Distributed Digital Enterprise Architecture for Transformation of Educational Organizations

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Abstract **– Enterprise architecture is of essential significance for organizations currently adapting to the digital transformation era. It is the application of modern digital technology in various organizational departments to drive efficiency. This research presents the development of a distributed digital enterprise architecture framework for education organizations that have applied the enterprise architecture concepts of The Open Group Architecture Framework, Zachman, and the Federal Enterprise Framework using an online questionnaire as a tool to collect data from 520 samples. The results revealed that the distributed digital enterprise architecture for education organizations is divided into seven dimensions: business architecture, data architecture, application architecture, technology architecture, security architecture, human capital architecture, and infrastructure architecture. The experts' evaluation of the architecture found that the overall appropriateness was at the highest level in all aspects. The research results indicate that enterprise architecture is essential for systematically integrating digital technology with an organization's workflow or mission for it to become a distributed digital enterprise.**

Keywords **– Digital transformation, distributed digital enterprise architecture, education organization, enterprise architecture.**

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1. Introduction

The rapid development of digital technology has become an essential mechanism for organizations to achieve digital transformation and sustainable development that enhances their flexibility to cope with constantly changing environments. Digital transformation involves adapting digital technology in an organization and formulating a digital strategy to adapt to the technology deployed [1]. Executives must implement digital strategies and tools to innovate, create new business models, and optimize customer needs and experiences. It also increases the efficiency and effectiveness of the organization's operation [2]. Digital transformation is a combination of innovation and digital technology, which leads to changes in the organization's structure, values, strategies, processes, culture, ecosystem, and environment, both internal and external to the organization, enabling organizations to cope with and adapt to the changing digital world [3]. Digital transformation is an effective process that promotes organizational management by integrating digital technology to support all operations [4] and connecting structural, strategic, and technological changes, highlighting the need to adjust both old and new organizations' operational systems. Combining new technology and digital transformation creates innovations focused on transforming organizational processes and solving existing and potential problems. It also creates a continuous interaction between organization members and digital technology that aligns with the organization's operation [5].

Digital transformation in education organizations with the implementation of enterprise architecture is a digital tool to help organizations achieve greater strategic agility and flexibility and improve organizational stability. An organization without enterprise architecture will result in the development of its operation system becoming redundant, its technology investment unsystematic, and the use of its budget unreasonable.

The organization may fail to make full use of systems it has developed, resulting in delays, and data security and reliability problems due to the failure to design the systems from the beginning [6]. Enterprise architecture can better understand the organization and reduce the cost risk and duplication of processes and technology. As various situations change, organizations can effectively adapt to the current environment and predict the future [7]. Digital transformation is also a blueprint that shows the relationships between all components and staff working within an organization to improve cooperation, collaboration, and coordination. It is also essential to demonstrate the alignment between information technology and organizational strategy [8]. Enterprise architecture defines the current state and future expectations of an organization's processes, capabilities, applications, data, and IT infrastructure. It is also the concept of organizing business processes and information technology infrastructure. It indicates the integration and standardization of the organization's operation model [9]. Enterprise architecture also serves as a blueprint that enables executives and relevant stakeholders to understand the overall business and various supporting factors such as business processes, data, infrastructure, and vision. Furthermore, it helps to systematize digital technology development, creates valuable investment, eliminates complexity, and minimizes digital technology threats and risks that may occur inside and outside the organization. It is also a tool to find effective methods of achieving the organization's current and future goals. Enterprise architecture enables new business innovations with emerging technologies [10]. The benefits of enterprise architecture can be divided into three perspectives: 1) the enterprise point of view, which enables executives and related stakeholders to understand the overall business. This makes effective connections between the operation process and digital technology. It establishes communication between those inside and outside the organization to achieve a common understanding, build relationships between departments and change management, and determine appropriate investment strategies in digital technology. 2) The business point of view, which improves operational efficiency and customer satisfaction, increases flexibility, generates strategic agility, increases operational transparency, provides a holistic view, makes more effective business decisions, reduces risk, and improves reliability. 3) The technology point of view, in which enterprise architecture reduces costs. It increases operational efficiency, reduces duplication, develops innovations that meet needs, and simplifies management [11].

Researchers recognize the importance of applying digital enterprise architecture for digital transformation. Therefore, this research examined distributed digital enterprise architecture for transforming education organizations, providing a conceptual framework for educational organizations and a guideline for application to improve operational efficiency in every dimension, being flexible and supporting seamless working, and adapting to changes in various situations.

2. Literature Review

The literature review discusses definitions and conceptualizations of several enterprise architectures, distributed enterprise, and digital transformation that will be used to develop a distributed digital enterprise architecture framework.

2.1. The Federal Enterprise Architecture Framework

The Federal Enterprise Architecture Framework (FEAF) was developed and published by the Federal Chief Information Officers (CIO) Council, United States, which has the goal of organizing, developing, and promoting processes and information sharing between government agencies and other agencies, including strategic management, business, and technology, as part of organizational design and performance improvement. It emphasizes the processes used in enterprise architecture development: identification and review, research and inquiry, definition and planning, investment and operations, and measurement [12]. The FEAF version two (V2) divides the consolidated reference model into six models. The performance reference model provides the organization's objectives, goals, and strategies, the relationship between organizational goals and other organizations, and tracking and measurement of organizational performance. The business reference model provides services shared within and outside the organization and business processes. The data reference model describes how to manage standardized data, exchange data within an enterprise, access data, and leverage information to support operations. The application reference model displays standards and technologies related to systems and applications and implements various applications according to business processes. The infrastructure reference model provides standards and technologies related to networks, cloud, and infrastructure used to support the facilitation of business management, applications, data, and security. The security reference model shows the control standards' design, protection system, risk management, security, and privacy in business operations and information technology.

2.2. The Zachman Framework

The Zachman framework is a conceptual framework that divides the details of enterprise architecture into various aspects suitable for individual needs. It also collects and organizes all the relevant parts of the organization into a system, such as organizational design, information system, database system, operation process, and workflow [13]. It is divided into two essential dimensions. The first dimension involves communication by answering six questions in respect of each item, (5W1H), which will help to gather, analyse, and discover the logical relationships. These are: data description (what), function or function description (how), network description (where), population description (who), time description (when), and motivation description (why). The second dimension is the perspective of the information user. This is a dimension that describes the perspective of those involved in enterprise architecture from six viewpoints: planner, owner, designer, builder, subcontractor, and enterprise [8].

2.3. The Open Group Architecture Framework

The Open Group Architecture Framework (TOGAF) is a standard framework that provides guidelines for designing, planning, controlling, and implementing enterprise architecture. It was developed and published by The Open Group, an international organization with more than 600 members from business, government, academic institutions, and various companies. The first version of TOGAF was released in 1995, based on the technical architecture framework of the US Department of Defence for data management. The TOGAF process has been developed based on experience and examples that can be improved for further use [14]. The Open Group has continually improved standards. TOGAF's architectural framework is unique because it puts business needs at the core of all design activities. It is an architectural framework that, if properly followed, can ensure that the digital systems created align with business goals [15]. The TOGAF framework provides guidelines and details for enterprise architecture development. It has an essential process for defining steps in enterprise architecture development, namely the Architecture Development Method (ADM). This TOGAF-ADM has the strengths of flexibility in using various components, connection and integration between layers, and adaptability to industry standards.

The steps of enterprise architecture creation consist of nine phases: preliminary, architecture vision, business architecture, information system architecture, technology architecture, opportunities and solutions, migration planning, implementation governance, and architecture change management [16].

2.4. Distributed Enterprise

Distributed enterprises are a characteristic of organizations in a global environment of technological progress, where organizations' geographical limitations are reducing. This involves working across geographical, political, and cultural boundaries. A successfully distributed organization must be able to deploy effective technology and dynamic governance mechanisms and clearly define its goals and objectives [17]. The growth of information and communications technology has led to a distributed organizational structure. In this structure, organizations adopt a hybrid method with three key components: 1) human resources are composed of remote and personnel teams in the central office; 2) all team members are in different places; and 3) the organization has offices or branches spread out in different regions. Distributed organizations differ from traditional organizational forms by adding remote workforces across cities, countries, and continents. In addition, such an organization or company also has a team within a central office that may work full-time or only part-time. Moreover, several remote offices or branches may be at different locations in each area [18].

The term distributed organization refers to a business model that prioritizes digital tools and remote working to provide a variety of experiences to customers and employees. Virtual services are critical to this model. Hybrid workplaces are easy to scale, and freelancers and special consultants can be hired. Distributed organizations rely on cloud services, high-speed WANs, and wireless and mobile telecommunications to connect headquarters with branches [19]. Furthermore, distributed organizations reflect a digital-first and remote business model to enhance the employee experience and create interactions between consumers and partners in a digital format by using digital technology as an intermediary. Therefore, it better responds to the needs of remote employees and consumers. Both groups have different requirements for virtual services and hybrid workplaces that allow them to connect and communicate quickly and conveniently [20].

Nowadays, remote and hybrid working models are increasing. Similarly, office-centred organizations from the past have also transformed into distributed enterprises that support more flexible working modes with employees and customers spread geographically, allowing employees to work from both the office and off-site.

This change requires IT leaders to adapt, expand, and develop technologies that support remote work and collaboration and provide services of seamless experience, such as new remote and on-site collaboration modes, security of remote data access, digital experience management, and IT operations' automation. However, such a working model may affect the business model; any organization needs to adjust its strategy and create new experiences to support a distributed working model [21]. Various digital technology and business data analytics tools enable distributed organizations to collect, store, and leverage data and information about relevant employees, customers, and stakeholders. Advanced tools and digital technology make decisions faster and more effective, improve operational efficiency, reduce costs related to collecting and analysing big data sets, share decision-making skills, and gain competitive advantage. These include digital platforms, blockchain technology, cloud computing, and machine learning technology. Adopting emerging technologies transforms organizational operations by improving connectivity, communications, restructuring, and services, creating organizational sustainability, and increasing efficiency [22].

2.5. Digital Transformation

Digital transformation is an organization's structural, strategic, and technological change to adapt to the digital age [23] by applying digital technology as a tool in every business process. It includes business models, customer experience, operations, internal workflow, strategic planning, employee participation, leaders' vision, innovation, and data analysis. Moreover, digital transformation also changes working practices, delivering value to customers, changing the working culture, innovating better ways of working, improving customer expectations, and creating new business opportunities [5]. Digital transformation is a process that integrates various digital technologies and involves changes in an organization's technology, culture, and operations. Organizations must transform themselves and their entire processes to take advantage of emerging technologies, which consist of three elements: customer experience, operation process, and business model [24]. Digital transformation usually brings new digital technologies such as social media, mobile devices, cloud technology, intelligent workflow, big data, data analytics, advanced data analytics, cloud computing, and the Internet of Things [25]. This results in organizations making decisions more quickly. The digital transformation brought about using technology will affect various dimensions of the organization.

Externally, the organization will focus on delivering digital experiences to customers. Internally, the change will affect the business operation, decision-making, and organizational structure. Holistically, all the departments and roles within the organization will be included and affected [26]. The digital transformation framework encompasses many theories, including discussion of McKinsey's principles, involving the following six elements: strategy and innovation, customer decision journey, process automation, organization, technology, and data and analytics [27].

Digital transformation in the public sector refers to new ways of working with stakeholders, designing a new service framework, and establishing new relationships [28]. Digital transformation in educational organizations and universities brings many benefits, such as cost savings from reduced administrative time, updated information, and improved communication, and relationships between personnel. Moreover, leveraging emerging technologies such as cloud computing, big data and learning analytics, artificial intelligence, and digital identity improves service and results in an excellent operation. Factors affecting the success of digital transformation in government organizations [29] include the executives' focus, as executives must set clear goals and strategic guidelines for digital transformation, including giving advice on solving problems, making decisions, and always following up on digital transformation. Personnel in the organization must participate in every process of implementing digital technology, understanding, and reflecting on problems in the implementation process so that enterprises can use information more effectively to analyse, improve, and develop digital technology.

3. Methodology

The methodology section describes the research methods and strategy. This research uses a mixed methodology to combine a quantitative online questionnaire survey and qualitative focus group discussions. The online questionnaire survey collects data on the opinions of factors influencing the transformation of education organizations. The focus groups conduct the suggestions and effectiveness of distributed digital enterprise architecture for education organizations.

3.1. Participants

The research population comprised executives and staff from the Office of the Basic Education Commission of the Ministry of Education, Thailand.

The sample was taken from 22 offices and included 1,102 participants. Based on the sample size criteria for using Comrey and Lee's factor analysis [30], 520 samples were obtained using cluster sampling, divided according to the organizational division structure, and then quota sampling was undertaken, divided according to the corresponding proportion and the appropriate data distribution.

3.2. Data Collection

The first stage in the development of a distributed digital enterprise architecture for an educational organization was the study, analysis, and synthesis of related documents and research, including digital enterprise architecture frameworks, technology for distributed organizations, and elements of distributed digital enterprise architecture published in international journals and databases. Then, a five-point Likert scale questionnaire was developed based on the factors influencing the transformation of education organizations by integrating the digital enterprise architecture framework, distributed enterprise technology, and digital enterprise architecture elements. The questionnaire quality was verified by nine experts using the Index of Item Objective Congruence. The score range was between 0.78 and 1.00. Furthermore, a 30-person pilot study was conducted to identify any discrimination using standard deviation, correlation, and reliability. The Cronbach alpha score was 0.991. Data was collected from 520 samples using the revised questionnaire. The data obtained from the online questionnaire was used to analyze the general data, standard deviation, and mean value. Then, the components, construct validity relationships among variables, and examination of the distribution of descriptive statistics were confirmed using confirmatory factor analysis (CFA).

The draft distributed digital enterprise architecture for education organizations applied the enterprise architecture development framework and concepts of TOGAF, Zachman, and Federal Enterprise frameworks, divided into business architecture, data architecture, application architecture, technology architecture, security architecture, human capital architecture, and infrastructure architecture. A focus group discussion and evaluation of the appropriateness of distributed digital enterprise architecture for education organizations was conducted in the second stage by brainstorming and summarizing the findings of nine experts, divided into the following groups: organizational development specialists as senior executives; information and communication technology specialists; and academic specialists.

4. Results

This section presents the results of the study. It is divided into three parts: a description of the distributed digital enterprise architecture elements, the examination of the distribution of descriptive statistics, and the distributed digital enterprise architecture framework.

4.1. The Synthesis of Distributed Digital Enterprise Architecture Elements

The information obtained from the digital enterprise architecture framework synthesis and the distributed organization technology synthesis from documents and research published in international journals and databases was synthesized into distributed digital enterprise architecture elements for educational organization consisting of seven dimensions, 28 elements, and descriptions, as shown in Table 1.

Table 1. The synthesis of distributed digital enterprise architecture elements

Dimensions	Elements	Descriptions	References
Business architecture	Consists of school and administration management system, innovation and educational technology development, educational management and promotion, and human resources development.	This is a business or operational process related to authority, duties, and mission and can be divided into three processes: management, core business, and support.	[10] [13] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48]
Data architecture	Consists of data stored by an internal database of each sector, Data stored in the central database, data stored as a document file, and data stored in electronic files.	Data architecture arises from operational processes that include the application of big data and the integration of data links within the organization to increase efficiency and support operational processes such as organization structure, personnel, plan/project, risk, research, and innovation.	[10] [13] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [43] [44] [45] [46] [47]
Dimensions	**Elements**	**Descriptions**	**References**
Application architecture	Consists of administrative management platform, knowledge management platform, school and academic services platform, and office management platform.	Application architecture consists of the operating system, platform, or program implemented within an organization that supports operations consistent with business processes, such as financial management, procurement management, supply and inventory management, office management, information and website management, data centre, and disaster recovery site.	[10] [31] [32] [33] [34] [36] [37] [38] [39] [40] [41] [43] [44] [45] [46] [47] [48] [49]
Technology architecture	Consists of operation technology, data processing and analytics technology, data storage and management technology, and educational management technology.	Technology architecture supports all aspects of the organization's operation, including business, application, information, human resources, infrastructure, and security, so that the organization can adapt and respond to changes in various situations and is not limited by place and time. This includes distributed technology, social media, network technology, mobile technology, big data, data governance, and API gateway.	[10] [13] [31] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42] [44] [45] [46] [47] [48] [49] [50]
Security architecture	Consists of information security law, information security policy, information security standards, information security requirements, and cybersecurity technology	Security architecture plays an operational support role in different fields due to the enormous amount of information generated from working groups, departments, or tasks in enterprises, hierarchy, and different access levels. Therefore, information risk management and security are critical, so it is necessary to adopt various appropriate digital tools and technologies as support mechanisms.	[13] [33] [34] [35] [38] [41] [42] [44] [45] [46] [47] [48]
Human Capital architecture	Consists of executive, policy and academic staff, technologist, and others	High-performance human resources architecture describes the management of digital personnel and digital competencies in an organization, such as digital literacy, digital leadership, digital transformation management, digital technology, digital process and service design, digital strategic and project management, and the Personal Data Protection Act (PDPA).	[33] [34] [35] [36] [38] [40] [41] [42] [44] [50]
Infrastructure architecture	Consists of hardware, software, network, server, client, and seamless working system	Infrastructure architecture supports organizational processes in various areas, including business, application, data, human capital, digital technology, and security such as operating systems, networks, Windows, Linux and Mac, LAN, VLAN, WAN, VPN, Wi-Fi, 5G, internet corporate, network operation centre, software-defined data centre.	[13] [33] [34] [35] [36] [37] [38] [39] [40] [42] [44] [45] [46] [48] [49] [50]

4.2. The Confirmatory Factor Analysis Statistics

The data obtained from an online questionnaire survey of 520 respondents underwent CFA, which found that the elements of the distributed digital enterprise architecture of education organizations include seven latent variables: business architecture, data architecture, application architecture, technology architecture, security architecture, human resource architecture, and infrastructure, with a total of 28 observable variables. The analysis found that the coefficient weight was between 0.64 and 0.87, with a value greater than 0.50, which meets the criteria for all observed variables [51].

There was a standard error (SE) between 0.04 and 0.08, R-squared (R2) between 41.0% and 75.0%, and average variance extraction (AVE) between 0.540 and 0.675, which was greater than 0.50, indicating that the measurement model had good convergent validity [52], [53]. Composite reliability (CR) is between 0.824 and 0.892, which was greater than 0.60, indicating that all observed and latent variables have high discriminant validity [51]. In addition, it can be concluded that all indicators of the CFA of digital enterprise architecture are consistent with the criteria, with significance at the 0.001 level, as shown in Table 2.

Table 2. The confirmatory factor analysis statistics

Digital Enterprise Architecture	**Path Coefficient**	**Std. Error**	**t-value**	**R^2**	**AVE**	**CR.**
Business Architecture					0.540	0.824
Educational management and promotion (parameter)	0.77	-	-	59.0%		
School and administration management system	0.64	0.05	15.966**	41.0%		
Innovation and educational technology development	0.73	0.06	15.722**	53.0%		
Human resources development	0.79	0.06	17.261**	63.0%		
Data Architecture					0.674	0.892
Data stored in the central database (parameter)	0.81	-	-	66.0%		
Data stored by an internal database of each sector	0.82	0.05	19.867**	68.0%		
Data stored in electronic files	0.81	0.05	20.232**	65.0%		
Data stored as a document file	0.84	0.05	18.774**	70.0%		
Application Architecture					0.591	0.852
Administrative management platform (parameter)	0.76	-	-	57.0%		
Smart office management platform	0.82	0.04	25.087**	67.0%		
School and academic services platform	0.77	0.06	17.951**	60.0%		
Knowledge management platform	0.73	0.06	16.947**	53.0%		
Digital Enterprise Architecture	**Path Coefficient**	**Std. Error**	**t-value**	**R^2**	**AVE**	**CR.**
Technology Architecture					0.606	0.860
Educational management technology (parameter)	0.81	-	-	66.0%		
Operation technology	0.73	0.05	15.984**	53.0%		
Data processing and analytics technology	0.78	0.05	18.036**	62.0%		
Data storage and management technology	0.79	0.06	15.440**	62.0%		
Security Architecture					0.675	0.892
Information security law (parameter)	0.75	-	-	56.0%		
Information security policy	0.82	0.05	20.645**	68.0%		
Information security standards	0.84	0.06	18.948**	71.0%		
Information security requirements	0.87	0.06	19.068**	75.0%		
Human Resources Architecture					0.648	0.880
Executive (parameter)	0.81	-	-	66.0%		
Policy and academic staff	0.82	0.05	21.690**	67.0%		
Technologist	0.82	0.06	18.886**	67.0%		
Others	0.77	0.06	17.135**	59.0%		
Infrastructure Architecture					0.563	0.837
Hardware (parameter)	0.68	-	-	47.0%		
Software	0.77	0.07	14.885**	60.0%		
Network and server	0.83	0.07	15.758**	69.0%		
Seamless working system	0.72	0.08	13.446**	52.0%		

** *Statistical significance ($p < 0.001$)*

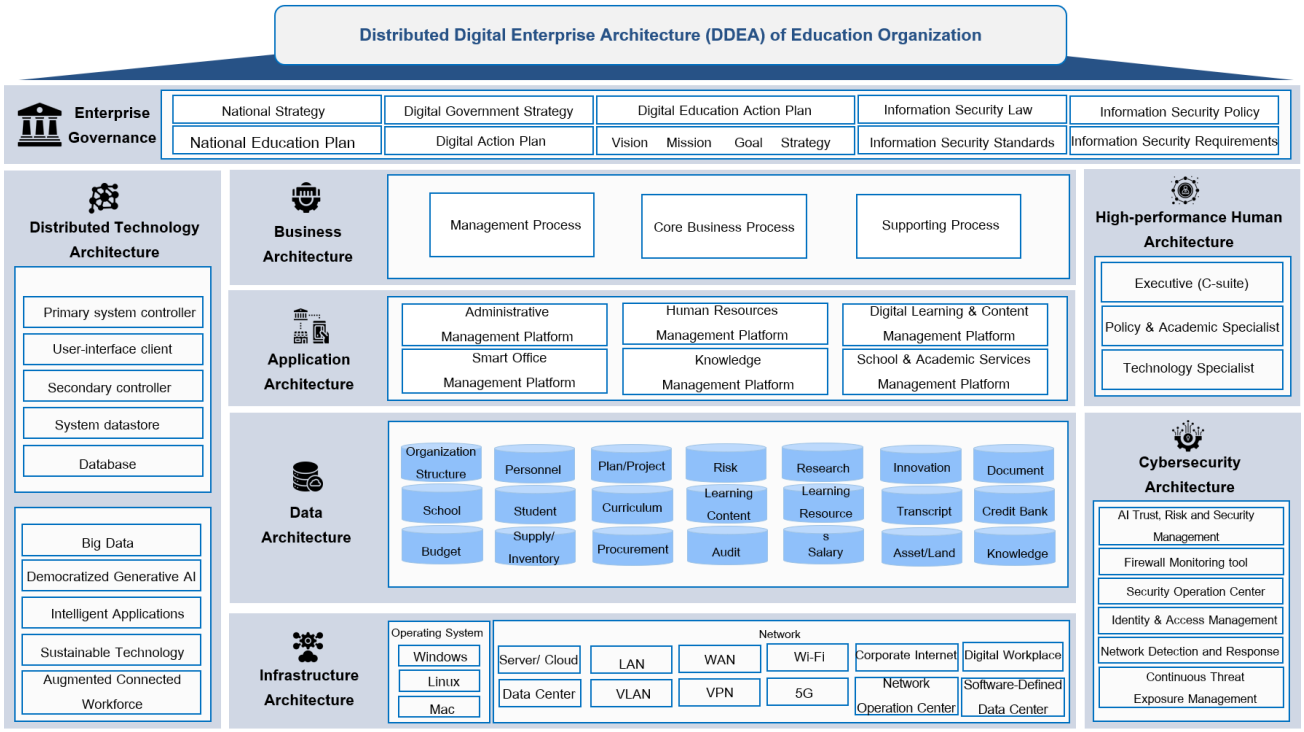

Figure 1. Distributed digital enterprise architecture for education organizations

4.3. The Development of Distributed Digital Enterprise Architecture for Education Organizations

Based on the CFA results, a distributed digital enterprise architecture for education organizations was developed. The architecture applied the concepts of TOGAF, Zachman, and Federal Enterprise Frameworks, divided into eight dimensions: enterprise governance, business architecture, data architecture, application architecture, technology

architecture, security architecture, human capital architecture, and infrastructure architecture. Next, a focus group discussion and brainstorm session were conducted, to provide suggestions and evaluate the appropriateness of the distributed digital enterprise architectures of education organizations. The overall results of the evaluation revealed the highest appropriateness score in every aspect (mean =4.93, S.D.=0.27). The details of the distributed digital enterprise architecture are shown in Fig. 1.

The distributed digital enterprise architecture for transformation of education organizations consists of eight main components:

4.3.1. Enterprise Governance

Enterprise governance is a framework of organizational good governance. It is an essential part of the distributed digital enterprise architecture for the transformation of education organizations.

Organizational governance is the responsibility and practice of executives to lead the organization to achieve its objectives and reach the organization's goals for its vision and strategy, whilst managing risks and using resources responsibly. It consists of three main aspects: 1) government policy, including national strategy, digital government strategy, national education plan, digital education action plan, and organizational digital action plan; 2) organization or executive policy, including vision, mission, goals, and strategies; and 3) regulatory compliance, including information security laws, policy, standards, and requirements.

4.3.2. Business Architecture

Business or process architecture is a business or operational process consistent with authority, duties, tasks, and missions. It is divided into three processes: 1) management processes, including developing and managing strategic plans, good governance, risk management, human resources development and management, and financial management; 2) core business processes, including core curriculum development, measurement and evaluation of learning outcomes, credit bank, distance learning management, and educational digital platform development; and 3) supporting processes, including guidance, assessment tools for learning, communication and public relations, international relations, legal, disciplinary and complaints, and research and development.

4.3.3. Application Architecture

The application, work systems, platforms, or programs architecture support operations in various areas consistent with business processes. This can be categorized into six main groups:

1) An administrative management platform, a system that provides information for administrative management and executives' effective decision-making, including an executive information system (EIS), decision support system (DSS), management information system (MIS), school management information system (School MIS), geographic information system (GIS), strategic information management system, and electronic budget reporting system.

2) A smart office management platform, a system that facilitates personnel and supports operational processes to access it efficiently, conveniently, quickly, and anytime and anywhere, including financial and accounting management, procurement management, supply and inventory management, electronic office, information management, data centre, and disaster recovery site.

3) A human resources management platform, a system that facilitates personnel management connected with a central database in the cloud to support work efficiency and rapid data management, including a human resources management system (HRMS), workforce database system, and complaint management system.

4) A knowledge management platform, a system that develops and collects various knowledge that is scattered throughout the organization and systematizes it in the form of documents with individuals, experiences, operational knowledge, best practices, and various workflows so that all those who need to use this information can quickly obtain it, apply it, and use it efficiently. It also provides convenience for learning anytime and anywhere, and it is open data that everyone can use freely, including big data for education, research database systems, and data catalogues.

5) A learning and content management platform, a system that supports learning, learning content, learning materials, content libraries, and learning resources, and provides high-quality, standardized, and accessible education for all, including a national digital learning platform (NDLP), an excellent digital education platform (DEEP), a content centre, distance learning television (DLTV), and distance learning information technology (DLIT).

6) A school and academic services platform, a system that promotes quality school management and various academic services for easy management and reduces the workload of preparing documents, including a school management system, an academic services system, and a student management system.

4.3.4. Data Architecture

The data architecture originates from the organization's work processes that include the application of big data and the integration of data links within the organization in all departments to increase efficiency and support work processes, including data on organizational structure, personnel, plans and projects, risk, research, innovation, documents, the school, students, curriculum, learning content, learning resources, transcripts, credit bank, budget, supply and inventory, procurement, auditing, salaries, assets and land, and buildings. It is divided according to the type of data used: 1) data stored in the central database; 2) data stored in an internal database of each sector; 3) data stored in electronic file formats; and 4) data stored as a document file.

4.3.5. Infrastructure Architecture

Infrastructure architecture supports organizational processes in various areas, including business, application, data, human resources, technology, and security. It comprises: 1) operating systems such as Windows, Linux, and Mac, software that controls the functions of computer systems within an organization and connects users with hardware so that computers and devices can work together efficiently; 2) network systems and digital ecosystems, which cover the entire organization with high-speed internet signals, support seamless working, and provide flexible and adaptable remote and hybrid working modes using LAN, VLAN, WAN, VPN, Wi-Fi, 5G, and corporate internet systems that are stable and fast. The network operation centre involves centralized control and maintaining computer network systems and related equipment throughout the organization, supporting the network system to be efficient and reliable and increasing the efficiency of the organization's performance. A software-defined data centre consists of network, storage and computing, control, management, and maintenance through management and automation systems. Working in a digital workplace format involves using digital tools, automated systems, and integration between applications in internal and external organizations, using cloud or social media and various organizational platforms, which supports working without restriction, no matter where users are.

4.3.6. Distributed Technology Architecture

The distributed technology architecture supports different functions of the organization, enabling it to adapt and respond to changes in various situations. It supports working without limitations in terms of location and time. It is divided into two groups: 1) the components of a distributed system include a primary system controller, a user-interface client, a secondary controller, a system datastore, and a database. The distributed system is open and extensible, convenient for long-distance and short-distance data sharing, and improves processing speed and reliability. 2) Technology supporting distributed systems include big data, democratized generative AI, intelligent applications, augmented connected workforce, and sustainable technology.

4.3.7. High-Performance Human Architecture

The high-performance human architecture explains the management of digital personnel in organizations and the development of digital skills of civil servants and personnel. It is divided into three groups: 1) executives (C-suite), consisting of chief executive officer (CEO), chief technology officer (CTO), chief financial officer (CFO), chief information officer (CIO), and chief digital officer (CDO); 2) policy and academic specialists; and 3) technology specialists.

4.3.8. Cybersecurity Architecture

The cybersecurity architecture plays a supporting role in various operations due to the data and information generated in the organization from operational processes, which is large scale, hierarchical, diverse, and involves different access levels. Therefore, information risk management and security are essential. It is necessary to use various appropriate digital tools and technologies as support mechanisms, including AI trust, risk and security management, firewall monitoring tools, security operation centres, identity and access management, network detection and response, and continuous threat exposure management.

5. Discussion

This study of distributed digital enterprise architecture for transforming education organizations has synthesized the framework and elements of a distributed digital enterprise architecture and developed and evaluated the architectures. The research results found that the elements of a distributed digital enterprise architecture for the transformation of education organizations are composed of seven dimensions: business architecture, data architecture, application architecture, technology architecture, security architecture, human resources architecture, and infrastructure architecture, according to the concepts of TOGAF, Zachman, and FEAF. The results of the experts' appropriateness evaluation found that the overview of distributed digital enterprise architecture of education organizations was at the highest level in all aspects. This is consistent with Afriliana *et al*. [54], whose study of the Intelligent Digital Enterprise Architecture Framework indicated that its elements consisted of digital governance, cybersecurity architecture, data architecture, application architecture, business architecture, technology architecture, and operation architecture. It is also consistent with the work of E. Gunawan and Sutedja [55], who designed information technology organizational architecture for banks, using the TOGAF elements to improve service quality and align between business and technology functions. Moreover, Tungpantong *et al*. [48] conducted a CFA to identify enterprise architecture elements for higher education institutions. They found that the elements included business architecture, data, applications, infrastructure, and security. The findings are helpful for higher education institutions to design blueprints for their institutional transformation to digital organizations.

Furthermore, Rujira *et al.* [44] studied the digital enterprise architecture framework for vocational education institutions. They found that the framework consisted of business, data, applications, infrastructure, security, and human resources architecture, and the appropriateness evaluation results were at a high level in all aspects. This could be a preliminary guide for digital transformation in vocational education institutions. It could also help to develop high-quality, convenient, and agile modern organizational management and processes for a high-performance digital organization. Niemi and Pekkola [56] stated that it is challenging to plan and drive the digital transformation of organizations to adapt to changing situations. Due to the complexity of organizations, enterprise architecture has been widely deployed to guide planning and governance, manage complexity and continuous change, and achieve goals. It is consistent with Shanks *et al*. [11], who indicated that the benefits of enterprise architecture can be divided into two perspectives. 1) The benefits of the project are better decision-making, improved project management efficiency and business capabilities, IT platforms and systems. 2) Organizational benefits are the long-term benefits that result from various changes, including agility and competitive advantage.

In addition, Berg *et al.* [57] researched how enterprise architecture can improve the quality of IT investment decision-making. They found that enterprise architecture is an essential tool to support an organization's IT investment decision-making because it provides insights that effectively support this.

6. Conclusion

This study examined, analyzed, synthesized, and verified the elements of a distributed digital enterprise architecture to develop a model for the transformation of education organizations. The research results found that the architecture elements consisted of seven dimensions: business architecture, data architecture, application architecture, technology architecture, security architecture, human resources architecture, and infrastructure architecture. Distributed digital enterprise architecture provides a framework and information for organizations to formulate strategies and operational plans. In addition, it includes the development of the organizational architecture of educational agencies themselves to cope with changes in digital technology and various environments.

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