The Development of Agile Enterprise Architecture for Digital Transformation in Higher Education Institutions

Sirinuch Sararuch[1], Panita Wannapiroon[1] & Prachyanan Nilsook[1]

[1] Division of Information and Communication Technology for Education, King Mongkut's University of Technology North Bangkok (KMUTNB), Bangkok, Thailand

Correspondence: Sirinuch Sararuch, Division of Information and Communication Technology for Education, King Mongkut's University of Technology North Bangkok (KMUTNB), Bangkok, Thailand. Tel: s66-819-960-565. E-mail: s6302052956065@kmutnb.ac.th

Abstract

The rapid evolution of digital technologies has led to significant transformations in various industries, including higher education. This study explores the role of Agile Enterprise Architecture (AEA) in supporting digital transformation initiatives within Higher Education Institutions (HEIs). AEA provides a flexible, adaptive, and iterative framework to manage the complex and dynamic nature of digital transformation. We conducted a qualitative study using a multiple case-study approach, investigating four HEIs that implemented AEA in their digital transformation initiatives. Data were collected through semi-structured interviews, document analysis, and participant observation. We employed thematic analysis to identify the key factors contributing to the successful implementation of AEA in these institutions. Our findings revealed that AEA plays a crucial role in facilitating digital transformation by providing a holistic, systematic, and adaptive framework. The AEA approach enables HEIs to effectively manage the complexities of digital transformation, enhance their agility, and respond to changing stakeholder needs. Key success factors include strong leadership, effective communication, a skilled workforce, and a culture of collaboration and continuous improvement. The study contributes to the understanding of AEA's role in promoting digital transformation in higher education and offers practical implications for HEIs looking to leverage digital technologies for improved performance and stakeholder satisfaction. Further research is needed to explore the generalizability of these findings to other contexts and industries.

Keywords: agile enterprise architecture, digital transformation

1. Introduction

The rapid globalization trends of the 21st century have compelled organizations, including educational institutions, to undergo significant shifts towards digital transformation. According to the OECD Digital Economy Outlook, digital transformation impacts economies and societies in intricate and interconnected ways, requiring sustainable strategic approaches (OECD, 2020). Organizations are increasingly embracing digital technologies such as cloud computing, big data, and artificial intelligence to maintain their relevance in an ever-evolving market (Omar, 2020).

Digital transformation has emerged as a crucial factor for the success of businesses and educational institutions alike, offering opportunities for enhanced efficiency, improved customer experience, and innovation (Mushtaha, 2022). Digital transformation is of significant importance for HEIs due to its ability to address the evolving demands and expectations of students in the digital era. Students now expect seamless digital experiences, personalized learning, and access to digital resources (Abad-Segura, 2020). By embracing digital transformation, institutions can enhance student engagement, improve learning outcomes, and boost overall satisfaction. Additionally, digital transformation offers the opportunity for institutions to streamline administrative processes, enhance operational efficiency, and achieve cost reductions. Through the implementation of digital systems, task automation, and leveraging data analytics (Nadkarni, 2021), institutions can optimize their operations, make informed decisions based on data insights, and allocate resources more efficiently than ever before (Benavides, 2020).

The COVID-19 pandemic and its associated financial and societal pressures have further heightened the urgency

for HEIs to define their strategic direction, and to drive substantive and sustainable operational changes to achieve financial stability and resilience (McKinsey, 2023). To effectively implement digital transformation in HEIs, a strategic and comprehensive approach is necessary, considering these institutions' unique needs and goals, as well as the challenges and possibilities presented by innovative technologies (Fernández, 2023). While several HEIs have already initiated digital transformation efforts, they face challenges due to the multidimensional nature of the digital transformation process (Rodrigues, 2017). Previous research in digital transformation in higher education has primarily focused on traditional Enterprise Architecture (EA) rather than Agile Enterprise Architecture (AEA) (Aston, 2016). However, as the need for agility in digital transformation becomes increasingly apparent, there is a growing interest in incorporating agile principles into EA practices (Sararuch, 2022). While research specifically into AEA in higher education is limited, there is recognition of its value in addressing emerging technologies and evolving user requirements (Hauder, 2014). AEA enables organizations to be more responsive to change and drive successful digital transformation initiatives.

The primary hypothesis of the study is that the development and implementation of AEA will positively impact the success of digital transformation initiatives in HEIs. It is crucial to synthesize the role and the model of AEA as a strategic framework to ensure the success of Digital Transformation in HEIs. By leveraging principles of agility, flexibility, and responsiveness, this framework seeks to provide valuable insights and recommendations. The goal is to equip HEIs with the necessary tools and strategies to navigate the digital transformation landscape successfully (Alamri, 2018).

The secondary hypothesis focuses on AEA enabling the effective alignment of digital strategies with organizational goals and stakeholder needs, facilitating collaboration among stakeholders, and improving efficiency and resource allocation in digital transformation projects. The study aims to provide insights into the benefits of AEA and its potential for enhancing digital transformation in HEIs.

The research design incorporates elements such as data collection methods, sample selection, data analysis techniques, and ethical considerations. These components are carefully designed to align with the research objectives and enable the testing of the hypotheses. By utilizing appropriate research design, the study aims to provide empirical evidence that Agile Enterprise Architecture plays a critical role in the success of Digital Transformation in Higher Education.

The research gap identified in this research paper pertains to the limited understanding of how the Agile Enterprise Architecture Framework (AEAF) can effectively guide Digital Transformation initiatives in sustainable HEIs. The main contribution of this research paper lies in addressing this gap by providing step-by-step guidelines for implementing AEA in HEIs to establish a sustainable framework.

2. Research Objectives

There are two research objectives:

1) To analyze and synthesize the role of AEA for digital transformation and challenges in HEIs.

2) To develop the AEAF for digital transformation in HEIs.

3. Literature Review

3.1 Agile Enterprise Architecture

AEA emphasizes the importance of iterative and adaptive development, collaboration, and responsiveness to change. It enables organizations to address emerging technologies, evolving user requirements, and dynamic market conditions quickly and effectively (Hauder, 2014). AEA is an approach to enterprise architecture that emphasizes flexibility, adaptability, and responsiveness to change (Ayaz, 2021).

AEA uses agile methods and principles to guide the development and evolution of enterprise architecture artifacts and activities, with a focus on delivering value quickly and continuously (Kotusev, 2020). In other words, AEA is a methodology for developing and managing enterprise architecture that is flexible and can quickly respond to changes in the business environment (Aston, 2016). It uses agile principles such as iterative development, continuous feedback, and collaboration to create enterprise architecture artifacts that deliver value to the organization in a timely and efficient manner (Kaddoumi, 2017).

AEA is a methodology for developing and managing enterprise architecture that is flexible, iterative, and focused on delivering value quickly and continuously. AEA has been found to provide a structured approach to digital transformation by aligning business and IT strategies, fostering collaboration among stakeholders, and promoting a culture of innovation and experimentation (Fuchs, 2018). AEA is a strategic approach that combines the flexibility of Agile Methodology with the comprehensive framework of Enterprise Architecture to drive

successful digital transformation in HEIs. The goal of AEA is to create a more adaptable and responsive enterprise architecture that can better support the business requirements of the organization.

AEA is critical for HEIs as it addresses challenges such as resistance to change, limited resources, and the dynamic nature of digital transformation. By leveraging AEA, institutions can effectively manage and align technology, processes, and organizational structures to support strategic objectives and capitalize on growth opportunities. In this way it can create a more responsive and adaptive environment, enabling such institutions to keep pace with the rapidly evolving technology landscape (Gomes, 2020).

AEA also fosters a more responsive and adaptive environment for HEIs, enabling them to keep pace with the rapidly changing technology landscape and to enhance their educational offerings (Sararuch, 2022). This approach allows HEIs to manage and align technology, processes, and organizational structures efficiently in such a way as to support their strategic objectives, address challenges such as resistance to change, and capitalize on growth opportunities to maintain their competitiveness.

The application of AEA in digital transformation initiatives in higher education brings several benefits. It promotes a more flexible and adaptive approach to change, allowing institutions to respond quickly to emerging technologies and evolving student needs (Sandkuhl, 2017). Agile EA fosters collaboration and communication among different stakeholders, facilitating a holistic and integrated approach to digital transformation. It also enables institutions to identify and address potential risks and challenges early on, improving the overall success rate of digital transformation initiatives.

3.2 Digital Transformation in Higher Education

Digital Transformation is a process that integrates digital technology with business strategy in all its aspects, and facilitates change in the areas of technology, culture, and operations, business processes, and human resources to create new business models and encourage innovation for the business to stay competitive in the market.

The implication of Digital Transformation is the result of advanced technologies to response and the disruption in customer demand. It requires organizations to reinvent themselves and transform all their processes with the support of digital technology in such a way as to respond to changing markets in an appropriate timescale. For this reason, Digital Transformation requires a change of focus which involves technological innovation and the modification of the institutional culture in such a way as to guarantee the evolution of Digital Transformation (Abad-Segura, 2020). The implementation of digital transformation in HEIs presents numerous challenges that have been studied extensively in the recent literature.

Key challenges include investing in sustainable infrastructure, fostering digital literacy among stakeholders, addressing resistance to change, integrating digital technologies with legacy systems, ensuring data privacy and security, and meeting the evolving needs of students (Aljanazrah, 2022). Institutions must meet these challenges by adopting a flexible, agile approach (Mahlow, 2019). This involves leveraging collaborative learning methods, applying data-driven insights, and fostering a culture of continuous improvement.

By cultivating a forward-thinking mindset, HEIs can better adapt to the rapidly changing educational landscape and embrace sustainable digital transformation strategies (Mohamed, 2022). The lack of a clear digital strategy poses a major challenge for HEIs undergoing digital transformation, leading to fragmented initiatives that may not align with the institution's broader goals and priorities (Mushtaha, 2022).

Balancing the adoption of emerging technologies with the maintenance of existing systems and infrastructure poses a critical challenge in the context of digital transformation (Rodrigues, 2017). HEIs face challenges related to privacy, security, digital skills gaps among faculty and staff, and ensuring equitable access to digital resources for all students.

The success of digital transformation in HEIs depends on effective leadership, stakeholder engagement, and a culture of innovation and experimentation that prioritizes student learning outcomes and institutional goals (Rodríguez, 2021). It is also crucial to ensure the success of digital transformation by having a clear strategy aligned with the institution's goals. Additionally, literacy and skills development for students and faculty are key factors in this process. HEIs should prioritize digital infrastructure investment, embrace emerging technologies such as artificial intelligence and blockchain, and ensure the sustainability and inclusivity of digital transformation efforts (Nadkarni, 2021).

Furthermore, effective regulatory frameworks balancing innovation with consumer protection and ethical considerations should be developed (Katyeudo, 2022). Overall, in terms of addressing the various challenges encountered, the success of digital transformation in HEIs depends on comprehensive strategies, strong leadership, and a supportive organizational culture (Fleaca, 2022).

4. Method

4.1 Phase of Analyzing and Synthesizing the Role of Agile Enterprise Architecture for Digital Transformation and Challenges in Higher Education Institutions

Figure 1 illustrates a comprehensive systematic review conducted on a total of 38 articles, purposefully chosen from a pool of 300 research articles obtained from international research databases published between 2014 and 2023. Additionally, 11 experts were interviewed using purposive sampling techniques, employing a discussion guide that consisted of open-ended questions.

The study employed purposive sampling to select participants who met specific criteria, including substantial experience in higher education and executive management roles, as well as involvement in digital transformation and enterprise architecture initiatives. The variables of interest took the form of Digital Transformation in HEIs, the challenges faced by such institutions, Agile Methodology, and Enterprise Architecture. The data collected from the systematic review and in-depth interviews were synthesized and analyzed using content analysis to gain insights and perspectives on the role of AEA for Digital Transformation in HEIs.

4.2 Phase of Developing an Agile Enterprise Architecture Framework (AEAF) Model for Digital Transformation in Higher Education Institutions

In the second phase, as shown in Figure 2, the decision-making process is influenced by the knowledge and understanding gained from the insights obtained in the first phase. The development of the AEAF model will employ Delphi Research Methodology conducted in three rounds (Skinner, 2015). The first round consists of content analysis of the model framework from the literature review, followed by in-depth interviews with 21 purposive experts from the 1st phrase using open-ended questions. Delphi research involves obtaining expert opinions or forecasts through a series of questionnaires. In each questionnaire round, the experts' responses are summarized, and a feedback report is sent to the experts to allow them to reflect on and revise their initial responses.
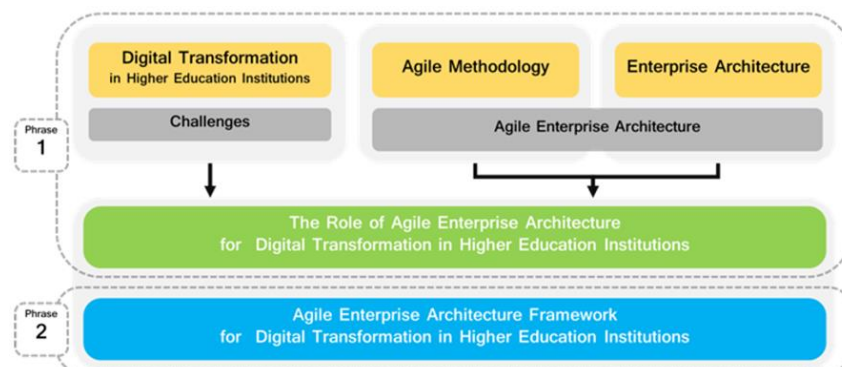

Figure 1. The research conceptual framework

The process continues until a consensus or agreement is reached among the experts. The second round is to provide a summary of the synthesis of the AEAF model with the AEAF from the content analysis and the result from in-depth interviews with the 21 experts. The objective of this round is to achieve a level of agreement on the part of the experts. The third round is to summarize the results of the second round using the Median and Interquartile Range (IQR), present them to the experts, and ask for their confirmation. The data analytics tools for representing the input from the experts are Median and Interquartile Range. The median is a statistical measure of central tendency used to represent the middle value of a dataset when arranged in ascending or descending order (Latif, 2017). If there are an odd number of observations in the dataset, the median is the middle observation, while for an even number of observations, the median is the average of the two middle observations.

The sample size for this study is 21 experts, and the formula for the median for a dataset with odd number of observations is $(n + 1) / 2$, where n is the number of samples (Latif, 2017). In Delphi research, the IQR is used to gauge the level of agreement or consensus among experts. It is preferred over other measures of variability as it is not influenced by outliers and helps identify significant disagreement or dispersion in the experts' responses. Refer to (1), the IQR provides a dependable measure for monitoring the level of agreement or consensus among experts. The IQR is calculated as the range between the 25th and 75th percentiles of the dataset (Latif, 2017), where Q1 is the 25th percentile and Q3 is the 75th percentile of the dataset.

$$IQR = Q3 - Q1 \tag{1}$$

Table 1. The Criteria of Interquartile Range

IQR	Descriptions
0.01 – 0.99	The result has the highest degree of consistency
1.00 – 1.99	The result has a high degree of consistency
2.00 – 2.99	The result has a low degree of consistency
3.00 onwards	The result has the lowest degree of consistency

From Table 1, an Interquartile Range (IQR) value of 0.01 to 3 indicates the spread or dispersion of a dataset. In this case, the range from 0.01 to 3 suggests that the middle 50% of the data falls within this interval (Latif, 2017).

The IQR is used to assess the level of consistency or agreement among the results. A range of 0.01 to 0.99 indicates the highest degree of consistency, while a range of 1.00 to 1.99 indicates a high degree of consistency. A range of 2.00 to 2.99 indicates a low degree of consistency, and a range of 3.00 and onwards indicates the lowest degree of consistency among the results. A smaller IQR, such as 0.01 to 3, indicates a relatively narrow spread of values. This suggests that most of the data points are concentrated within a small range, indicating a limited amount of variability or dispersion. It implies that the data points are relatively close together, and do not deviate significantly from the central tendency (Habibi, 2015).

5. Results

5.1 The Results of Analyzing and Synthesizing the Role of Agile Enterprise Architecture for Digital Transformation and Challenges in Higher Education Institutions.

5.1.1 The Role of AEA for Digital Transformation

Figure 2 illustrates the role of AEA in facilitating digital transformation within HEIs. AEA enables strategic alignment, fosters collaboration and communication, promotes flexibility and adaptability, drives innovation and continuous improvement, reduces complexity, enhances scalability, supports informed decision-making and risk management, ensures interoperability and integration, and facilitates the adoption of an agile framework for effective digital transformation in HEIs (Erwin; Aston, 2016; Sararuch, 2022).
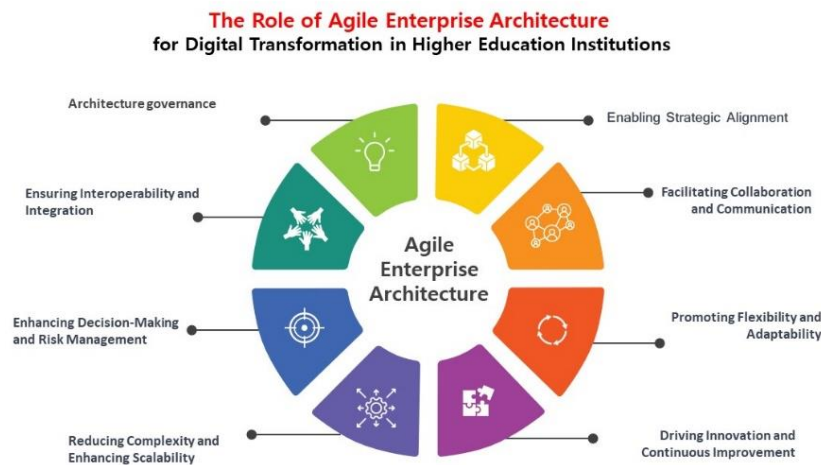

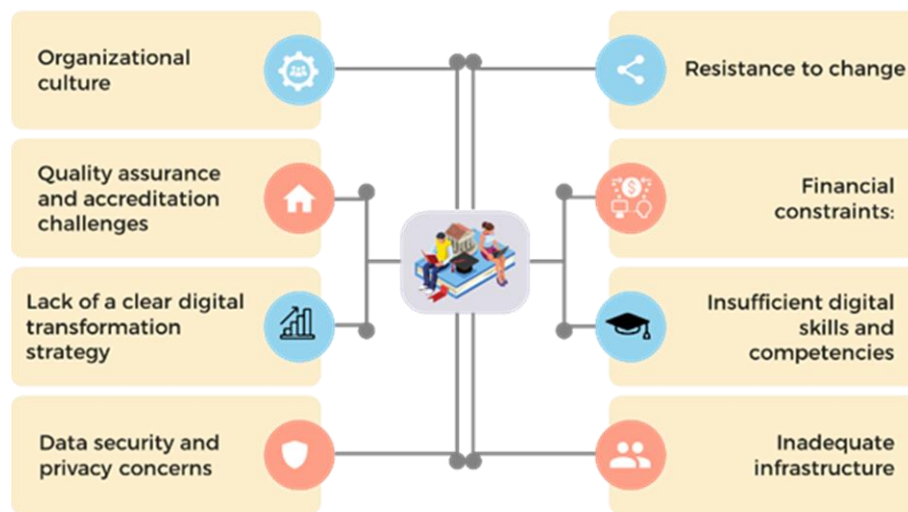Figure 2. The role of agile enterprise architecture for digital transformation in higher education institutions

Figure 3. The challenges of Digital Transformation in Higher Education Institutions

5.1.2 The Challenges of Digital Transformation in Higher Education Institutions

The challenges of digital transformation in HEIs, as illustrated in Figure 3 from the literature review, are as follows.

1) Resistance to Change: A lack of willingness to embrace change among stakeholders, including educators, administrative personnel, and students, often becomes a hindrance to the adoption of new digital technologies (Aljanazrah, 2022; Rodrigues, 2017).

2) Financial Constraints: Implementing digital technologies usually necessitates significant monetary investments in infrastructure, software, and training programs (Tungpantong, 2021; Aljanazrah, 2022; Fleaca, 2022).

3) Insufficient Digital Literacy and Skills: The successful implementation of digital transformation relies heavily on stakeholders' ability to develop the necessary digital skills (Brown, 2020; Tungpantong, 2021).

4) Infrastructure Shortcomings: Some institutions may lack the essential infrastructure, such as high-speed internet access and appropriate hardware, to enable digital transformation (Demartini, 2020; OECD ILibrary, 2019).

5) Data Security and Privacy Concerns: Increased reliance on digital technologies escalates the risk of data breaches, privacy violations, and cybersecurity issues (Tungpantong, 2021).

6) Absence of a Comprehensive Digital Transformation Strategy: Institutions often grapple with creating a comprehensive and integrated strategy for digital transformation, leading to disjointed efforts and suboptimal outcomes (Tungpantong, 2021).

7) Quality Assurance and Accreditation Challenges: Upholding the quality of digital education and maintaining accreditation standards can pose complex and resource-intensive challenges (Demartini, 2020; Shaughnessy, 2018; Volungevičienė, 2021).

8) Organizational Culture: Digital transformation necessitates a significant shift in organizational culture, promoting new modes of thinking, learning, and collaboration (Hanelt, 2021; Michael, 2017; Reis, 2018).

5.1.3 The Agile Enterprise Architecture Framework (AEAF) for Digital Transformation in Higher Education Institutions

The result of the literature review on the process of AEAF (Agile Enterprise Architecture Framework) for Digital Transformation in HEIs is as follows. The AEAF entails a multi-stage process that includes envisioning, planning, design, development, delivery, implementation, governance, and management, as illustrated in Figure 4.

1) The Envision stage includes key components such as mission, vision, and core values directed towards digital

transformation policy, specific characteristics of digital transformation, goals and objectives, external factor analysis, stakeholder requirements, and an examination of the existing enterprise architecture (Fuchs, 2018; Kuzu, 2020; The Open Agile Architecture, 2020; Tungpantong, 2021).

2) The Planning stage involves the creation of a digital transformation plan rooted in Agile principles and the formulation of an implementation plan for Agile EA (Gill 2015; Hauder, 2014; Sararuch, 2022; The Open Agile Architecture, 2020; Tungpantong, 2021).

3) The Design stage involves crafting the future state of Agile EA, including elements of business, information system, data, technology, and security architecture (Fuchs 2018; Kotusev 2020; Mansor. 2018; Sararuch, 2022).

4) In the Develop stage, a roadmap for digital transformation is generated alongside an Agile EA implementation framework (The Open Agile Architecture, 2020; Sararuch, 2022; Sulaiman and Mansor, 2018).

5) The Deliver stage includes the application of Agile principles for project implementation, the development of training programs, management tools, test and refine programs, and the implementation of Agile EA migration (Erwin; Aston, 2016; Sararuch, 2022).

6) The Implementation stage involves the governance of Agile EA, generation of reports for performance tracking, and the development of a robust communication plan (The Open Agile Architecture, 2020; Kotusev, 2021; Sararuch, 2022).

7) The Governance stage oversees the agile implementation and management of goals and strategies, and change management in the HEIs (Sararuch, 2022; Sulaiman & Mansor, 2018; The Open Agile Architecture, 2020).

8) Lastly, the Management stage ensures the effective governance of Agile implementation, the management of goals and strategies, and change management (Aston, 2016; Fuchs, 2018; Hauder, 2014; Sararuch, 2022; Sulaiman and Mansor, 2018; Tungpantong, 2021).
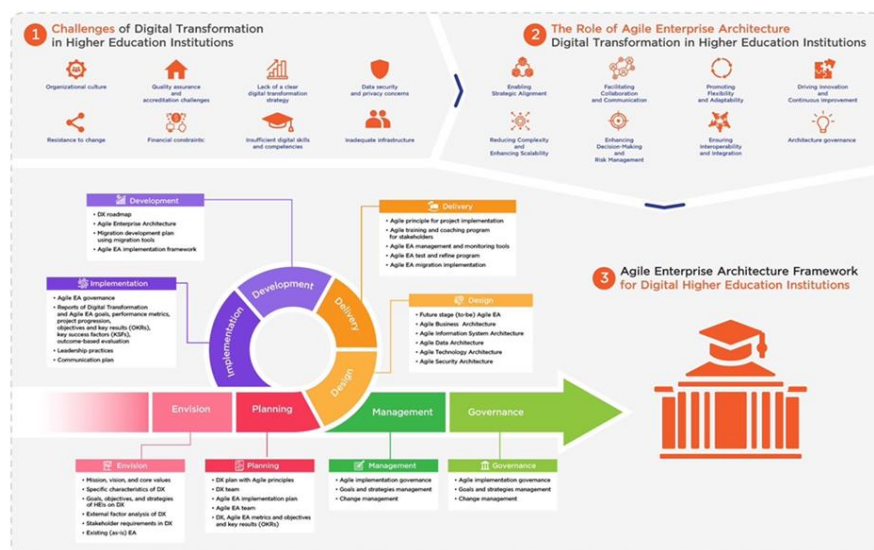

Figure 4. The Agile Enterprise Architecture Framework (AEAF) for Digital Transformation in HEIs

The AEAF provides a comprehensive guide for navigating digital transformation within HEIs, utilizing Agile principles for flexible and effective implementation as illustrated in Figure 4.

5.1.4 The Results of the Assessment of the Consistency of Agile Enterprise Architecture Framework on the Envision and Planning Stages

Table 2. The results of the assessment of the consistency of Agile Enterprise Architecture Framework on the Envision and Planning stages

Agile Enterprise Architecture Framework for Digital Transformation in HEIs	The results of data analytics			
	Median	IQR	Level of agreement	Level of consistency
Envision stage				
Mission, vision, and core values, towards Digital Transformation Policy of HEIs	5	1.00	Strongly agree	Consistent
Specific characteristics of Digital Transformation	5	1.00	Strongly agree	Consistent
Goals, objectives, and strategies of HEIs on Digital Transformation	5	0.00	Strongly agree	Very consistent
External Factor Analysis of Digital Transformation	5	1.00	Strongly agree	Consistent
Stakeholder requirement in Digital Transformation	5	1.00	Strongly agree	Consistent
Existing (as-is) Enterprise Architecture for HEIs.	4	1.00	Agree	Consistent
Planning stage				
Digital Transformation Plan with Agile Principles	5	1.00	Strongly agree	Consistent
Digital Transformation team for HEIs	5	1.00	Strongly agree	Consistent
Agile Enterprise Architecture Implementation Plan	5	1.00	Strongly agree	Consistent
Agile Enterprise Architecture team for SHEIs	5	1.00	Strongly agree	Consistent
Digital Transformation, Agile EA metrics for HEIs and objectives and key results (OKRs)	5	0.50	Strongly agree	Very consistent
Digital Transformation Plan with Agile Principles	5	1.00	Strongly agree	Consistent

As demonstrated in Table 2, during the Envision stage of the AEAF for Digital Transformation in HEIs, the foundations for the digital transformation journey are established. This phase includes defining the mission, vision, and core values specific to the Digital Transformation Policy of the HEI, setting goals and strategies, considering external factors, incorporating stakeholder requirements, and conducting a comprehensive assessment of the existing enterprise architecture. In Table 2, data reveals a strong consensus and consistency on the part of the experts, as most components received outstanding scores, indicating a high level of agreement as to their effectiveness. The only exception is the Existing (as-is) Enterprise Architecture for HEIs, which obtained a slightly lower median score of 4, but remained within an acceptable range. This demonstrates a solid consensus regarding its overall effectiveness.

The Planning stage of the Agile Enterprise Architecture Framework for Digital Transformation in HEIs involves creating a Digital Transformation Plan with Agile principles, forming a dedicated team, and preparing an Agile Enterprise Architecture Implementation Plan specifically for HEIs. It also focuses on establishing performance metrics, objectives, and Key Results (OKRs) to measure the success of digital transformation and Agile Enterprise Architecture in HEIs. The data analytics results in Table 2 indicate a strong consensus among the experts, with most components of the framework receiving a median score of 5. There is also a narrow IQR of 1.00, indicating high agreement and consistency. Notably, the aspect of Digital Transformation metrics and OKRs showed even stronger agreement among the experts.

5.1.5 The Results of the Assessment of the Consistency of Agile Enterprise Architecture Framework on the Design and Delivery Stages

Table 3. The results of the assessment of the consistency of Agile Enterprise Architecture Framework on the Design and Delivery stages

Agile Enterprise Architecture Framework for Digital Transformation in HEIs	The results of data analytics			
	Median	IQR	Level of agreement	Level of consistency
Design stage				
Future Stage (To-Be) Agile EA for HEIs.	5	1.00	Strongly agree	Consistent
Agile Business (capability and process)Architecture	5	1.00	Strongly agree	Consistent
Agile Information System Architecture of HEIs	5	1.00	Strongly agree	Consistent
Agile Data Architecture of HEIs	5	1.00	Strongly agree	Consistent
Agile Technology Architecture of HEIs	5	1.00	Strongly agree	Consistent
Agile Security Architecture of HEIs	5	1.00	Strongly agree	Consistent
Delivery stage				
Agile Principles of HEIs on Delivery Process	5	1.00	Strongly agree	Consistent
Agile Digital Skill Development and Capability	5	0.50	Strongly agree	Very consistent
Agile Business Process for HEIs	4	1.00	Agree	Consistent
Stakeholders in Agile Enterprise Architecture	5	1.00	Strongly agree	Consistent

In Table 3, the Design stage of the AEAF for Digital Transformation in HEIs involves developing the future state of Agile Enterprise Architecture for such institutions. This includes designing Agile Business Architecture, Agile Information System Architecture, Agile Data Architecture, Agile Technology Architecture, and Agile Security Architecture specifically tailored to HEIs. The comprehensive design approach ensures the integration of all aspects of enterprise architecture, enabling agility and supporting effective digital transformation in HEIs. The data analytics results from Table 3 demonstrate a strong consensus and consistency among the experts regarding the components of the AEA Framework for the Design stage. All components received a median score of 5 with an IQR range of 1.00, indicating a high level of agreement among experts. These findings highlight the effectiveness of the AEAF in guiding the design of Digital Transformation initiatives in HEIs.

From Table 3, the Delivery stage of the AEAF for Digital Transformation in HEIs centers on the integration of Agile principles in the HEIs' delivery processes, Agile digital skill advancement, and institution-specific Agile business processes. This stage also acknowledges the crucial involvement of stakeholders in Agile Enterprise Architecture. The data analytics results indicate a strong consensus among the experts regarding the components of the framework during the Delivery stage, as reflected by a median score of 5. This indicates that the overall results underscore the effectiveness and agreeability of the Delivery stage. Notably, the Agile Digital Skill Development and Capability of HEIs stood out, with an interquartile range (IQR) of 0.50, indicating highly consistent agreement.

5.1.6 The Results of the Assessment of the Consistency of Agile Enterprise Architecture Framework on the Development and Implementation Stages

Table 4. The results of the assessment of the consistency of Agile Enterprise Architecture Framework on the Development and Implementation stages

Agile Enterprise Architecture Framework for Digital Transformation in HEIs	The results of data analytics			
	Median	IQR	Level of agreement	Level of consistency
Development stage				
Digital Transformation Roadmap for the HEIs	5	1.00	Strongly agree	Consistent
Agile Enterprise Architecture for HEIs	5	1.00	Strongly agree	Consistent
Migration Development plan using migration tools	4	1.00	Agree	Consistent
Agile EA Implementation framework for HEIs	5	1.00	Strongly agree	Consistent
Implementation stage				
Agile principle for project implementation of HEIs	5	1.00	Strongly agree	Consistent
Agile Training and coaching Program for stakeholders of HEIs	5	1.00	Strongly agree	Consistent
Agile EA Management and monitoring tools	5	0.00	Strongly agree	Very consistent
Agile EA Test and Refine program of HEIs	5	1.00	Strongly agree	Consistent
Agile EA Migration implementation of HEIs	5	1.00	Strongly agree	Consistent

In Table 4, the Development stage of AEAF for sustainable HEIs consists of a digital transformation roadmap, Agile Enterprise Architecture, a migration development plan using migration tools, and an Agile EA implementation framework. The data analytics results indicate a high level of agreement and consistency among experts for each stage, with median scores of 5 and a narrow IQR of 1.00. This demonstrates a strong consensus on the effectiveness and consistency of the framework components, highlighting their suitability for facilitating digital transformation in HEIs.

From Table 4, the Implementation stage of the AEAF for sustainable HEIs consists of several components. These include the application of Agile principles for project implementation, the implementation of Agile training and coaching programs for stakeholders, the use of Agile EA management and monitoring tools, the implementation of Agile EA test and refine programs, and the execution of Agile EA migration. The data analytics results show a strong consensus and consistency among experts, with high median scores of 5 and a very narrow IQR between 0.00 and 1.00. This indicates a unanimous agreement on the effectiveness and consistency of these components in terms of driving successful AEA implementation in HEIs.

5.1.7 The Results of the Assessment of the Consistency of Agile Enterprise Architecture Framework on the Governance and Management Stages

Table 5. The results of the assessment of the consistency of Agile Enterprise Architecture Framework on the Governance and Management stages

Agile Enterprise Architecture Framework for Digital Transformation in HEIs	The results of data analytics			
	Median	IQR	Level of agreement	Level of consistency
Governance stage				
Agile Enterprise Architecture Governance	5	1.00	Strongly agree	Consistent
Reports of Sustainability Goals, Performance Metrics, Project Progression, Objectives and Key Results (OKRs), Key Success Factor (KSFs), Outcome-Based Evaluation	5	1.00	Strongly agree	Consistent
Leadership Practices in Sustainability	5	1.00	Strongly agree	Consistent
Communication Plan across HEIs	5	1.00	Strongly agree	Consistent
Management stage				
Agile Implementation Governance	5	1.00	Strongly agree	Consistent
Goals and Strategies Management	5	1.00	Strongly agree	Consistent
Change Management of HEIs	5	1.00	Strongly agree	Consistent

From Table 5, the data analytics results regarding the Governance stage of the AEAF for Digital Transformation in HEIs indicate a significant level of expert agreement and consistency. All elements under scrutiny — Agile Enterprise Architecture Governance, Reports of Sustainability Goals, Performance Metrics, Project Progression, Objectives and OKRs, Key Success Factor (KSFs), Outcome-Based Evaluation, Leadership Practices in Sustainability, and Communication Plan across HEIs — earned a median score of 5 and an IQR of 1.00. These results indicate strong agreement and consistency among experts, which further solidifies the effectiveness and acceptance of this framework in guiding the governance of digital transformation initiatives in HEIs.

In Table 5, the Management stage of the AEAF for Digital Transformation in HEIs received strong validation through the data analytics from Table 5. The experts showed strong agreement and consistency in their ratings across all three components of this stage. The Agile Implementation Governance, which is crucial for overseeing and steering the digital transformation process, received a median score of 5 with an IQR of 1.00, indicating strong agreement and high consistency among the experts. Similarly, Goals and Strategies Management, vital for aligning transformation efforts with institutional objectives, also received a median score of 5 with an IQR of 1.00. Lastly, Change Management of HEIs, essential for managing the transition and adaptation to new digital systems and processes, received the same high score of agreement and consistency level.

Based on the findings derived from the data analytics conducted across Table 2 to Table 5, the results indicate a high level of agreement among experts, with an IQR ranging from 0.00 to 1.00. This signifies a strong consensus among the experts regarding the effectiveness of the AEAF in guiding Digital Transformation initiatives in sustainable Higher Education Institutions (HEIs).

The step-by-step guideline for applying AEAF for sustainable HEIs can indeed encompass multiple stages. These stages typically involve various activities and tasks aimed at achieving sustainable digital transformation in such institutions.

1) The Envision stage: This stage includes defining the mission, vision, and core values specific to the Digital Transformation Policy of HEIs. It also involves setting clear goals, objectives, and strategies, analyzing external factors that impact the transformation, incorporating stakeholder requirements, and conducting a comprehensive assessment of the existing enterprise architecture.

2) The Planning stage: This stage includes creating a Digital Transformation Plan with Agile principles, forming dedicated teams for digital transformation and AEA, and developing an AEA Implementation Plan specific to HEIs.

3) The Design stage: This stage includes developing the Future Stage (To-Be) Agile EA for HEIs, Agile Business Architecture, Agile Information System Architecture, Agile Data Architecture, Agile Technology Architecture, and Agile Security Architecture of HEIs.

4) The Delivery stage: This stage involves implementing Agile principles of HEIs regarding the delivery process, Agile digital skill development and capability, and the involvement of stakeholders in Agile Enterprise

Architecture, and Agile Business Process for HEIs.

5) The Development stage: This stage includes developing a digital transformation roadmap for HEIs, an Agile Enterprise Architecture for HEIs, a migration development plan using migration tools, and an Agile EA implementation framework for HEIs.

6) The Implementation stage: This stage includes applying Agile principles for project implementation, implementing Agile training and coaching programs for stakeholders, utilizing Agile EA management and monitoring tools, executing Agile EA test and refine programs, and conducting Agile EA migration.

7) The Governance stage: This stage includes developing AEA governance, the generation of reports on sustainability goals, performance metrics, project progression, objectives, OKRs, KSFs, and outcome-based evaluation. Additionally, it involves the implementation of leadership practices focused on sustainability and the development of a communication plan throughout the HEIs.

8) The Management stage: This stage includes applying Agile implementation governance, effective management of goals and strategies, and efficient change management within HEIs.

6. Discussion

The research objectives of this study were to analyze and synthesize the role of AEA for Digital Transformation in HEIs, and to develop a model of the AEAF for Digital Transformation in HEIs. The study findings indicated that the implementation of digital transformation in HEIs faces several challenges, including limited financial resources, resistance to change, insufficient digital skills, data security concerns, and the necessity for organizational culture shifts. These obstacles align with the research conducted by Fleaca (2022). To address these difficulties, the research investigated the influence of the AEAF on the success of Digital Transformation in HEIs. The study asserted that adopting and developing AEAF would result in positive outcomes, which aligns with previous research conducted by Fuchs (2018).

The strategic capacity of AEAF to align digital strategies with organizational goals, facilitate stakeholder collaboration, and enhance resource allocation efficiency, formed the study's ancillary hypotheses. These hypotheses were tested using a robust research design encapsulating specific data collection and analysis methods, sample selection, and ethical considerations. The study findings confirmed the initial hypothesis and provided convincing evidence of the significant contribution of the AEAF to successful digital transformation in HEIs (Ayaz, 2021). The research demonstrated high scores in terms of Agile Implementation governance, goals and strategies management, and change management, supporting secondary hypotheses and highlighting AEA's role in achieving strategic alignment, collaboration, and resource management efficiency during HEI digital transformations. The study underlines the importance of AEA as a strategic framework for digital transformation in higher education, providing a foundation for future research in different contexts to enhance generalizability and applicability.

7. Conclusion

In conclusion, this research has addressed the research gap concerning the limited understanding of how the AEAF can effectively guide Digital Transformation initiatives in sustainable HEIs. The findings of this research contribute to expanding the knowledge and understanding of how AEA can support and drive Digital Transformation in sustainable HEIs. The research findings were achieved by employing a mixed research methodology that combined a comprehensive literature review with the collection of valuable insights from selected universities and experts in the field. The main contribution of this study has been the provision of a comprehensive step-by-step guideline for implementing AEA in HEIs in such a way as to establish a sustainable framework. The findings of the research, indicating a high level of agreement among experts regarding the effectiveness of AEA in driving Digital Transformation in sustainable HEIs, significantly contribute to the field of HEI management and digital transformation. The practical insights and recommendations offered in this paper serve as valuable resources for leveraging AEA in such a way as to achieve sustainable outcomes in HEIs. The research underscores the potential of AEA as a strategic tool in digital transformation within higher education, laying a foundation for future studies and providing actionable insights for institutions seeking to navigate the success of digital transformation.

Acknowledgments

References

Abad-Segura, Emilio, Mariana Daniela González-Zamar, Juan C. Infante-Moro, & Germán Ruipérez García. (2020). Sustainable Management of Digital Transformation in Higher Education: Global Research Trends. *Sustainability, 12*(5), 1-24. https://doi.org/10.3390/su12052107

Agile Enterprise Architecture in Higher Education | Erwin. (2023). Retrieved from https://bookshelf.erwin.com/agile-enterprise-architecture-in-higher-education

Alamri, Samar, Manal Abdullah, & Adnan Albar. (2018). Enterprise Architecture Adoption for Higher Education Institutions. *International Journal of Simulation: Systems, Science and Technology, 19*(5), 16.1-16.8.

Aljanazrah, Ahmad, George Yerousis, Ghadeer Hamed, & Zuheir N. Khlaif. (2022). Digital Transformation in Times of Crisis: Challenges, Attitudes, Opportunities and Lessons Learned from Students' and Faculty Members' Perspectives. *Frontiers in Education, 7*, 828. https://doi.org/10.3389/feduc.2022.1047035

Aston, Dan. (2016). *Digital Transformation & Agile Enterprise Architecture*. Corso Blog.

Benavides, Lina María Castro et al. (2020). Digital Transformation in Higher Education Institutions: A Systematic Literature Review. *Sensors, 20*(11), 3291. https://doi.org/10.3390/s20113291

Demartini, Claudio G, Lorenzo Benussi, Valentina Gatteschi, & Flavio Renga. (2020). *Education and Digital Transformation: The 'Riconnessioni' Project.* https://doi.org/10.1109/ACCESS.2020.3018189

Fernández, Antonio, Beatriz Gómez, Kleona Binjaku, & Elinda Kajo Meçe. (2023). Digital Transformation Initiatives in Higher Education Institutions: A Multivocal Literature Review. *Education and Information Technologies*, 1-32. https://doi.org/10.1007/s10639-022-11544-0

Fleaca, Bogdan, Elena Fleaca, & Sanda Maiduc. (2022). Digital Transformation and Current Challenges of Higher Education. *TEM Journal, 11*(3), 1235-41. https://doi.org/10.18421/TEM113-32

Fuchs, Christoph. (2018). Becoming Agile in the Digital Transformation: The Process of a Large-Scale Agile Transformation. *Proceedings of the 39th International Conference on Information Systems (ICIS 2018) At: San Francisco, USA*. Retrieved from https://www.researchgate.net/publication/330353717_Becoming_Agile_in_the_Digital_Transformation_The_Process_of_a_Large-Scale_Agile_Transformation

Gill, Asif Qumer. (2015). Agile Enterprise Architecture Modelling: Evaluating the Applicability and Integration of Six Modelling Standards. *Information and Software Technology, 67*, 196-206. https://doi.org/10.1016/j.infsof.2015.07.002

Gomes, Rui, Antonio Miguel Rosado Da Cruz, & Estrela Ferreira Cruz. (2020). *EA in the Digital Transformation of Higher Education Institutions.* Iberian Conference on Information Systems and Technologies, CISTI 2020-June. https://doi.org/10.23919/CISTI49556.2020.9141086

Habibi, Arash, Azam Sarafrazi, & Sedigheh Izadyar. (2015). Delphi Technique Theoretical Framework in Qualitative Research. *The International Journal of Engineering and Science (IJES).* Retrieved from www.theijes.com

Hanelt, André, René Bohnsack, David Marz, & Cláudia Antunes Marante. (2021). A Systematic Review of the Literature on Digital Transformation: Insights and Implications for Strategy and Organizational Change. *Journal of Management Studies, 58*(5), 1159-97. https://doi.org/10.1111/joms.12639

Hauder, Matheus, Sascha Roth, Christopher Schulz, & Florian Matthes. (2014). *Agile Enterprise Architecture Management: An Analysis on the Application of Agile Principles*.

Kaddoumi, Tarek, & Mohamed Watfa. (2017). *A Proposed Agile Enterprise Architecture Framework*. 2016 6th International Conference on Innovative Computing Technology, INTECH. pp. 52-57. https://doi.org/10.1109/INTECH.2016.7845126

Katyeudo, Katyeudo K., & Ricardo A.C. de Souza. (2022). Digital Transformation towards Education 4.0. *Informatics in Education, 21*(2), 283-309. https://doi.org/10.15388/infedu.2022.13

Kotusev, Svyatoslav. (2020). What Is Agile Enterprise Architecture? *The British Computer Society*. Retrieved from https://www.researchgate.net/publication/342882846_What_Is_Agile_Enterprise_Architecture

Latif, Rusnani Ab et al. (2017). The Delphi Technique as a Method to Obtain Consensus in Health Care Education Research. *Education in Medicine Journal, 9*(3), 89-102. https://doi.org/10.21315/eimj2017.9.3.10

Mahlow, Cerstin, & Andreas Hediger. (2019). Digital Transformation in Higher Education—Buzzword or Opportunity? *eLearn, 2019*(5). https://doi.org/10.1145/3329488/3331171

Managing Inclusive Digital Transformation, Lessons from 100 Countries. (2023). *Development Co-Operation Report 2021: Shaping a Just Digital Transformation, OECD ILibrary.* Retrieved from https://www.oecd-ilibrary.org/sites/aee58e91-en/index.html?itemId=/content/component/aee58e91-en

Mansor, Zulkefli Bin, Mohd Abdul, Halim Sulaiman, & Zulkefli Mansor. (2018). Critical Success Factors in Agile Enterprise Architecture: A Conceptual Paper Using Green Data Modelling of Quarry Environment for STEM Education to Enhance Open Data Readiness View Project Management View Project Critical Success Factors in Agile Enterprise Architecture: A Conceptual Paper. *Article in Journal of Computational and Theoretical Nanoscience, 24*, 467-70. https://doi.org/10.1166/asl.2018.11706

McKinsey Global Institute. (February 2023).

Michael, Von Kutzschenbach, & Carl Brønn. (2017). *Education for Managing Digital Transformation: A Feedback Systems Approach.* In ICSIT 2017 - 8th International Conference on Society and Information Technologies, Proceedings, International Institute of Informatics and Systemics, IIIS. pp. 187-92.

Mohamed Hashim, Mohamed Ashmel, Issam Tlemsani, & Robin Matthews. (2022). Higher Education Strategy in Digital Transformation. *Education and Information Technologies, 27*(3), 3171-95. https://doi.org/10.1007/s10639-022-10924-w

Mushtaha, Emad et al. (2022). The Challenges and Opportunities of Online Learning and Teaching at Engineering and Theoretical Colleges during the Pandemic. *Ain Shams Engineering Journal, 13*(6), 101770. https://doi.org/10.1016/j.asej.2022.101770

Nadkarni, S., & Prügl, R. (2021). Digital Transformation: A Review, Synthesis and Opportunities for Future Research. *Management Review Quarterly, 71*, 233-341. https://doi.org/10.1007/s11301-020-00185-7

OECD Digital Economy Outlook 2020. (2020). *OECD Digital Economy Outlook 2020.*

Omar, Abdulfattah, & Ahmed Almaghthawi. (2020). Towards an Integrated Model of Data Governance and Integration for the Implementation of Digital Transformation Processes in the Saudi Universities. *International Journal of Advanced Computer Science and Applications, 11*(8), 588-93. https://doi.org/10.14569/IJACSA.2020.0110873

Reis, João, Marlene Amorim, Nuno Melão, & Patrícia Matos. (2018). Digital Transformation: A Literature Review and Guidelines for Future Research. *Advances in Intelligent Systems and Computing, 745*, 411-21. https://doi.org/10.1007/978-3-319-77703-0_41

Rodrigues, Luis Silva. (2017). *Challenges of Digital Transformation in Higher Education Institutions: A Brief Discussion.* Retrieved from https://www.researchgate.net/publication/330601808_Challenges_of_Digital_Transformation_in_Higher_Education_Institutions_A_brief_discussion

Rodríguez-Abitia, Guillermo, & Graciela Bribiesca-Correa. (2021). Assessing Digital Transformation in Universities. *Future Internet, 13*(2), 52. https://doi.org/10.3390/fi13020052

Saleem Ayaz, Muhammad, Zaeem, & Shaukat Masteroppgave. (2021). *USE OF AGILE METHODOLOGIES IN DIGITAL TRANSFORMATION BARRIERS.* Retrieved from https://brage.inn.no/inn-xmlui/handle/11250/2989328

Sandkuhl, K., & Holger Lehmann. (2017). *Digital Transformation in Higher Education - The Role of Enterprise Architectures and Portals.* undefined.

Sararuch, Sirinuch, Panita Wannapiroon, & Prachyanun Nilsook. (2022). Dimensions of Agile Enterprise Architecture. *Proceedings - 2022 Research, Invention, and Innovation Congress: Innovative Electricals and Electronics, RI2C 2022*, 304-9. https://doi.org/10.1109/RI2C56397.2022.9910275

Shaughnessy, Haydn. (2018). Creating Digital Transformation: Strategies and Steps. *Strategy and Leadership, 46*(2), 19-25. https://doi.org/10.1108/SL-12-2017-0126

Skinner, Richard, R. Ryan Nelson, Wynne W. Chin, & Lesley Land. (2015). The Delphi Method Research Strategy in Studies of Information Systems. *Communications of the Association for Information Systems, 37*, 31-63. https://doi.org/10.17705/1CAIS.03702

The Open Agile Architecture™ Standard. (2023). Retrieved from https://publications.opengroup.org/c208

Tungpantong, Chanin, Prachyanun Nilsook, & Panita Wannapiroon. (2021). A Conceptual Framework of Factors for Information Systems Success to Digital Transformation in Higher Education Institutions. *2021 9th International Conference on Information and Education Technology, ICIET 2021*, 57-62. https://doi.org/10.1109/ICIET51873.2021.9419596

van de Wetering, Rogier, Sherah Kurnia, & Svyatoslav Kotusev. (2021). The Role of Enterprise Architecture for Digital Transformations. *Sustainability, 13*(4), 2237. https://doi.org/10.3390/su13042237

Volungevičienė, Airina et al. (2021). *DEVELOPING A HIGH-PERFORMANCE DIGITAL EDUCATION ECOSYSTEM INSTITUTIONAL SELF-ASSESSMENT INSTRUMENTS.* Retrieved from www.eua.eu

Copyrights