS-based Architectural Development Method (ADM) to make IT design faster, more successful, more skilled, and more coordinated in a single business network (Fianty, 2023). ADM has a tool consisting of eight main phases for event change and maintenance of specific hierarchical techniques (Supriyadi and Amalia, 2019). The eight phases are vision architecture, business architecture, is architecture, technology architecture, opportunities and solutions, migration planning, implementation governance, and architectural change management (Girsang and Abhimanyu, 2021).

Design of this EA, recommendations will be generated in the form of a blueprint consisting of proposed applications and detailed plans to be a reference in decision-making related to the development of secondary school information systems. These recommendations aim to assist the high school in addressing challenges such as student enrollment, student data management, hybrid learning, accurate information services to parents, performance reports for school evaluation, and integrity between one function and another. The implementation of this SI solution aims to help high schools overcome data flow challenges. This goal can be achieved by suggesting a business engineering approach, which includes data design, application, and technology recommendations to help the school address its shortcomings and promote a more modern educational environment.

Materials

Research conducted at high schools in an effort to implement information system architecture using the Togaf and Ward Peppard method. Data was collected in several ways, namely observation and interviews with several people (Person in Charge) from each department. The result will be a Blueprint Information System Architecture which will help the organization achieve its business goals.

Methods

This research employed qualitative research methods, specifically conducting case studies involving observations and interviews with relevant companies. Referring to Fig. 1, it becomes apparent that several stages of the structure will be undertaken in this investigation, as outlined:

- Identification of problems is conducted to discover areas where weaknesses may exist or where certain areas of a company might be less than optimal
- Subsequently, researchers conduct a literature study to augment theoretical references supporting the study through books, journals, articles, and other sources related to this research
- After the literature study, researchers can select the appropriate framework to address the previously identified issues researchers chose the TOGAF ADM framework as the method for designing enterprise architecture because this framework offers a structured approach concerning the steps in each phase of architecture development and can be tailored to the organization's needs. This research also incorporates the methods from ward Peppard, which will be combined with the TOGAF framework
- Next, researchers collect data by directly observing a high school to understand its current conditions and ongoing business processes. This is done to obtain the necessary data for this research
- Following the observation, researchers conduct interviews with several departments of the high school organization to gather more detailed data regarding business processes, strengths and weaknesses of the company and the roles of each organizational unit to acquire the necessary data for the research
- Once the data is gathered, researchers analyze the obtained data using SWOT, value chain, and organizational issue identification methods to understand the problems and conditions of the high school
- Then, researchers will create a company architecture design using the TOGAF ADM framework to provide solutions related to the issues faced by the high school. This involves proposing designed applications and how these applications can be integrated
- Subsequently, this research will be combined with the ward Peppard method, especially in mapping the proposed applications that have been designed in the architectural design. Mapping these proposed applications will be analyzed using McFarlan's strategy grid to identify the extent to which the proposed applications can contribute to the organization. This analysis can also serve as a reference for decision-makers to choose or prioritize the proposed applications to be implemented first
- After designing the company architecture and mapping proposed applications, researchers will provide a blueprint recommendation to the high school based on the research findings. This blueprint contains explanations regarding the recommended applications and their integration. These recommendations can serve as a guide in creating an information system that can support the ongoing business processes (Tannady *et al*., 2020)
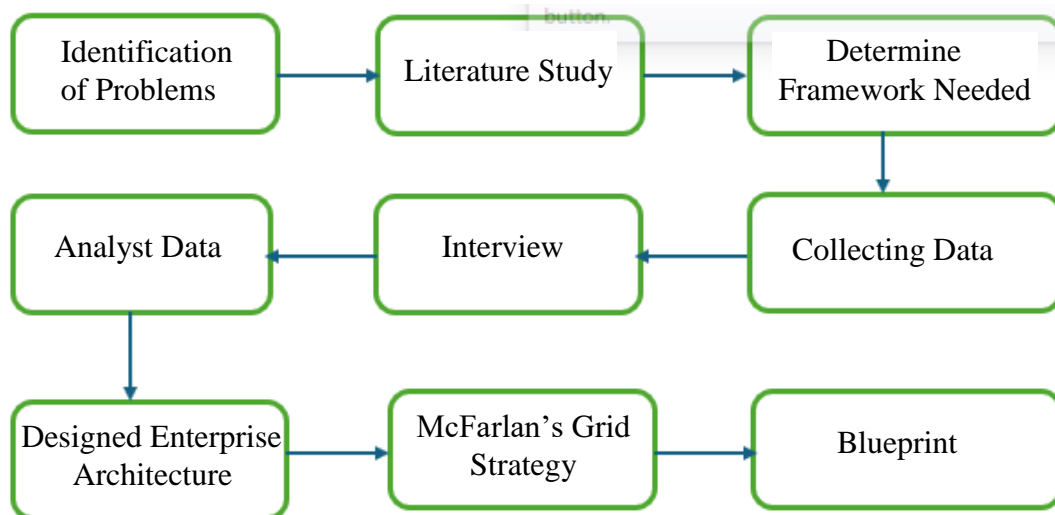

Fig. 1: Research method (Sudarsono *et al*., 2020)

Results

Preliminary Phase

This phase is the initial phase in research to design enterprise architecture. This phase presents the value Chain and SWOT for the decision-making process regarding the architecture to be designed within the organization.

Value Chain Analysis

This stage will be explained in relation to the current technology and systems existing in high schools using the value chain. This model divides the business process into two activities, namely primary activities and support activities. The purpose of conducting a value chain analysis is to understand the ongoing business processes and identify areas that may require efficiency improvements (Andry *et al*., 2023).

Primary Activities

1. Inbound logistics. It consists of the process of admitting new students held annually through registration forms, the development of the learning curriculum for the new academic year adjusted to government education policies, and the preparation of the academic schedule for school learning activities, including class schedules and exam schedules
2. Operation. In this section, there is a process of teaching and learning activities and extracurricular activities
3. Outbound logistic. In this section, there are outputs, namely student graduation and quality learning
4. Marketing and sales. In this section, there is a promotion process through social media such as Instagram, promotional banners, and posters as well as cooperation with various partners such as universities in Indonesia
5. Service. In this section, there are information services for student activities or parents of students and services to school alumni (Guntara *et al*., 2020)

Supporting Activities

1. Firm infrastructure. In this section, there are elements such as school buildings, school grounds, and libraries in the needs of the school academic process
2. Human resource development. In this section, there are new teacher recruitment activities and training for teachers/staff
3. Technology development. In this section, schools receive support from a limited set of government-provided technologies including Microsoft office for reporting school data, along with supplementary applications like Google Meet, zoom, and similar tools
4. Procurement. In this section, there is the provision of school facilities such as tables, chairs, blackboards, computers, projectors, speakers, and musical instruments (Geasela and Legowo, 2022)

SWOT Analysis

This stage will explain the SWOT analysis of the high school, which is used to assess the strengths, weaknesses, opportunities, and threats. This analysis is conducted to plan the design so that weaknesses in the organization can be addressed, strengths can be optimized and risks from external threats can be minimized (Susar *et al*., 2022).

Strengths

1. The location is close and easily accessible by the surrounding community
2. School fees are quite affordable for the private sector
3. Have teachers who meet the qualifications and in accordance with their respective fields of study
4. Sufficient facilities meet a*l*l the needs of students to support the learning process
5. Providing services related to the assistance of underprivileged students

Weaknesses

1. Facilities and infrastructure that are lacking such as shared school fields and learning support tools such as projectors, musical instruments, and others
2. Limited in the number of rooms, all rooms are used as classes to accommodate all study groups
3. There is no digitalization implemented by schools to support learning
4. There has been no related development research and funding for the development of high school projects

Opportunities

1. There is good trust from the surrounding community regarding the needs of students and parents of students
2. There is trust in the government regarding teaching and learning activities
3. There is trust from various partners such as universities and other parties
4. Schools can produce the output of outstanding school graduates who are not inferior to other schools

Threats

1. The threat from public schools in terms of free tuition fees and complete facilities
2. There are schools that are more advanced and developed, especially in the field of technology
3. Schools have not implemented digitalization at all
4. Student's education is genuinely low so the school is challenging to decide the educational program that needs to be run (Fikri and Putra, 2022)

Requirement Management

This phase aims to analyze and manage the architecture by identifying the problems of each activity and creating information system solutions to the identified problems. Organizational problems will be used for problems identified in the company (Saputra and Putra, 2020):

1. Information services: The provision of information that is still often left behind with other messages so that it is not conveyed properly and precisely
2. School management data: Mapping data flows is still manual and quite a problem if the data is not neat and still uses paper
3. Learning: A learning process that has not achieved the intended mission of the school, which is to combine mastery of science and technology in learning
4. Assets: Maintenance of assets that are still lacking and prone to miscalculation related to budget and assets
5. Reports: Manual submission of reports to the principal using paper or assisted by Microsoft Excel

Information System Architecture

The designed information systems architecture incorporates the application architecture and data architecture that will be utilized by the association. These two architectures will be described in data architecture entities and components and continued.

Data Architecture

Data architecture aims to have the capability to identify and provide solutions for the architectural needs of a set of data that supports business processes within an organization. Table 1, data architecture describes all data entities that will be generated, managed, and utilized by all parties in the business functions of the organization, ranging from information services, learning, data management, and inventory, to reports. This data is useful in organizing and interpreting business needs into a system that manages how data is processed within the high school organization.

Table 1: Data architecture entity

Business function	Data Entity
Information services	School information data, partner data, event data, activity data
Learning	Grade data, exam data, class schedule data, lesson data, student attendance data
Data management	New student data, student data, prospective student data, administration data, SPP data, teacher data, position data, registration data
Inventory	Room data, facility data, budget data, asset usage data, asset purchase data
Report	Report data, work evaluation data, service data

Table 2: Incoming application architecture

Application	Function
The school website	Provide information to the community regarding the school profile consisting of the school's vision and mission, academic and non-academic activities, academic and alumni services, school facilities and registration columns for prospective new students
Data management	To accommodate new student admission data, student data, student graduation data (alumni), academic and non-academic achievement data, administrative data, tuition data, teacher data and position data
Student learning	To be able to display student lesson schedules, school activity schedules, students' school grades and exams, upload student assignments, download school online materials, student attendance data
Inventory management	Assist the process of maintaining school equipment and facilities and procuring replacement of equipment damage that supports student learning
Report management	For the preparation of reports that will be directed to the principal transparently and in real-time and also as a performance evaluation for decision making

Table 3: McFarlan's strategic grid

| Strategic	High Potential
School website	Data management and report management
Key operational	Support
Student learning	Inventory management

Application Architecture

The application architecture is designed to identify the applications needed by the organization for data management and to facilitate their operational processes. This architecture is designed based on the data obtained from the previously established data architecture. The application architecture design starts by identifying candidate applications needed to manage data and support integrated business processes in each unit using database storage. Table 2, shows the results in the form of proposed applications derived from the research along with their explanations. These proposed applications consist of a school website, data management, learning management, inventory management, and report management.

Table 3, This section will also describe the results of portfolio analysis of proposed applications in application architecture using McFarlan strategic Grid:

1. Strategic, a system to support future business strategies. School websites are included in this quadrant because this system will assist high schools in promoting school, registration of new students,

expanding connections, and facilitating the provision of information to the wider community. In it there are also academic and alumni services that can help students and graduates in finding college scholarship needs, complaints in the learning process, and others

2. High potential, is a system used to achieve future organizational goals. School data management is included in this quadrant because this system helps high schools with admission data for prospective new students, student data and student graduation data for each school year, achievement of all students, administrative data, and teacher and position data. Report system is also in this quadrant because this system can assist teachers and principals in reporting and receiving school reports accurately and in real time for decision-making considerations

3. Key operational is a system used to maintain the company's main operations or processes. Student learning is included in this quadrant because this system helps schools provide materials and assignments to students through applications, provide assignment and exam scores to students through the system, student attendance data, information related to students' academic and nonacademic schedules, and grade data through the system

4. Support is a system used to improve business performance and management accuracy, but does not increase competitiveness advantages. Inventory management falls into this quadrant to assist schools in maintaining facilities and devices that can support learning systems (Pakusadewa *et al.*, 2021)
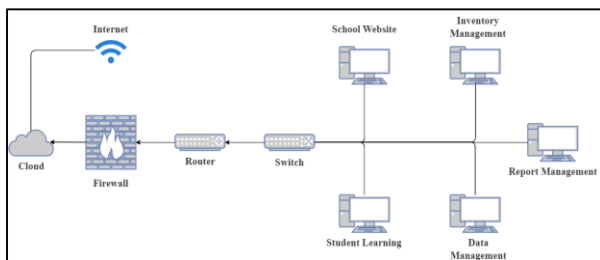
Fig. 2: Proposed network topology

Table 4: Hardware recommendation

Hardware recommendation	Description
LAN switch TP link gigabit 5 port TL-SG1005D	Serves as a receiver of information from various sources connected to it
Rj45 Cat 5e Belden AP700007	As a connector cable in the topology of computer networks, LANs and various other types of computer networks
Lan cable UTP Belden cat 6 50M	To support data communication and maintain a stable internet connection within the school

Technology Architecture

Planning and development of the desired technology architecture begins with the initial step of making a list of technology suggestions described in the application architecture phase to see the state of the network infrastructure that will be utilized in designing future design models.

Network Architecture

This phase will outline network architecture as a recommendation for high school. The technological architecture is drawn on the basis of the architecture of the information system.

Currently, the enterprise network architecture has only 2 computers connected to 1 switch. Computers in high school are used for a variety of government applications and data processing applications. The switch will connect to the router. Regarding Fig. 2, the network architecture proposal includes the introduction of three additional PCs for recommended applications, and one switch to facilitate communication with several other PCs. The aim is to prevent network downtime across all PCs due to high utilization by numerous users. Furthermore, the addition of a firewall is suggested as a precautionary measure against unwanted viruses.

Recommendation Hardware Equipment

Table 4, the result of the architecture technology recommendation requires a data storage area for each unit to store its data on its own computer. Each unit requires a system that is integrated with each other so that sending and receiving data can run in real-time and accurately. To accomplish the execution of the recommended technology there are a few recommended hardware to prepare. Schools likewise need a sufficient storage capacity for putting away school data and the network cables that organizations need to integrate their systems with one another so they can exchange data rapidly and in real-time.

Discussion

This stage designs the processes of moving from the old system to the new system that has been arranged and recommended. This phase encompasses the categorization and prioritization of data system application implementations, which are adjusted based on their level of necessity and the execution plan (Hadaya *et al.*, 2020).

Roadmap Application

There is a sequence of execution blueprints coming from research results as a functional point of view to decide the request for execution of information system applications (Chondamrongkul *et al.*, 2020):

1. Short-term, school websites to assist schools in promoting their schools with school activity content and school achievements to school facilities. As a forum to establish relationships with parents and students, as well as assist in the registration process of prospective new students
2. Medium-term, inventory management helps in the maintenance of school facilities that can support learning in which there are asset purchase data, asset usage report data, and budget data needed
3. Term, data management to help accommodate new student admission data, store student achievement data during learning, record student attendance during learning, assist students in learning such as subject information, school activity information, download and upload schoolwork, assignment information, and test scores and download school materials until there is also teacher data in it

Planning targets for the implementation of the proposed high school application and the time sequence for its implementation consists of:

1. System planning, this stage will determine the problem and determine the purpose of the system needed. This analysis will be carried out for approximately 1 month
2. System analysis, this stage will be done examination of existing systems and recommendations by recognizing issues and defining data needs. This analysis will be carried out for approximately 1 month along with the planning system
3. System design, this stage will be completed by making database modeling, process modeling, and interfaces which will be carried out for approximately 2 months
4. Implementation, this stage will make a system comprising of coding, testing, and update of revision for approximately 4 months (Rerung *et al.*, 2020)

Blueprint Information System Architecture

The ongoing and recommended business processes in the school will be described in each process in detail as follows.

Website Portal

Figure 3, the school portal website blueprint recommendation has been made in planning a system that can help schools in advancing their schools and assist prospective new students in enrolment. This website requires an admin to manage website content and answer academic and alumni complaints on academic and alumni services.

Data Management

Figure 4, a data management blueprint has been made in planning a system that can help administration and student representatives manage school and administrative data.

Student Learning

Figure 5, proposed recommendations for a student learning blueprint have been formulated to design a system that can assist student representatives and curriculum representatives in the effective management of contemporary learning systems, manage lesson schedules, and evaluate students in learning.

Inventory Data Asset

Figure 6, in the recommendation of the blueprint for asset data inventory, has been made to plan a system that can help administration and finance for asset management and the preparation of asset maintenance reports and budgets.

Report

Figure 7, a report application blueprint recommendation has been made in planning a framework that can help all units and headmasters to manage reports and really take a look at reports. Student learning applications, data management applications, and asset data inventory applications are integrated with report administration because they all affect reports.
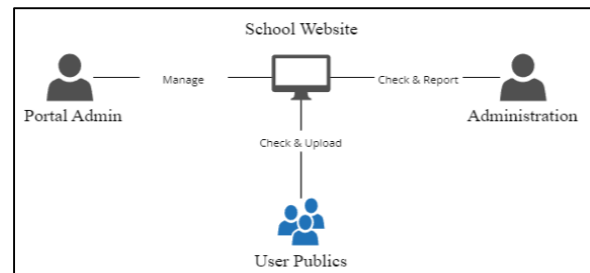

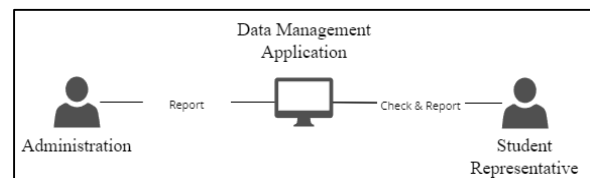**Fig. 3:** Blueprint school website recommendation

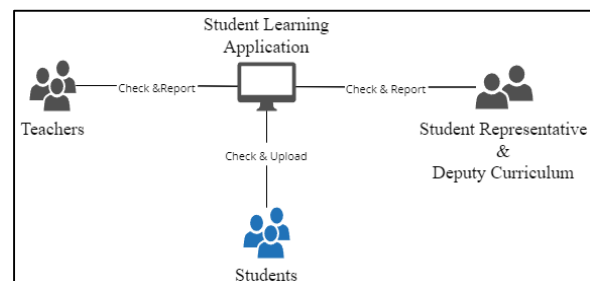**Fig. 4:** Blueprint data management recommendation

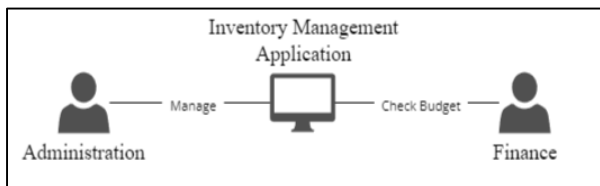**Fig. 5:** Blueprint student learning recommendation

Fig. 6: Blueprint inventory data asset recommendation
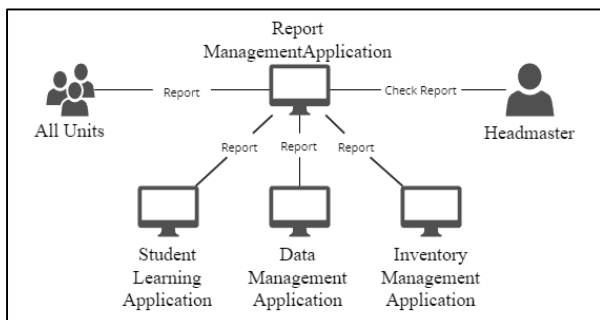

Fig. 7: Blueprint report recommendation

Conclusion

The research findings indicate that high schools have not implemented an information system in their organizational business processes. The organization acknowledges the importance of information systems in supporting integrity within business processes. This study highlights the necessity for an enterprise architecture design. Therefore, the researcher aimed to design enterprise architecture to enhance the performance of high school business processes in terms of both business process integrity and information systems. The information system design was conducted using the TOGAF ADM framework combined with the Ward Peppard method. Following the design process, we proposed five application designs, including school websites, data management, reporting systems, asset data inventory, and student learning. From these proposed applications, the researcher also analyzed strategic planning using McFarlan's strategy grid to map the proposed applications based on their contribution to the organization. The benefits of implementing this information system include integrated data, hybrid learning, facility maintenance through the system, and online registration for high schools. This enables organizations to review the application of enterprise architecture from current business processes to using integrated information systems to enhance organizational performance. The researcher also provides suggestions for the continuation of this information system design towards implementation and suggests that this research can be further developed to meet the future needs of high schools.

Author's Contributions

Jordan: Started the research concept, collected related literature sources, collected data, complained about the stages of research to be carried out, interpreted the results, and prepared manuscripts. Designed applications obtained from research results. It enables pattern identification, correlation, and predictive features.

Johanes Fernandes Andry: Formulate problems, interpret results using TOGAF ADM and Ward Peppard method for analysis identify the required application architecture, and determine the hardware specifications that need to be added to the technology-designed architecture.

Fransiskus Adikara: Identify application requirements needed by high schools that can support organizational business processes to address factors that affect business process challenges in high school.

Yemima Monica Geasela: Defined the research concept of why researchers designed information systems in high schools to integrate business processes with information technology, gather related literature resources, and interpret results.

Francka Sakti Lee: The process of designing and recommending from research results in high school, to integrate business processes with information technology, is there a correlation between them? Identify data entities in high school that are needed for information system compounding purposes.

Ethics

This article is original and unpublished. In this research, significant emphasis was placed on ethical considerations, especially considering the sensitivity of the topic related to the design of information systems in high schools. The data collected originated from interviews with the involved parties, was anonymized, and did not include any personally identifiable information.

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