Enterprise Architecture in Higher Education: Processes, Principles, Challenges, Success Factors and Agility

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Abstract

There has been growing interest in the use of Enterprise Architecture (EA) in the public sector, including in higher education (HE) institutions. Many HE institutions have adopted EA to help align their vision, objectives, and needs with their IT strategy and objectives, to support decision-making and to improve business processes. They have used specific tools, models and EA frameworks to simplify the adoption and development of EA.

The main goal of this research is to answer the following question: *How is EA being used in HE institutions and what lessons can be learned that will help improve EA in HE?*

To achieve our goal, we first conducted literature reviews (Chapter 2 and Chapter 3). These showed that there is a lack of studies of this topic, with gaps in knowledge about the longer-term evolution of EA implementation, tools and frameworks used, challenges and success factors of EA adoption, and the adoption of the agile EA. Then we followed an exploratory sequential mixed method process. We first used grounded analysis by conducting interviews with 21 higher education enterprise architects (HEEAs) in 6 countries. We analyzed the interviews and identified the main themes and categories. From these, we developed a survey and received responses from 115 HEEAs in 29 countries.

Our key contributions are to present a descriptive analysis of EA in HE institutions and to provide a set of recommendations and lessons learned based on our findings.

Some observations were these: Key motivations and objectives for HEEAs are to facilitate the alignment of projects with the university's goals, to align business and IT sectors, to reduce duplication, and to enable digital transformation and automation. HEEAs do the vast majority of their modelling using generic tools like spreadsheets, with ease of use, cost-effectiveness, and collaboration being the most-needed tool attributes. Keeping models up to date and the lack of automatic population of data are key tool challenges. TOGAF is the dominant framework, but Gartner and CAUDIT approaches also have significant influence. Critical challenges include resistance to change and finding ways to support the university's mission and goals. A key practice to follow is enterprise thinking. Most respondents indicated that their EA process was moderately agile.

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List of Acronyms

Acronym	Definition
ADP	Architecture Development Process
ADM	Architecture Development Method
AEA	Agile Enterprise Architecture
AEAF	Agile Enterprise Architecture Framework
BA	Business Architecture
BIA	Business and IT Alignment
BUSITAME	Business IT Alignment Modeling and Evaluation
CAUDIT	Council of Australasian University of Directors of Information Technology
CC	Cloud Computing
CHE2A	Colombian Higher Education Enterprise Architecture
CIO	Chief Information Officer
CSF	Critical Success Factor
DGS	Deanship of Graduate Studies
EA	Enterprise Architecture
EAAM	Enterprise Architecture Adoption Method
EAF	Enterprise Architecture Framework
EAI	Enterprise Application Integration
EISA	Enterprise Information Security Architecture framework
EAM	Enterprise Architecture Management
EAP	Enterprise Architecture Planning
EBA	Enterprise Business Architecture
EEA	Education Enterprise Architecture
EISA	Enterprise Information Security Architecture
ERPS	Enterprise Resource Planning Systems
FEA	Federal Enterprise Architecture
GT	Ground Theory
HE	Higher Education
HEEA	Higher Education Enterprise Architect
HEI	Higher Education Institution
HORA	Hoger Onderwijs Referentie Architectuur
IA	Information Architecture
IAM	Identity and Access Management
ICT	Information and Communication Technology
IS	Information System
IT	Information Technology
JISC	Joint Information Systems Committee
KPI	Key Process Indicator
LEAP	Lightweight domain-specific modeling language for EA
NORA	National Overall Reference Architecture
RA	Reference Architecture
RATL	Reference Architecture for Teaching and Learning
REAP	Resistance in Enterprise Architecture Adoption Process
RF	Reference Framework

Acronym	**Definition**
RM	Reference Model
SA	Systems Architecture
SAFe	Scaled Agile Framework
SLR	Systematic Literature Review
TA	Technology Architecture
TIER	Trust and Identity in Education and Research reference framework
TOGAF	The Open Group Architecture Framework
TRM	Technical Reference Model
UML	Unified Modeling Language
UNITA	University IT Architecture
ZFW	Zachman Framework

Chapter 1 Introduction

There has been an increased interest by academics and practitioners in Enterprise Architecture (EA) in recent years, especially in the use of EA in the public sector, including higher education (HE). The research published in this field has explored some issues related to EA such as the benefits of using EA in the public sector, the challenges organizations face in adopting EA, and the problems that EA can help solve. In this thesis we analyse the state of EA in HE through grounded theory and a survey. We uncover the state of the art, including motivations, principles and lessons learned that can help guide EA practitioners in this domain.

1.1 The Higher Education Context

The context of this thesis is Higher Education Institutions (HEIs), which have shown increasing interest in using EA during the past few years. This is evident in the number of HEIs that have implemented EA, some of whom have documented their EA journeys (Liimatainen, Hoffmann, Heikkilä, 2007; Experiences of EA, 2014). Also, several EA pilot studies have been performed to illustrate how EA can be implemented in HEIs (Anderson & Backhouse, 2008; Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009; Oderinde, 2012; CSC, 2011).

An institution of higher education (HEI) has been defined by the Canadian Information Centre for International Credentials (CICIC, 2011) as an institution that "grants its own degrees and normally undertakes the creation and extension of knowledge through research and scholarly activity, and the dissemination of knowledge through teaching, publication, and presentation." The CICIC (2011) confirms that an HE includes three levels: an undergraduate level that leads to a bachelor's degree, a graduate level that leads to master's degree or diploma or certificate program, and a third level that enables students to obtain a doctorate (Ph.D.). There are three core activities of HEIs: learning, teaching, and research. HEIs are large and decentralized organizations which are influenced by different internal and external factors (Oderinde, 2010). HEIs work with varying demands from students, staff, regulators, and industry partners but have limited resources and facilities to deal with these needs (Oderinde, 2010). HEIs face multiple issues that require using EA, such as duplicated functionality, complex infrastructure, as well as siloed data and applications (Oderinde, 2010).

The amount of published research about the adoption of EA in the HEI context is low as indicated by Oderinde (2012). However, the systematic literature review we present in Chapter 3 shows that the number of studies in this era has increased, especially in the last five years.

EA has been noted to be a valuable tool for addressing many issues faced by HEIs. It is used to improve HEIs' key processes by standardizing or integrating them, managing complex infrastructure, supporting decision-making, and providing a holistic view for all stakeholders of HEIs (Oderinde, 2010). One of the most important drivers that have made HEIs adopt EA is legislation ratified by various governments that makes EA mandatory in public organization including HEIs. Other reasons that have led HEIs to use EA include difficulty integrating their systems, misalignment of their business with their IT strategy, and the need to improve their business processes (Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009; Oderinde, 2010; Carrillo, Cabrera, Román, Abad & Jaramillo, 2010; Syynimaa, 2015b; Amalia & Supriadi, 2017).

1.2 Basic Concepts of Enterprise Architecture

EA was first introduced in 1987 by Zachman in the IBM Systems Journal as "A Framework for Information Systems Architecture," which set out both the challenge and the vision of EA (Zachman, 1987). It has evolved since that time to include other aspects in addition to information systems; it focuses not only on IT but also on business.

EA has multiple definitions from different points of view as presented by The Open Group (2002) and Gartner (2017). However, in general, EA consists of two fundamental elements: Enterprise and Architecture. An enterprise, in the context of EA, is defined as, "a whole or part of an organisation that has a common goal" (TOGAF, 2009). Architecture is defined as "a set of design artifacts, or descriptive representations, that are relevant for describing an object such that it can be produced to requirements (quality) as well as maintained over the period of its useful life" (Zachman, 1997).

Syynimaa (2015a) studied several different definitions and came up with a unified definition that, “Enterprise Architecture is; (i) a formal description of the current and future state(s) of an organisation, and (ii) a managed change between these states to meet organisation’s stakeholders’ goals and to create value to the organisation.” Hence, EA is about description and change management. Thus, the purpose of EA is to meet the goals of stakeholders and create values for their organization (Syynimaa, 2010b).

EA can be defined using different methods or tools to describe the enterprise using the four-layer models: Business Architecture (BA), Information Architecture (IA), Systems Architecture (SA), and Technology Architecture (TA) (Syynimaa, 2010b). It includes not only the technical structures and processes of the enterprise, but also the business structures and processes (Ambler, 2009, 2015).

Institutions of higher education, like any other public organizations, seek to achieve a set of goals such as competitiveness, growth, and stability. Therefore, EA is an appropriate tool to help accomplish these goals. It also helps add or create value for organizations via concepts such as agility, strategic planning, efficiency, and innovation (Syynimaa, 2010b).

However, some recent studies have shown that traditional EA is not preferred by some stakeholders because they think it is complex, and it consumes time and resources without real value creation (Kaddoumi & Watfa, 2016; Velumani, 2017). These studies suggest using Agile Enterprise Architecture (AEA) to resolve this issue (Ambler, 2009, 2015; Kaddoumi & Watfa, 2016; Velumani, 2017). AEA is defined as a, “flexible, easily extended, and easily evolved collection of structures and processes upon which your organization is built” (Ambler, 2015). However, this field is new, and we did not find any study on AEA that was performed specifically in the higher education context.

1.3 Motivation for Our Research

We conducted a systematic literature review and found that EA research in the HE context is not comprehensive. Key early studies in this context were published in 2009 (Green, Beeson & Kamm, 2009; Oda, Fu & Zhu,2009), with only one earlier research study dating to 2007 (Ahmadi, Soltani & Gheitasi, 2007). However, there has been growing interest in the research in this field in the last five years, with six studies in 2016, seven in 2017, five in 2018, one in 2019, and two studies in 2020.

Our preliminary research and the systematic review showed that there is a lack of research that identifies challenges faced by HEIs in the adoption EA as well as critical factors that help to use or apply EA in HEIs successfully. Seppänen (2014) states that there are not many studies of the problems or the critical success factors of the EA adoption process in general. Thus, he wrote his Ph.D. dissertation on this subject, but it was not specific to HEIs. The studies we found focused on the early stages of the EA adoption in HEIs such as work done by Syynimaa (2015b) on the challenges and critical success factors of EA in HEIs, while research that focused on the later stages of the EA adoption in institutions of higher education is lacking. Also, there is no study on the implications of using EA in HEIs beyond the planning phase.

There is limited research that discusses the use of EA as a tool to resolve the issues of HEIs. A few of them discussed the importance of using EA in aligning the business strategy of HEIs with IT, but there is almost no research that addresses the importance of using EA to support decision making at universities or improve their business processes.

There are no studies that provide an evaluation of EA frameworks used in HEIs or the tools used to support EA in HEIs. Some studies have used specific tools or frameworks but do not include evaluation or explanation of the reason of using them. There is a need to conduct a study that evaluates the EA frameworks and tools and proposes a systematic method for selecting the best among them depending on the status of HE institutions.

Finally, Oderinde (2010) emphasizes the importance of the feasibility of formalized frameworks and components of EA specifically tailored to HEIs. There are also other studies in the literature that proposed reference models and architectures for HEIs. However, there is a lack of empirical studies to validate these models.

Therefore, the top-level objective of this thesis is to acquire a deeper understanding of the process of using EA in HEIs. We aim to provide recommendations about how EA practices can be improved. By doing this research, we can help enterprise architects in HEIs better understand the EA process and avoid the problems and pay attention to the critical factors for successfully implementing EA in HEIs.

1.4 Research Questions

Some of the general questions we posed at the outset of the research were: Are HE institutions able to make EA work effectively? Are there any indicators about how HEIs use EA and whether it is successful or not? What aspects of EA are they using, and what aspects they are not? How do HEIs manage to sustain EA after implementing it? Are they using every aspect of EA, or choosing a subset? How does the EA process evolve after its initial implementation? Are there any empirical studies that investigate and discuss the results of using the EA successfully in the HE context? What are the possible specializations or additions that may be made to EA tools and frameworks to tailor them for HEIs? Are HEIs using agile EA (AEA)? If yes, how do they implement AEA?

More formally, we address the following questions in this thesis:

1. How is EA being used in HEIs, specifically to drive IT strategy, software development or procurement, business processes, and decision-making?

The objectives are to:

a. Better understand the patterns of usage or development of EA in various institutions
b. Determine the motivations and objectives of using EA in HEIs.
c. Explore the use of EA in HEIs to align business needs and IT, support decision-making processes, improve business processes, and enhance both business and software modeling.
d. Determine the methods (including frameworks, models and tools) used in EA currently, along with their strengths and weaknesses.

2. How well does EA work for HEIs and what are the tangible and intangible results of implementing EA effectively in the HE context?

The objectives are to:

a. Determine the impacts of using EA in HEIs.
b. Identify the challenges, critical success/failure factors and lessons learned from using EA in HEIs since implementation.
c. Suggest changes that might be made to improve the process of EA in HEIs.

3. Is the agile approach being adopted to the traditional Enterprise Architecture in HEIs? What are the aspects that contribute to increasing or decreasing the agility of EA?

1.5 Research Design

The outcome of our systematic literature review (to be discussed in Chapter 3) shows that there is very little research about the use of EA in the HE domain. Therefore, we decided to perform an exploratory sequential mixed method design to explore this topic (Creswell & Plano Clark, 2011). We started by qualitatively exploring the area of using EA in HEIs, and then, based on the qualitative findings, we conducted a second, quantitative phase to test or generalize the initial findings.

We used Grounded Theory (discussed below and in more detail in Chapter 4) as the first phase within an exploratory sequential mixed design. Grounded theory is an explorative research approach. Its logic of inference is to interplay between induction and abduction. It was first introduced by Glaser and Strauss (1967), who stated that researchers could use this method to construct theories from the qualitative data they collect and analyze. It is one of the most popular qualitative research methods today. It allows exploring ideas and uncovering information to generate new theory through the grounded analysis of collected data, without being biased by preconceived theory. Ideally, researchers should not have any preconceived hypotheses or pre-existing assumptions about the data they will collect. Instead, they should set aside theoretical ideas or notions they have in order to generate new theory from the collected data. The grounded analysis process aims to construct a grounded theory of the phenomenon under study that makes sense of or explains the phenomenon. The result of performing grounded analysis will be a theory formed through the connections among categories that will have uncovered, and hypotheses that explain the theory (Glaser, 1992; Glaser and Strauss, 1967).

We used semi-structured interviews as a primary method to collect data during this process. From an initial grounded theory qualitative phase, we identified the emergent theories of the various themes of the EA process in HEIs and their related variables and state propositions and we evaluated them using a survey method. We also used a systematic

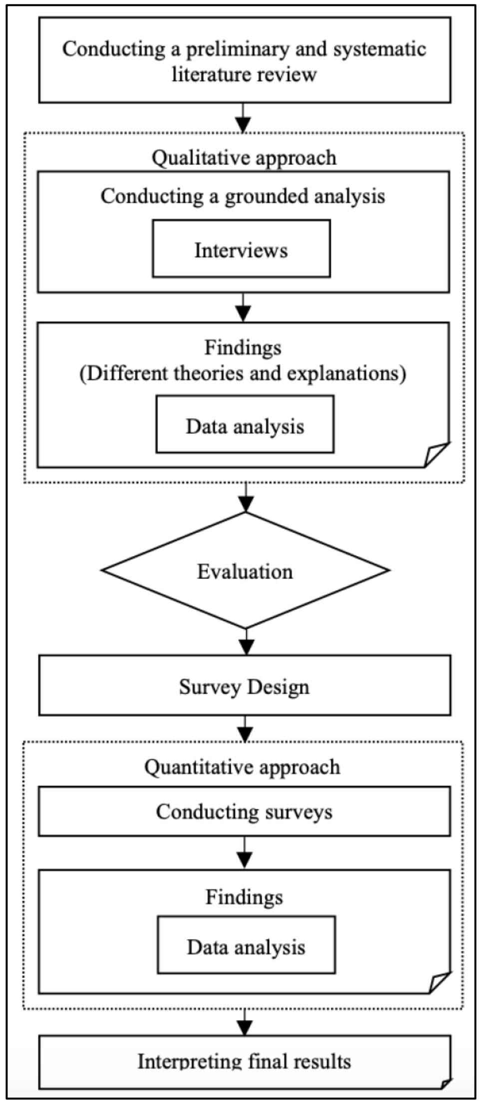

Figure 1 Thesis research methodology flow chart

literature review (SLR) as a secondary method to identify the gaps in the area of research. Figure 1 shows the flow of the research process that we undertook during this study.

The findings of our work help obtain a better and deeper understanding of how EA is being used in HEIs. We created narrative explanations and some diagrams about the results of our grounded analysis. There are different studies provided guidelines on how to create the final grounded theory report such as presenting the generated theory, and the development of an analytical story (Creswell, 1998; Leedy & Ormrod, 2005; Corbin & Strauss, 2008).

We were agile in our research method. In fact, we were open to what data told us from the interviews, and this is exactly what grounded theory study is all about.

When we obtained the "emergent" theories or frameworks from an initial grounded analysis phase, we used them to build a survey instrument to see if the qualitative findings were effective and applicable. The purpose of using a second, quantitative phase was to ensure that "the study was accurate, believable, and correct" (Creswell, 1998). We constructed a survey based on the questions asked in the interviews, refined by the grounded theory findings. We provided the interviews questions and the survey in Appendices C and E.

1.6 Thesis Contributions

The major contribution of the thesis is a descriptive analysis of how EA is being used in HEIs. We provided:

- Lists of categories, concepts, and relationships between them that discover the areas of EA in HEIs as an outcome of the grounded analysis.
- Evaluation of the results obtained from the grounded theory using the survey that was distributed to 115 HE institutions worldwide.
- Recommendations and lessons learned to enhance the implementation of EA in HEIs based on the research findings:
    - ✓ The most important motivations and objectives for using EA in HEIs are facilitating the alignment of projects with the university's goals and the alignment of business and IT sectors and reducing duplications.
    - ✓ The definition of EA from The Open Group (2011) is the definition that applies most strongly to what EA is in HEIs.
    - ✓ Half of the HE institutions participating in this study have a full EA program. Some other participating institutions adopt at least some aspects of EA.
    - ✓ EA positively impacts most of the participated HEIs, and it is still being actively developed.
    - ✓ The most-used tools to develop EA in HEIs are spreadsheets, generic drawing tools, word processors and presentation tools. Tool vendors should see if they can make their tools work as well as these, or perhaps integrate with them.

- ✓ The most desired aspects of the tools used by HE enterprise architects are ease of use, cost-effectiveness, and capabilities for collaboration. Tool vendors should focus on these.
- ✓ Among the most problematic aspects of the tools used by HE enterprise architects are difficulty in keeping the models up-to-date, lack of automatic population of data, lack of integration between the tools, lack of a central repository, and lack of validation of the data. Tool vendors should address these. It seems clear that participants are using office tools because they value their flexibility and ease of use. EA-specific tools do exist but seem not to be favoured even though they might provide some benefits. This thesis has clearly uncovered the need and opportunity for better tools to support the EA community in HE, and likely in other industries. Such tools should enable better collaboration and better importing and automatic updating of data, while maintaining the flexibility and ease of use of office tools. One possibility is extensions or plugins to office tools.
- ✓ The most used EA framework in HEIs is the TOGAF framework, although the Gartner and CAUDIT approaches also have significant influence.
- ✓ The most widely used managed types of models by HE enterprise architects are application models, capacity models, and data models. Tool and framework developers perhaps should consider focusing on these.
- ✓ The most important principles applied by HE enterprise architects are aligning decisions and architecture with the university's strategic mission, vision, and values, maximizing the benefits to the university, keeping data secure and managing security risks, and ensuring the interoperability of technological components. Tool and framework developers should keep these in their focus.
- ✓ The most critical EA adoption challenges in HEIs is the resistance to change. All EA stakeholders need to therefore emphasize the benefits of change arising from EA.
- ✓ The most critical factor for the successful EA adoption in HEIs is supporting the university's mission and goals.

- ✓ The EA team members should acquire good interpersonal skills to succeed in implementing EA at their HEIs.
- ✓ The most significant positive impacts of EA are on the alignment of IT strategies with the university's mission and goals and security.
- ✓ The top practices of EA in HEIs are pushing for enterprise thinking, sharing information across systems, and informing business and technology decisions. This should be taken into account by tool and framework developers.
- ✓ Some indications of the successful implementation of EA in HEIs are having better communication between different university parties, increasing EA maturity, and getting tangible benefits from implementing EA.
- ✓ Some indications that the implementation of EA in HEIs has failed are having outdated roadmaps and models, having an immature EA, and not developing or following standards.
- ✓ Overall there is no consistent, systematic process for evaluating EA in HEIs.
- ✓ The most important factors contributing to the increased agility of EA are avoiding doing too much, focusing on responding quickly to requirements and needs, communicating and collaborating with stakeholders, and being pragmatic.
- ✓ The most important factors detracting from the agility of EA are resisting changes, dealing with large applications and technology, and having very strict university policies.

1.7 Publication

The following has been published; other publications are being developed.

Lethbridge, T., & Alghamdi, A. (2019, November). Framework, model and tool use in higher education enterprise architecture: an international survey. In Proceedings of the 29th Annual International Conference on Computer Science and Software Engineering, CASCON (pp. 138-147).

1.8 Thesis Outline

The rest of this thesis is organized as follows:

Chapter 2 presents preliminary research on the use of EA in the HE sector.

Chapter 3 provides a systematic literature review on the studies that discussed the use of EA in HEIs.

Chapter 4 discusses the research process used in this study.

Chapter 5 presents the demographics, motivations, and objectives of the enterprise architects.

Chapter 6 discusses the frameworks, models and tools used to support EA in HEIs.

Chapter 7 provides EA principles in the HE context.

Chapter 8 presents the challenges, critical success factors and impacts of EA on HE institutions.

Chapter 9 illustrates the EA processes in HE institutions with a focus on agility.

Chapter 10 presents conclusion and summarizes the limitations and future work.

Chapter 2 Preliminary Research on EA in the HE Sector

In 2017, we conducted a literature review with "Enterprise Architecture" and "Higher Education" keywords to shed light on the level of available EA literature in the context of the HE sector. We used Google and Google Scholar, and found that the majority of results are 'grey' literature – material that is not formally peer reviewed or that does not appear in high quality journals and conference proceedings – but nonetheless is informative. The material in this chapter is an update of this review. Chapter 3 presents a more formal Systematic Literature Review that covers the background from a different angle.

During goal-directed but not formally systematic literature research, we found a series of studies and theses that discuss the use of EA in Higher Education Institutions (HEIs) from different perspectives. In Table 1, we provide a classification of the different themes of these studies. Most of the studies focus on two main areas: the alignment of business needs and goals with IT, and the adoption of EA in HEIs.

The first area investigates how EA is used as a tool to align IT strategies with business needs and objectives in HEIs (Yunis, Surendro & Telaumbanua, 2010; Oderinde, 2010; Barn, Clark & Hearne, 2013; Amalia & Supriadi, 2017). The authors studied in depth the most prominent challenges facing HEIs in achieving IT-business alignment and how to use EA as a solution to address these problems. The second area illustrates how and why EA is being adopted in the HE sector, and what challenges, success factors, and benefits are gained by adopting EA in HEIs (Oderinde, 2011; Olsen & Trelsgård, 2016; Oderinde, 2012; Seppänen, 2014; Syynimaa, 2015a; Hope, 2015).

Another study presents a proposal of a roadmap for implementing EA in the HE sector (Carrillo, Cabrera, Román, Abad & Jaramillo, 2010). Additional studies discuss how to develop EA frameworks to resolve specific problems in HEIs or deal with specific changes (Carrillo, Cabrera, Román, Abad & Jaramillo, 2010; Llamosa-Villalba, Carreño, Paéz, Delgado, Barajas & Sneyder, 2015; Amalia & Supriadi, 2017). Also, some practical examples were presented explaining how to develop and implement EA in HEIs (Kontio & Venho, 2013; Adwan & Al-Soufi, 2016).

Table 1 Related work in the use of EA in HE institutions

Reference	Title	Type	Theme
(Yunis, Surendro & Telaumbanua, 2010)	Enterprise Business Architecture in Higher Education	Conference Paper	IT-Business Alignment
(Yunis, Surendro & Telaumbanua, 2010)	Enterprise Business Architecture in Indonesia Higher Education: A Case Study	Conference Paper	IT-Business Alignment
(Carrillo, Cabrera, Román, Abad & Jaramillo, 2010)	Roadmap for the implementation of an enterprise architecture framework oriented to institutions of higher education in Ecuador	Conference Paper	Development and implementation of EAF
(Oderinde, 2010)	Using Enterprise Architecture (EA) as a Business- IT Strategy Alignment for Higher Educational Institutions (HEIs)	Conference Paper	IT-Business Alignment
(Oderinde, 2011)	Emerging Issues Of Enterprise Architecture In UK Universities	Conference Paper	Review challenges in the adoption of EA
(Kontio & Venho, 2013)	First Steps In Creating Enterprise Architecture – A Case Study	Conference Paper	Development of a system architecture that serves the EA
(Barn, Clark & Hearne, 2013)	Business and ICT Alignment in Higher Education: A Case Study in Measuring Maturity	Conference Paper	IT-Business Alignment
(Llamosa-Villalba, Carreño, Paéz, Delgado, Barajas & Sneyder, 2015)	Enterprise Architecture of Colombian Higher Education	Conference Paper	Development and implementation of EAF
(Olsen & Trelsgård, 2016)	Enterprise Architecture Adoption Challenges: An exploratory Case Study of the Norwegian Higher Education Sector	Conference Paper	EA adoption challenges and benefits for HEIs Common EA for HEIs
(Amalia & Supriadi, 2017)	Development of enterprise architecture in university using TOGAF as framework	Conference Paper	Development and use of EAF IT-Business Alignment
(Adwan & Al-Soufi, 2016)	Practical EA Model Development: A Case Study of An Educational Institution in Bahrain	Journal Article	Development of baseline and target EA for HEI
(Sanchez-Puchol, Pastor-Collado & Borrell, 2017)	Towards an Unified Information Systems Reference Model for Higher Education Institutions.	Journal Article	Domain-specific EA Framework for HEI
(Oderinde, 2012)	Understanding Enterprise Architecture in four UK universities	Ph.D. Thesis	Reasons and the impacts of adopting EA in HEIs; how to adopt EA in HEIs
(Seppänen, 2014)	From Problems to Critical Success Factors of Enterprise Architecture Adoption	Ph.D. Thesis	Challenges and CSFs of adopting EA in public organizations including HEIs
(Syynimaa, 2015a)	Enterprise Architecture Adoption Method for Higher Education Institutions	Ph.D. Thesis	Challenges of adopting EA in HEIs; improving the traditional EA adoption method in HEIs.
(Hope, 2015)	The Critical Success Factors of Enterprise Architecture	Ph.D. Thesis	Define CSFs of EA and their influence on architecture
(CAUDIT, 2013)	Enterprise Architecture Commons for Higher Education.	Website	Domain-specific EA Framework for HEI
(Charles Sturt University, 2010)	Higher Education Process Reference Model.	Website	Reference Models for HEIs
(Hazelton, 2016)	The TIER Reference Architecture (RA).	Website	Domain-specific EA Framework for HEI
(ITANA Working Group, 2013)	Reference Architecture for Teaching and Learning (RATL).	Website	Domain-specific EA Framework for HEI
(SURF, 2013)	Hoger Onderwijs Referentie Architectuur (HORA).	Website	Domain-specific EA Framework for HEI
(The Reform Support Network, 2014)	Education Enterprise Architecture Guidebook.	Website	Domain-specific EA Framework for HEI
(Kondeth, 2016)	A common Architecture framework for Educational institutions.	Website	Domain-specific EA Framework for HEI

2.1 Business-IT Alignment in the HE Sector

Higher education institutions, like other public organizations, face a problem in aligning their IT strategies with their adapting vision, business needs, and objectives. This problem often arises as a result of challenges that require HEIs to use the best solutions and approaches to address them.

Some of the studies explore the challenges that might occur while trying to align IT strategy with business in HEIs. One of these challenges is the transformation that results from rethinking the business and adding new strategic directions (Yunis, Surendro & Telaumbanua, 2010). Also, the urgent demands to acquire new technologies to serve students, academics, and management is another challenge that leads to change not only the technology infrastructure of institutions but also the business processes and models of HEIs as well as student activities (Oderinde, 2010; Yunis, Surendro & Telaumbanua, 2010). Another challenge of business-IT alignment is that HEIs do not follow a thoroughly modern development and implementation of IT such as architectures and frameworks in the governance process (Amalia & Supriadi, 2017). To deal with these challenges, Oderinde (2010) claimed that the institutions often take ad-hoc solutions. However, HEIs should adopt systematic solutions with a holistic view of the organization to deal with changes occurred to create an alignment between IT and their business needs and strategy (Oderinde, 2010). There is also a common issue that there is a lack of measurement of the maturity of the business and IT alignment (BIA) in the HE sector as stated by Barn, Clark, and Hearne (2013).

The attempt to make IT in HEIs consistent and aligned with new needs and changes is one of the critical challenges that institutions must handle. Therefore, some studies suggested the use of EA and some of its tools, methods, and frameworks to achieve this alignment.

Oderinde (2010) and Amalia and Supriadi (2017) emphasize that there are several potential outcomes that HEIs would gain from using EA as a tool for aligning IT with business. Amalia and Supriadi (2017) state that the use of EA frameworks and methods such as TOGAF (The Open Group Architecture Framework) is vital to produce the best solution in making a blueprint that is aligned with business needs. Oderinde (2010) pointed some of the benefits of using EA in HEIs such as a coordinated strategy aligned with the architecture, a central decision-making system, and a unified vision of an organization through the integration and standardization of core systems and processes (Oderinde, 2010). Thus, Yunis, Surendro, and Telaumbanua (2010) suggested using Enterprise Business Architecture (EBA) in HEIs to overcome the challenges of the aligning their business with IT. According to Yunis, Surendro and Telaumbanua (2010), EBA contributes to the development of a blueprint to explain why and how to conduct business in detail and also to the establishment of the vision of the institution, strategy, processes, and execution strategies including IT strategies. It also contributes to clarifying the complexity within the organization and establishing responsibilities within HEIs at different levels.

To measure the maturation of strategic alignment of an institution in HE, Barn, Clark, and Hearne (2013) stated that a strategic SICT toolkit, developed by JISC (Joint Information Systems Committee) in the United Kingdom, can be used to help HE institutions to analyze, evaluate and develop their strategic use of IT as well as to measure the maturity levels of BIA.

2.2 Development and Use of EA Frameworks in the HE Context

Carrillo, Cabrera, Román, Abad, and Jaramillo (2010) proposed a comprehensive and integrated roadmap that shows how to implement EA framework in any HE institution to make better use of IT resources, especially HEIs in Ecuador. It had an objective to achieve the alignment of institutional vision with IT and to establish effective IT governance.

In another context, Llamosa-Villalba, Carreño, Paéz, Delgado, Barajas, and Sneyder (2015) explained the process of developing a framework for EA of HEIs in Colombia and stated that the purpose of this framework was to manage the system-of-systems lifecycle of higher education programs in Colombia. This framework is called CHE2A (Colombian Higher Education Enterprise Architecture). They clarified the context, perspective and use of this framework by presenting their models and explained how these models allow navigating the life cycles of products and services offered by HE institutions. This framework can be used to develop model scenarios for the regulator of HE services (government), HE providers (HEIs), and clients of HE services (individual citizens). In this context, all stakeholders can be involved and participate in the planning, developing, transferring, using and controlling of all the products and services lifecycles of HE (Llamosa-Villalba, Carreño, Paéz, Delgado, Barajas & Sneyder, 2015).

Amalia and Supriadi (2017) conducted a case study at the University of XYZ [1] to show the importance of using the TOGAF framework and Architecture Development Method (ADM) to resolve the problems of IT infrastructure and to align business needs with IT, and also to establish IS/IT strategic planning to develop the IS/IT as well as in designing the IT infrastructure. According to Amalia and Supriadi (2017), one of the most critical issues facing the University of XYZ is the complexity of IT, which leads to independent management of IT, rather than a fully integrated IT infrastructure. The other issue is that the university does not use a particular architecture and framework in the current implementation of IT. These issues led to the emergence of the need for integration of ISs between divisions and also the organization of innovations, which requires the use of EA frameworks to develop architecture easily.

2.3 Practical Development of EA for HE Institutions

Adwan and Al-Soufi (2016) used a Bahraini educational department of Information Systems (IS-Dep) as a case study to highlight the importance of using EA to evaluate the need for investing in new technologies and applications. The IS-Dep intended to invest in a new dashboard application, and therefore there was a need to assess its readiness for this investment. To do so, Adwan and Al-Soufi (2016) provided a plan consisting of several stages to develop EA models. The steps started with the development of an EA baseline for the IS-Dep, then the development of a target EA for the IS-Dep to demonstrate the new requirements. After that, they modeled unified architectural artifacts for the IS-Dep by utilizing the ArchiMate modeling language.

In another way, Kontio and Venho (2013) explained how to create a system architecture for HE institutions and consider developing this architecture as a first step in establishing EA for these institutions and helping understand the importance of using EA in the HE sector. To do that, they conducted a case study of the Information Systems of Turku

[1] 'XYZ' is the terminology that Amalia and Supriadi (2017) use in the paper to keep it confidential

University of Applied Sciences (TUAS) in Finland. They analyzed the ISs of this university to collect the necessary information to establish the system architecture.

In addition, Yunis, Surendro, and Telaumbanua (2010) showed how to create EBA model for the Human Resources Management (HRM), Student Administration, and Finance at the STMIK Mikroskil private university in Indonesia. They stated that creating EBA could be used as a starting point for the development of other architectures of HEIs.

2.4 Challenges, Benefits, and Critical Success Factors of EA Adoption in HEIs

There are only a few studies and Ph.D. dissertations that have reviewed the challenges facing public organizations, including institutions of higher education in the adoption of EA, and that also investigated the critical factors that lead to the success of the adoption process. Some of these studies also illustrate the usefulness and impact of EA on institutions and organizations.

Oderinde (2011) outlines the issues that emerged during the EA adoption process in certain HEIs. Oderinde (2012) conducted a critical review of the traditional methods used for the adoption of EA in HEIs in the UK universities and provided a list of critical success factors (CSFs) for adopting EA in HEIs. Another Ph.D. dissertation was performed by Seppänen (2014), who identified the challenges and the CSFs of adopting EA in the public sector organizations in Finland. He also demonstrated that CSFs could be turned into drivers for adopting EA successfully in Finnish public organizations. The final Ph.D. dissertation was conducted by Syynimaa (2015a) who studied the different traditional methods of EA adoption in HEIs in Finland. He proposed a solution to improve the methods of adopting EA for HE institutions called EA Adoption Method (EAAM) based on a comprehensive understanding of the issues surrounding the EA adoption.

2.4.1 Challenges of the Adoption of EA in the HE Sector

Oderinde (2011), Seppänen (2014), Syynimaa (2015a), and Olsen and Trelsgård (2016) identified the challenges organizations encounter while adopting EA. Oderinde (2011), Syynimaa (2015a) and Olsen and Trelsgård (2016) focused on the context the HE while Seppänen (2014) explored the challenges that face public organizations in general. Seppänen (2014) confirmed that understanding the challenges and success factors for EA adoption is essential in enabling any subsequent stages of the EA life cycle. Table 2 summarized the set of the EA adoption challenges as identified by (Oderinde, 2011; Seppänen, 2014; Syynimaa, 2015a; Olsen & Trelsgård, 2016).

Table 2 EA adoption challenges as referenced in the literature review (Oderinde, 2011; Seppänen, 2014; Syynimaa, 2015a; Olsen & Trelsgård, 2016)

Challenges	(Oderinde, 2011)	(Seppänen, 2014)	(Syynimaa, 2015a)	(Olsen & Trelsgård, 2016)	Context	
					HEIs	Public org.
Scale of EA work to be achieved within short time.	♦				♦	
Scope of areas that EA should cover.	♦				♦	
Operational Personnel Development		♦				♦
Resources		♦				♦
Message formulation			♦		♦	
Inter departmental decision model			♦		♦	
Challenges to learn new things			♦		♦	
Lack of integration and problems of merging.			♦		♦	
EA language and terminology	♦		♦	♦	♦	
Support from top-level management and key stakeholders.	♦	♦		♦	♦	♦
Lack of competence and skills needed for EA as well as expertise and how it affects doing EA work	♦	♦		♦	♦	♦
Internal communication between IT and business groups.	♦		♦		♦	
Method, tools, standards, and frameworks used for EA.	♦	♦			♦	♦
Governance structure within the institutions.	♦	♦			♦	♦
Costs of adopting EA work.	♦				♦	
Dedicated roles for EA teams.	♦				♦	
Knowledge gap and lack of experience.	♦		♦		♦	
Lack of strategy linkage and not relating EA to strategy.		♦	♦		♦	♦
Organizational issues and moving staff around.		♦	♦		♦	♦
Duplication of business processes, neglecting process description, and difficulty of managing process.			♦		♦	
Change performed without proper knowledge.			♦		♦	
Lack of high-level directions from the ministries of education.				♦	♦	
Lack of architecture boards.				♦	♦	

2.4.2 Critical Success Factors for the Adoption of EA in the HE Sector

Critical Success Factors (CSFs) are defined as a limited number of areas where satisfactory outcomes ensure successful competitive performance at the individual and institution levels and contribute to the flourishing of business and the achievement of management objectives (Seppänen, 2014). Few studies investigated the critical success for adopting EA in the HE institutions in developed countries such as the UK and Finland (Oderinde, 2011, 2012, Syynimaa, 2015, Seppänen, 2014), and only one study in developing countries (Cruz, 2020) such as the Philippines. In Table 3, we provided a set of CSFs as identified by those studies.

Oderinde (2011, 2012) identified a set of critical influencing factors of the EA adoption in HE institutions in the UK. These set of factors are:

- Gaining senior management support.
- Establishing appropriate organizational structures.
- Identifying actors and scope of EA work.
- Ensuring stakeholders commitment.
- Having a set of evaluation metrics.
- Creating necessary support structures for the institutional actors and cultures such as a formalized governance structure, the right people skills, a systematic and continuous approach to business processes review, and the development of a simple and flexible IT infrastructure.

In addition, Syynimaa (2015) defined three classes of CSFs in the HE sector in Finland, which are: organizational factors, EA related factors, and environmental factors. He defined these three classes of factors as follows. The organizational factors refer to "the capabilities, culture, or structure of the organization," the EA related factors imply "the EA discipline or profession," and finally, the environmental factors related to "the context where the organization is operating."

With regard to the CSFs of EA in the HE institutions in developing countries, Cruz (2020) provided a list of these factors in the Philippine HE institutions. She concluded her study by identifying seven motivational factors for the EA adoption in Philippine universities.

On the contrary, Seppänen (2014) focused on the public sector where he proposed a 3D model of CSFs to adopt EA in the Finnish public sector organizations successfully. According to Seppänen (2014), the 3D model can be used to turn the CSFs into drivers of

EA adoption. Seppänen's 3D model of CSF is not specific to a particular type of organization or industry due to its generality. In other words, this proposed CSFs can be applied to public organizations as well as HEIs. This can be achieved by:

- Characterizing the relationships between the core categories of CSFs to illustrate how their synergic nature can move forward the adoption process.
- Relating the axial problem categories with CSFs, and thus giving suggestions for selecting the approach that is most likely to be best applied to a particular organization.
- Using motivational factors to enhance different CSFs and to support the adoption process.

Seppänen (2014) defined these three dynamic classes (core categories) in a 3D model of CSFs of EA adoption as follows. 'Determination' describes the factors of the institution's dedication and willingness to adopt EA. 'Destination' refers to the purpose or focus of the EA adoption. 'Dexterity' refers to competence with the ability to adapt when needed rapidly. In addition to the critical skills, it is necessary to possess the skills of critical thinking, problem-solving, motivation, negotiation, and others.

Table 3 List of critical success factors in EA adoption in HE institutions as referenced in the literature review

Type	Critical Success Factors	(Seppänen, 2014)	(Syynimaa, 2015)	(Oderinde, 2011, 2012)	(Cruz, 2020)
Organisational Factors	Appropriate organizational structures		♦	♦	
	Change management capability		♦		♦
	Need for change in organizational culture		♦		
	Organization's capability to adopt changes		♦		
	IT portfolio management		♦		
	Strategy driven change		♦		
	Structured decision-making process		♦		
	Conformance in change		♦		
	EA frameworks' lack of focus on social perspective		♦		
	EA adoption brings cultural clash to surface		♦		
	Social perspective is important		♦		
	EA is more about people than technology		♦		
	Adaptable to change		♦		♦

Type	Critical Success Factors	(Seppänen, 2014)	(Syynimaa, 2015)	(Oderinde, 2011, 2012)	(Cruz, 2020)
	Importance of leadership		♦		
	Top management support		♦	♦	
	Organizational position of EA function	♦	♦		
	Communication (motivational skills, negotiation skills, and other soft skills)	♦	♦		
	Clear scope and goal set of EA work	♦	♦	♦	♦
	Viewpoint and qualities affecting the decision-making capabilities				♦
	Key stakeholders buy-in and commitment	♦		♦	
	Knowing the relevant stakeholders	♦			♦
	Evaluation metrics			♦	
	Applying critical thinking and different problem-solving techniques.	♦			
	Revolutionary innovation and activities meeting the needs of the future				♦
EA Related Factors	Selection of the EA framework		♦		
	Vague definition of EA		♦		
	Use of principles		♦		
	Experience and skills of EA staff (technical skills such as EA-related knowledge)	♦	♦	♦	♦
	Right people availability			♦	
	Techniques consisting of proposed structures to achieve the future state.				♦
Environmental Factors	Initiator and organization's internal drivers for EA adoption	♦	♦		
	Interoperability issues of related EAs		♦		
	Steering power of external parties		♦		
	Formalized governance structure			♦	
	Resources			♦	
	A systematic and continuous approach to business process review			♦	
	Simple and flexible IT infrastructure to enable requirements for integration, accessibility, and agility.			♦	
	Positive peer pressure and encouraging experiences of other organizations.	♦			
	Combining the EA adoption with other organizational development projects or enterprise IT development activities.	♦			
	Competence	♦			

2.4.3 Benefits of the Adoption of EA in the HE Sector

EA benefits refer to the value that EA gives to organizations and HEIs which in turn enables organizations and institutions to build enhanced capabilities and strengthen their expectancy performance (Oderinde, 2012; Seppänen, 2014; Syynimaa, 2015a). In Table 4, some EA benefits are identified for both public and HE organizations.

Table 4 EA benefits as referenced in the literature review (Oderinde, 2011, 2012; Seppänen, 2014; Syynimaa, 2015a)

EA benefits	(Oderinde, 2011, 2012)	(Seppänen, 2014)	(Syynimaa, 2015a)	Context	
				HEIs	Public org.
Ability of senior management to make better-informed decisions	♦		♦	HEI	♦
Better visualisation of institutional capability including IT resources and help departments share reusable resources	♦			HEI	
Better focus and optimisation for critical business functions/operations	♦			HEI	
Ensure IS departments become more successful by looking at how IS impacts on an organisation's strategy.	♦			HEI	
Improved responsiveness to business requirements	♦			HEI's IT	
Better visibility across processes & systems	♦			HEI's IT	
Ability to maximise some level of control over IT solutions & decisions	♦			HEI's IT	
Improved compliance to regulations and data requirements	♦			HE Sector	
Improvements in the overall IT capability of institutions	♦			HE Sector	
IT governance	♦			HEI	
Improved business-IT alignment and interoperability		♦	♦	HEI	♦
Support the structural change throughout all the levels of administration.		♦		HEI	
Increased revenues and cost reductions.			♦		♦
The simplification of system or architecture management.	♦		♦	HEI	♦
Adaptability and agility	♦	♦	♦	HEI	♦
Increase operational effectiveness			♦		♦
Process improvement	♦	♦	♦	HEI	♦
Standardisation and consistency			♦		♦
Win new business			♦		♦
Planning			♦		♦
Product selection			♦		♦
Speak a common language	♦		♦	HE Sector	♦
Move organization forward			♦		♦

2.5 Domain-Specific Framework of EA for HEIs

There have been several attempts to build enterprise architecture frameworks for institutions of higher education. However, these attempts have some drawbacks or shortcomings. This is not surprising due to the lack of research in this area.

There is a tendency to use a common EA in HEIs. In fact, HE institutions are very similar in structures, sharing many business processes, procedures, concepts and services. Most

HE institutions have core activities such as learning, teaching, and research. They collaborate with each other but at the same time compete with each other. Typical HE business structures can be differentiated from other business types in that they have disjointed departments within an umbrella organization (Kondeth, 2016). Thus, there is a need to create a common EA framework for the HE sector based on a common set of principles and concepts. It would be beneficial to use a common template for EA to share the same services and provide a more interoperable environment. The domain-specific framework for EA can be used as a general reference for creating and deploying EA for HE institutions. Using the domain-specific framework may shorten the time and effort HEIs may take in adopting EA.

However, there is limited research investigating the use of a common EA for the HE sector as stated by Olsen and Trelsgård (2016). For example, Kondeth (2016) illustrates the need for a domain-specific framework of EA to be applied in HE in the UAE to address the problems that may face institutions of HE in general, especially in IT such as the deployment of diverse technologies for different autonomous departments that may cause security problems. Though, he did not elucidate what this framework should look like. Another example was presented by Olsen and Trelsgård (2016) who clarified that the Norwegian HE sector had started the process to have a common EA, especially in the field of IT. The CIO forum of the universities in Norway formed a workgroup to write a draft of IT architecture principles in 2014. As a result, this draft contributed to the realization of common EA for the HE sector (Olsen & Trelsgård, 2016). However, this draft was not sufficient as there are still many unexploited potentials for creating a common EA such as common processes, data models, and systems (Olsen & Trelsgård, 2016).

Olsen and Trelsgård (2016) defined a set of problems that could lead to the suspension of creating a common EA for HE, which can be summarized as follows:

- Lack of top-level directions from the Ministry of Education and Research.
- Not establishing an overarching architecture council.
- Misunderstanding the concept of EA among top managers at the individual institutions.
- Lack of the support and commitment to EA efforts by the top managers.

- Lack of EA competence at the top managers at the individual HE institutions.

The adoption of a domain-specific framework for EA in HE institutions has several benefits, according to Kondeth (2016) and Olsen and Trelsgård (2016). They include reducing the time of implementing EA and the human errors by providing reusable templates, providing documentation of case studies and experiences, creating best practices and guides, creating common documentation standards, creating security standards, and sharing a knowledge base (Kondeth, 2016). In the same way, some benefits of using the common EA at the institution level sector levels include increasing business agility and flexibility, better decision making, better alignment between IT and business, better common systems requirements, reduction of development time, reduction of IT risk issues, and ability to change processes as needed (Olsen & Trelsgård, 2016).

There are some examples of domain-specific EA frameworks applied in other context. In Table 5, some of the main contributions of developing and creating frameworks of EA for specific domains are summarized; these mainly emerge from the practitioners and the grey literature.

Table 5 Contributions related to creating frameworks for EA for specific domains and industries

Reference	Contribution		Focus	Scope	Breadth
(Alloush, Aoun, Kermarrec & Rouvrais, 2014)	An EAF for integrating IT commonalities in various domains, essentially creating a common domain.	Enterprise Architecture Framework for a Common IT domain (EAF1T)	Information Systems (ISs) Information Technology (IT)	Heterogeneous ISs in various domains	General
(Covington & Jahangir, 2009)	A Hybrid EA framework influenced by TOGAF, FEA and Gartner. Business-driven for IT - business strategies alignment.	Oracle Enterprise Architecture Framework (OEAF)	Business Information Technology (IT)	General	General
(Weinert, Hahn & Norkus, 2016)	A domain specific architectural methodology to align and integrate existing system architectures in the maritime domain.	Maritime Architecture Framework (MAF)	Business Information Systems (ISs) Information Technology (IT)	The maritime domain	General
(Smart Card Alliance's Transportation Council, 2016)	A framework for reference EA for open payment in the public transportation space. It provides a model for implementing a seamless fare payment system.	Transit Open Payment System (TOPS) Framework	Business Information Application Technology	Transportation industry's payments ecosystem	General
(Open Group Standard, 2014)	A reference framework decomposes of four components: Business Process reference Model, Business Capability Reference Map, Information Reference Map, and Application Reference Map	Exploration and Mining Framework (EM framework)	Business Information Application	The exploration and mining industry	General

In addition, we found a few approaches had been made towards generating a domain-specific EA framework for use in the HE sector as illustrated in Table 6.

Table 6 Contributions related to creating reference models and architectures for HE domain

Reference	Contribution		Focus	Scope	Breadth
(The Reform Support Network, 2014)	A strategic framework provides the structure, plan and processes to accomplish the vision and goals of an education agency.	Education Enterprise Architecture (EEA)	Business Architecture Information Architecture Application Architecture Technology Architecture	Education	US
(SURF, 2013)	HORA was developed to organize the structure and information management of Dutch HEIs.	HORA (Higher Education Reference Architecture)	Business Architecture Information Architecture Application Architecture Technology Architecture	HE	Netherlands
(Hazelton, 2016)	Enterprise Reference Architectures for HEI	TIER (Trust and Identity in Education and Research) Reference Architecture	Business and IS views	HE	USA
(ITANA Working Group, 2013)	Enterprise Reference Architectures for HEI to architecting teaching and learning enterprises.	Reference Architecture for Teaching and Learning (RATL)	Business and IS views	HE	USA
(CAUDIT, 2013)	Enterprise Architecture Commons for Higher Education	CAUDIT Higher Education EA Reference Architecture	Business Reference Model and Data Reference Model	HE	Australia

There are other works conducted in the era of EA of HE, but they focused on a specific domain. For example, Charles Sturt University (CSU) (2010) produced a list of reference models and templates that may be used a reference for other institutions in HE to support them in their EA journeys (Charles Sturt University, 2010). However, these models describe only the business processes of HEIs. Another example is the unified information systems (IS) reference model for HEIs built by Sanchez-Puchol, Pastor-Collado, and Borrell (2017). The focus of their work was on the IS and applications in HEIs. In addition, Pardeshi (2014) created Cloud Computing (CC) Architecture for HE. The focus of his work was on cloud computing (CC) environments. The CC Architecture is an enterprise reference architecture that consists of three cloud service models, and four cloud deployment models, and user domain (Pardeshi, 2014). Also, it provides a five-phase strategy to transition from traditional systems in HE to cloud-based systems.

Below, we provide an overview of each framework. Then in Table 8, we define the components of each framework, its advantages, and limitations. This enables the reader to study the commonality and differences between them.

The first work is conducted by The Reform Support Network (2014) to create Education Enterprise Architecture (EEA). The scope of this work is not limited to HE; it includes all the agencies in the education field whether they are schools, colleges, universities, or others. The reason behind using the EEA is to increase resources and expertise, sustain reforms and change and support educational agencies (The Reform Support Network, 2014). EEA, as shown in Figure 2 is defined as "a strategic framework that can provide the structure, plan and processes to achieve an education agency's vision and goals by aligning its business and program side with information technology (IT)" (The Reform Support Network, 2014).

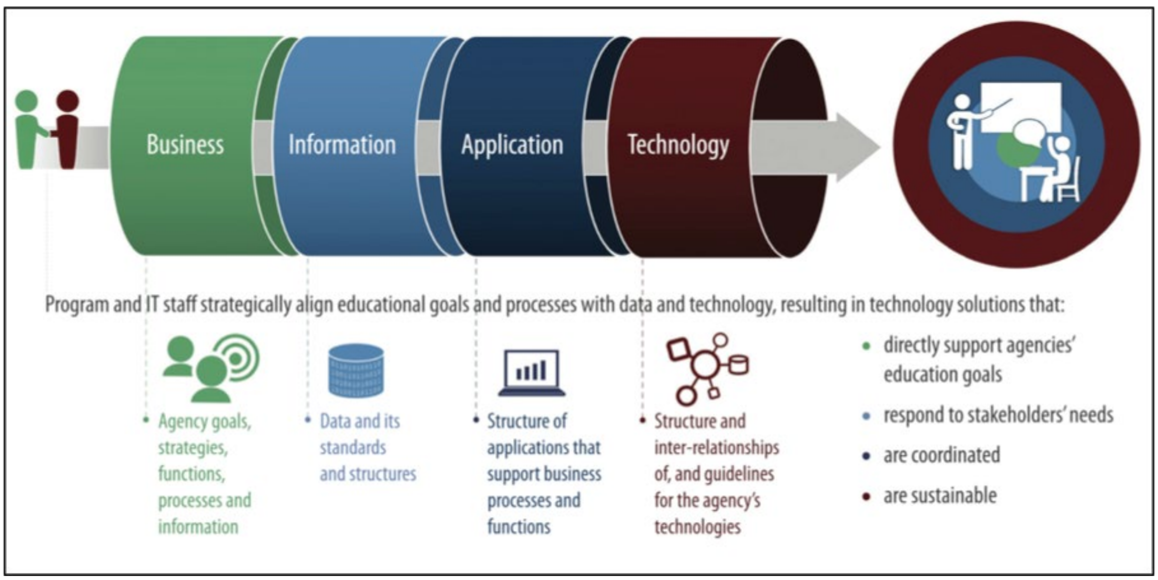

Figure 2 Education Enterprise Architecture (EEA) framework (The Reform Support Network, 2014)

The contents of structure, plan, and process of EEA is described in Table 7. In terms of *structure*, this framework consists of four main components: Business, Information, Application, and Technology Architectures (The Reform Support Network, 2014). The EEA specifies what should be considered and defined for these architectures. It illustrates that EEA includes creating the current and future state of all architectures involving identifying the inputs to the process of creating the current state and the outputs from developing the future state of architectures. They provide a table of certain "resources"

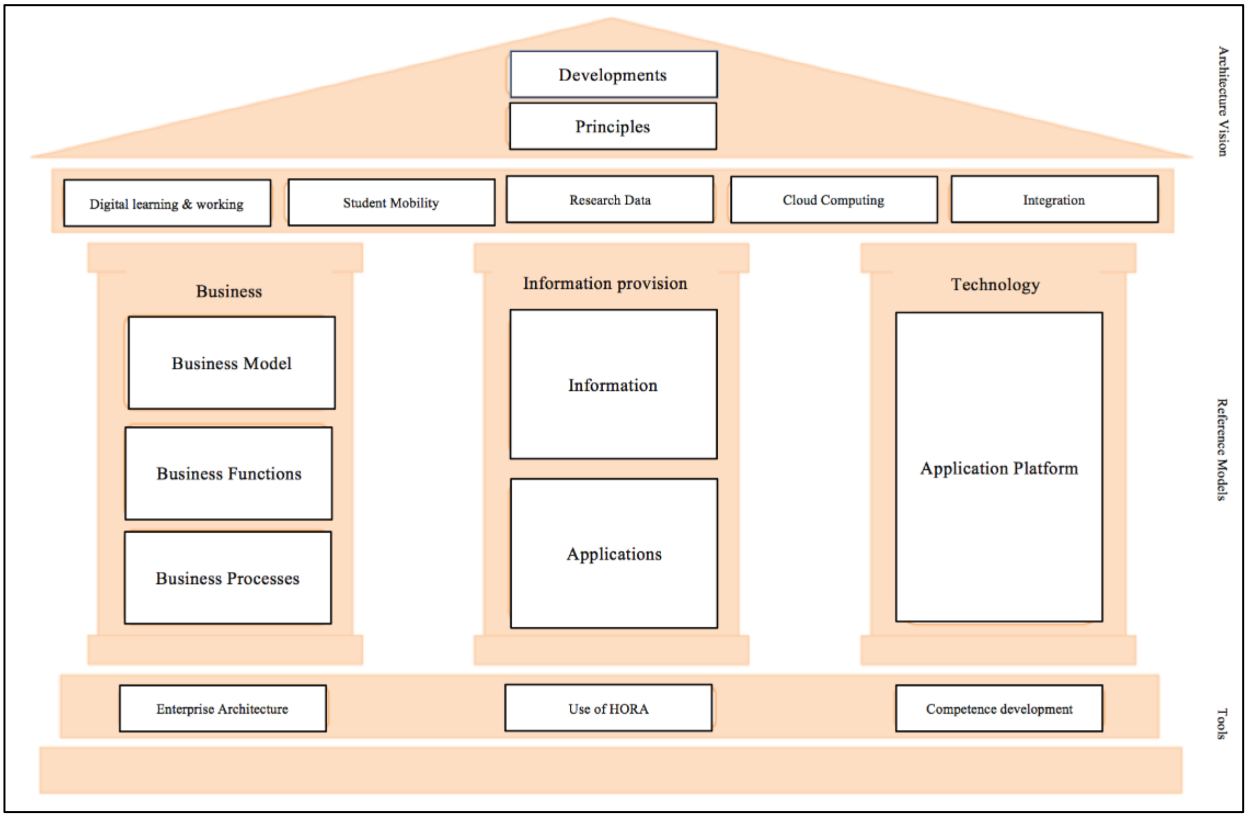

Figure 3 Three parts of HORA (translated from SURF, 2013)

defined as essential "inputs" into the EEA process, and some materials and resources developed as outputs through the process as supporting materials to facilitate this process. However, they did not provide templates or reference models for these four architectures. In terms of ***plan***, a checklist for EEA project plan is developed which includes six steps as follows (The Reform Support Network, 2014). In terms of ***process***, EEA has a development process that consists of six activities to create the current and future state of the educational agency and define the gap between them to prepare the implementation plan (The Reform Support Network, 2014).

The EEA has a set of benefits as described in (The Reform Support Network, 2014):

- More effective change management
- More planning for sustainability
- More efficient IT operations
- Better return on investment
- Faster, simpler and cheaper procurement

Hoger Onderwijs Referentie-Architectuur (HORA) is a Dutch national Higher Education Reference Architecture that was drawn up as part of the 'Directing in the Cloud' project in 2013 (translated from SURF, 2013). It is still under development as of early 2018. The HORA reference architecture was developed to reinforce the optimal management of the information resources complexity and risks, enable the cohesion and flexibility, and promote the quality assurance in HEIs (translated from SURF, 2013).

Table 7 Components of EEA framework

Component	Description
Structure	• Business Architecture • Information Architecture • Application Architecture • Technology Architecture
Plan	Six steps of EEA project plan: 1. Establish an implementation plan that address the gaps identified between the current and future state of the educational agency. 2. Identify desired outcomes or results. 3. Articulate goals and objectives clearly. 4. Create project deliverables. 5. Establish project organization. 6. Schedule and staff project action plan.
Process	Six activities of EEA development process: 1. Establish a vision and architecture principles of the educational agency early in the planning for the EEA implementation. 2. Define scope of the EEA to be implemented whether it is limited or comprehensive. 3. Analyze and document the current state and future state of the four architectures of the EEA. 4. Transition from current state to future state of the agency. It also includes the gap identification between the current and future state for all four architectures as well as the establishment of a road map. 5. Create a project plan for the EEA. 6. Establish governance for the EEA because it is critical for long-term sustainability.

HORA consists of three parts: architecture vision, reference models, and implementation tools to support the implementation of the reference models as shown in Figure 3. HORA provides a set of reference models for all four architectures: Business, Information, Application, and Technology. As illustrated in Appendix B, the reference models that described the business architecture of HEIs are business model ("Business model canvas of a higher education institution"), business function model, and business process model. The reference model that described the information architecture of HEIs is 'information model.' The reference models that described the application architecture of HEIs are 'application model' and generic 'applications model.' The reference model that described the technology architecture of HEIs is 'application platform model.'

The benefits of using the HORA reference architecture, as described in (translated from SURF, 2013), are that using it enables:

- Comparing the settings of different institutions
- Providing insight into possibilities for collaboration within an institution and with other institutions
- Allowing an institution to set up its own EA much faster.
- More clear communication to stakeholders
- Providing insight into the relevant aspects and complexity of a changing area
- Providing insight into possibilities for improvement
- Providing insight into the scope of projects and the relationships with other projects
- Facilitating discussion and decision making about ownership of processes and data

The Trust and Identity in Education and Research (TIER) reference framework was developed as a part of Internet2's Trust and Identity in Education and Research (TIER) program in 2016 (Hazelton, 2016). It is still under development as of 2018. The focus of this work is to illustrate the components of identity and access management (IAM) in HE institution and illustrate their relationship to each other (Hazelton, 2016). The aim is to help HE institutions satisfy their functional IAM needs (Hazelton, 2016). The TIER Reference Architecture in Figure 4 demonstrates the functional components for IAM in HE

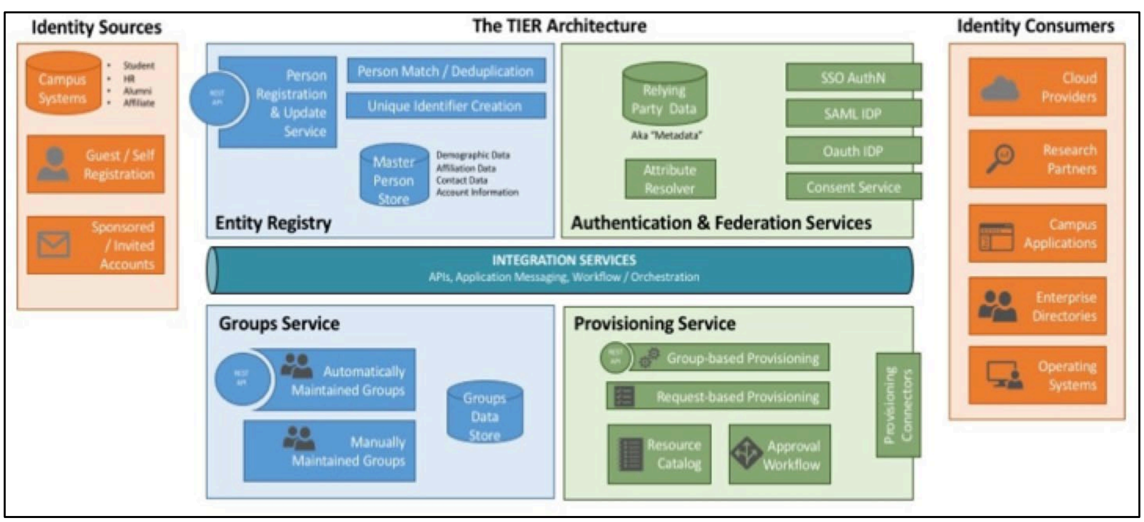

Figure 4 TIER Architecture Framework (Hazelton, 2016)

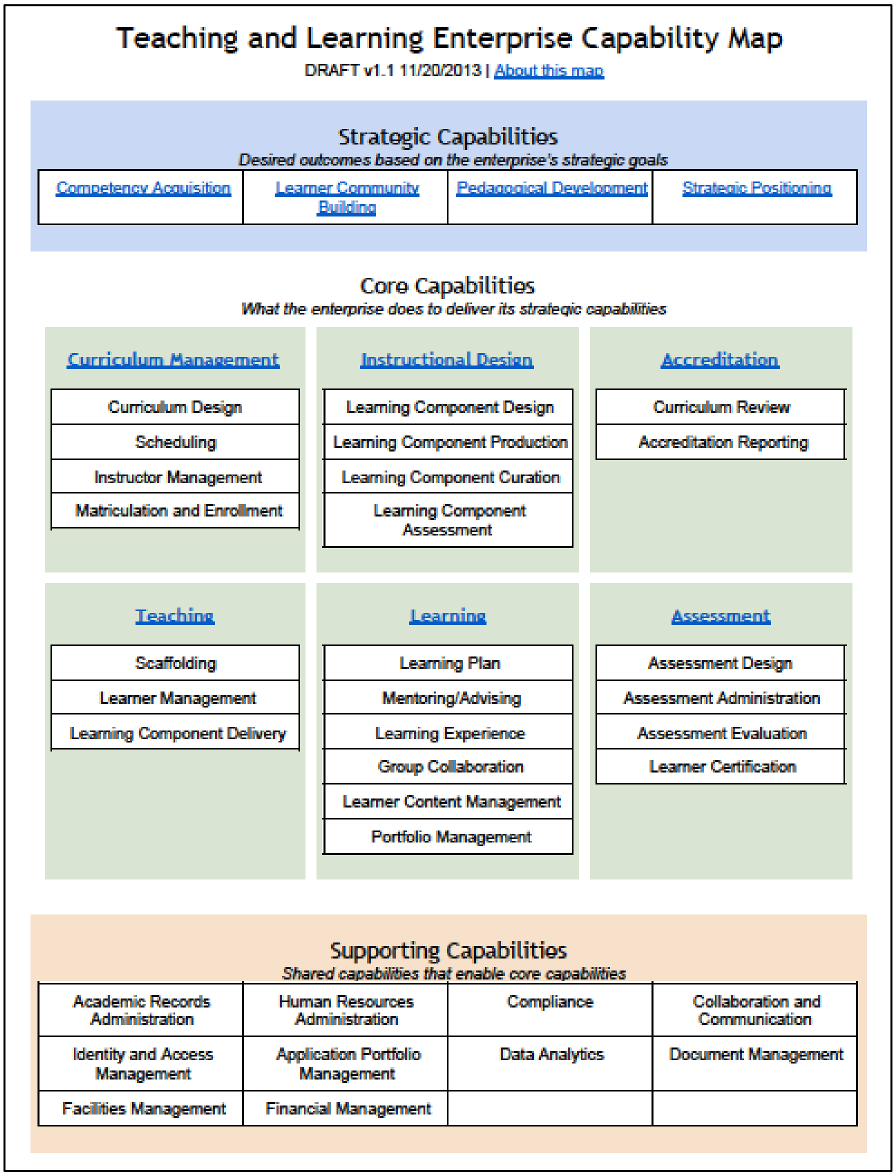

Figure 5 RATL Capability Map (ITANA Working Group, 2013)

institutions. The TIER offers "tools, software and architectural patterns that enable institutions to effectively and securely manage access to institutional resources and to foster inter-institutional collaboration" (Hazelton, 2016).

The Reference Architecture for Teaching and Learning (RATL) was developed by the ITANA Learning Working Group in 2012-2014 (ITANA Working Group, 2013). It is still under development as of 2021. RATL can be used as a resource for the architecture of teaching and learning activities of HE institutions (ITANA Working Group, 2013). It provides a Teaching and Learning Capability Map, which is a reference model of the strategic, core, and supporting capabilities covered in the RATL as shown in Figure 5. The

RATL map illustrates the main core capabilities of HEIs such as curriculum management, instructional design, accreditation, teaching, learning, and assessment. However, it does not demonstrate the capabilities related to research or community services.

According to the ITANA Working Group (2013), the RATL can be used to map the learning and teaching enterprise, assess its maturity, model the effect of new goals, and plan for proposed changes.

Another work to consider is the Enterprise Architecture Commons for Higher Education (CAUDIT Higher Education EA Reference Architecture), which was developed by CAUDIT (Council of Australasian University of Directors of Information Technology) (CAUDIT, 2013). EA commons for HE institutions is a repository of a standardized set of RAs that describe the structure of HEIs (CAUDIT, 2013). It includes the architectures of only two domains: Business architecture and Data architecture. It proposes the CAUDIT Higher Education Business Reference Model and the CAUDIT Higher Education Enterprise Architecture Data Reference Model. It provides a whole view of the organization of universities and the information they use (CAUDIT, 2013). It is hard to collect information about this framework since the access to the required materials is only limited to CAUDIT members.
A purpose of CAUDIT EA Reference Architecture is to help HEIs to speed up the creation of the business and data architecture, explore commonalities and differentiators, and to use it as a communication tool among stakeholders (CAUDIT, 2013).

Table 8 illustrates the strengths as well as weaknesses of each framework. In fact, we did not find empirical studies that proved the effectiveness or usefulness of this type of framework for HEIs. Also, we did not observe any study that shows the use of a domain-specific framework tailored for HEIs in a real case study during this initial literature review. Thus, we need to dig deeper and conduct a systematic literature review (SLR) to search for more studies if they exist.

Table 8 Components, strengths, and weaknesses of domain-specific framework of HE institutions

Framework	Components	Strengths	Weaknesses
EEA	• Four main components (architectures): Business, Information, Application, and Technology	• Provides a clear development process for using EEA. • Provides an example to show to use EEA framework and	• The scope of the EEA is not limited to the HE • Does not provide templates or models described the four architectures.

Framework	Components	Strengths	Weaknesses
	• EEA project plan • EEA development process	process to create Segment architecture of an agency	
HORA	• Architectural vision and principles • Reference models of four architectures: Business, Information, Application, and Technology • Implementation tools to support implementing the reference architecture	• Provides a set of reference models that can be immediately recognizable to people outside the institution show in Appendix B. • Provides a complete business process, and landscape of IS applications and technologies that can be deployed in an educational context. • Describes HEI independently from institution-specific choice. • It can be applied directly to HEI without tailoring it because it is rich.	• A knowledge access barrier: It has been totally written in Dutch • The reference models are built using a semantic wiki and also in the form of an ArchiMate which may restrict understanding by non-IT stakeholders.
TIER	• Business context diagram - to help executives understand the business context of TIER components. • TIER technical component diagram – to provide a more detailed technical view of TIER • The components related to the TIER reference architecture and depicted in the technical diagram.	• It is a general reference framework which means it is applicable to any type of HEI • Provides flexible packaged and deployable components. • Uses a set of APIs to provide consistency among the components and to ease integration • Provides a Glossary of TIER components • Provides a series of narrative walkthroughs to illustrate how to use TIER components	• The focus is on IAM. It aims to help HEIs solve the IAM challenges • Provide a lower level of detail on the architectural objects • Does not cover the IT domain • Uses the canonical specification language for HTTP-oriented APIs in TIER (Swagger 2.0) which may not be understandable by non-technical stakeholders
RATL	• Statement of scope • Capability maps • Data models • Scenarios/processes • List of actors and activities • Roles and responsibilities • Inventory of tools • Standards in the learning ecosystem • Learning ecosystem maturity survey	• The RATL Library includes a reference model for understanding teaching and learning enterprise. ✓ Capability Library. ✓ Roles Library. ✓ Process Library. ✓ Data Library. ✓ Tools Library • Provide a Reference Capability Map called Teaching and Learning Capability Map that summarizes the capabilities covered in the RATL.	• Focus on teaching and learning activities; does not include research activity. In the architecture scope, the developer clarified that only research that is part of a course will be included. • It only defines the data sub-layer architecture which means that they do not offer concrete detail on IS or applications. • Some libraries of RATL are under development, which means they are not completed. • Using specific standards: IMS standards, IEEE standards (LOM), Student Academic Record standards, and Identity and access management (HTML 5)
CAUDIT Reference Architecture	• The CAUDIT Higher Education Business Reference Model • The CAUDIT Higher Education Enterprise Architecture Data Reference Model	N/A	N/A

In the systematic literature review presented in the next chapter, we aim to further identify works on domain-specific EA frameworks for the HE industry. We also investigate to what extent the institutions benefit from applying this kind of framework, how effective have these been if the HE institutions using them, and what effects they have on the process of EA in institutions of higher education. If they do not use this kind of frameworks or templates, we want to know the reasons behind this.

2.6 The Reasons Why HE Institutions Use EA

There are several reasons why HEIs do adopt and use EA. Some of these reasons have emerged as an inevitable consequence of some of the problems facing these institutions. However, some institutions have adopted and used EA as a result of their governments' commitment to mandate using EA in the public sector, including the HE sector.

The Finnish Ministry of Finance published a report showing that 67 percent of governments already have an EA program, and the percentage increases to 93.3 when adding countries that have plans to launch an EA program within a year or two (Liimatainen, Hoffmann & Heikkilä, 2007). This report showed how EA works in 15 different countries including some Scandinavian countries, European countries, North American countries, and other countries in Asia (Liimatainen, Hoffmann & Heikkilä, 2007).

For example, the Finnish Parliament ratified the Act on Information Management Governance in 2011 in Public Administration (Syynimaa, 2015a; Syynimaa, Maltusch &Suominen, 2016). The act mandates public sector organizations to start adopting EA by 2014 and included HEIs in the mandate.

Another example of these governments is the USA federal government which has established the Federal Enterprise Architecture (FEA) and legislated through the Clinger-Cohen Act of 1996 that every government agency must have an EA (Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009). Other countries with noted EA programs are Canada, the UK and Germany (Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009). In the Middle East, the government of the Kingdom of Saudi Arabia tends to adopt EA to enable the transformation of government agencies, including the Ministry of Education-Higher Education (MOE-HE) (E-Government Program (Yesser), 2017).

Some studies discussed the other reasons that make the HE institutions tend towards using EA. Table 9 summarizes some of these reasons.

Table 9 Reasons for using EA in HE institutions

Reasons	Source
Increasing the efficiency and effectiveness of the HE institutions.	(Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009)
Facilitating a high-level understanding of the HE institution as a holistic entity.	(Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009; Oderinde, 2010)
Achieving the business and IT alignment.	(Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009; Carrillo, Cabrera, Román, Abad & Jaramillo, 2010; Oderinde, 2010)
Gaining precise and informed IT governance.	(Yunis, Surendro & Telaumbanua, 2010a, 2010b; Carrillo, Cabrera, Román, Abad & Jaramillo, 2010; Oderinde, 2010; Oderinde, 2011; Barn, Clark & Hearne, 2013; Syynimaa, 2015a; Amalia & Supriadi, 2017)
Improving key business processes.	(Oderinde, 2010; Kontio & Venho, 2013)
Representing IT management innovation in the HE sector.	(Oderinde, 2011)
Enhancing agility in HEIs.	(Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009; Oderinde, 2010; Olsen & Trelsgård, 2016)
Getting better decision-making.	(Carrillo, Cabrera, Román, Abad & Jaramillo, 2010; Oderinde, 2011; Syynimaa, 2015a; Olsen & Trelsgård, 2016; Adwan & Al-Soufi, 2016)
Responding to business and organizational change in an effective way.	(Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009; Oderinde, 2010; Syynimaa, 2015a)
Understanding the current and future state of HEIs.	(Oderinde, 2010)
Achieving the current and future business objectives.	(Kontio & Venho, 2013; Adwan & Al-Soufi, 2016)
Providing consistent view for all stakeholders.	(Oderinde, 2010)
Capturing and managing IT resources.	(Oderinde, 2011)
Aligning administrative process.	(Oderinde, 2011)
Leveraging IS investments and managing effectively huge infrastructures investments.	(Oderinde, 2010; Oderinde, 2011; Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009)
Structuring the responsibilities within the HE institutions and within primary processes as well as with regard to IT support.	(Yunis, Surendro & Telaumbanua, 2010a, 2010b)
Serving as a basis for the delivery of information to the governance of universities.	(Carrillo, Cabrera, Román, Abad & Jaramillo, 2010)
Handling interdependencies among people, business process, applications, data, and underlying technologies.	(Carrillo, Cabrera, Román, Abad & Jaramillo, 2010; Oderinde, 2010)
Supporting IS planning and managing.	(Oderinde, 2011; Amalia & Supriadi, 2017)
Removing the duplication of business processes and enhancing the process description and management.	(Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009)

2.7 Previous HEI EA Pilots, Case Studies, and Experiences

There are a few EA pilots, and case studies that examine the use of EA in the HE sector from different perspectives. There are also several EA journeys have been documented and published showed how HE institutions and universities have adopted EA. Here, we will discuss some of these studies, including providing background information and a summary of each of them.

2.7.1 EA Pilot Projects

Two EA pilot projects have been done to investigate the use of EA in the HE sector. These pilots can be used as sources for empirical data to help researchers to explore the area of using EA in HE context.

The first pilot projects were funded by JISC (former Joint Information Systems Committee) on several UK universities to explore the applicability of EA in HE context at the beginning of 2008. The EA pilot program funded these universities to explore the potentials of EA approaches, to trial TOGAF over 12 months, and to provide evaluations based on their experiences. The EA pilot program targeted ten projects, but because the number of universities that met the stringent criteria for the readiness for adopting EA was small, only four out of 10 projects were funded (Anderson & Backhouse, 2008; Anderson, Backhouse, Townsend, Hedges, & Hobson, 2009). The universities involved in this project wrote their experiences as EA short stories (Enterprise architecture, 2014).

The JISC EA pilot program was later studied in a Ph.D. dissertation conducted by Oderinde (2012). He used this pilot as the unit of analysis to answer the question of "How is EA adopted in HE institutions?" (Oderinde, 2012). The data provided by this pilot helped Oderinde (2012) making comparisons among four UK universities to understand how the adoption process of EA in HEIs.

The second EA pilot was conducted by the Finnish Ministry of Education on 12 Finnish HE institutions in 2010 (CSC, 2011). The preparation phase for this pilot project fell out between September 2009 and January 2010. The actual pilot activities took place between February 2010 and February 2011. There were initially 12 institutions involved in this pilot, but two of them merged at the beginning of the pilot (CSC, 2011c). This pilot project had two primary objectives. The first was to start the work of EA in the HE sector, and the second goal was to create conditions for continuous EA development for the HE sector. As a result, several positive results were reached that exceeded the expectations according to the final report of the pilot project. These results include the development and use of the EA framework for HEIs, especially for Finnish HE institutions, called Karturi. Also, a draft for a shared EA conceptual level was prepared. Some HE institutions and groups also developed reference architectures for their internal use (CSC, 2011c).

This EA pilot was used by (Syynimaa, 2015a) in his Ph.D. dissertation as a source for empirical data to analyze the EA adoption challenges and the problems of the traditional EA adoption process. He defined a set of change resistance during the planning and execution EA adoption in HEIs. Then he built an improved EA adoption method to address these challenges.

2.7.2 Case Studies on the Use of EA in HE Institutions

A few case studies were done in the context of the use of EA in the HE sector. The list of case studies and the goals for conducting them are illustrated in Table 10.

Table 10 Summary of case studies conducted to discover the use of EA in HE institutions

Related work	Context	Goal of a case study
(Yunis, Surendro, & Telaumbanua, 2010)	STMIK Mikroskil private university in Medan of North Sumatera, Indonesia	Creating EBA model for the Human Resources Management (HRM), Student Administration, and Finance at HEIs at the STMIK Mikroskil private university.
		Goals achieved: • Creating an EBM of integration system in HEIs using RUP (Rational Unified Process) method and UML. • The recommendation was to replace the legacy systems with common integrated systems. • Creating a set of general models of EBA using UML to represent: o The 'as-is' Human Resources Management (HRM). o The 'to-be' Human Resources Management (HRM). o The detailed recruitment processes. o The recruitment applicants.
(Barn, Clark & Hearne, 2013)	HEIs in the UK	Developing a strategic ICT (SICT) toolkit to be used in the UK HEIs to measure the maturity of the extent of business and ICT alignment (BIA) in a HEI
		Goals achieved: • Emphasizing that EA and the integration requirements of business and information systems planning are fundamental to increase the maturity levels of universities involved in business and IT alignment. • Illustrating the benefit of using the SICT toolkit to measure the value and maturity of ICT provision.
(Kontio & Venho, 2013)	Turku University of Applied Sciences (TUAS) in Finland	Analyzing the current Information Systems of TUAS and providing information to create a system architecture that helps in developing EA.

Related work	Context	Goal of a case study

		Goals achieved:
		• Providing an analysis of the system architecture of Turku University of Applied Sciences (TUAS), especially the state of the art of its current information systems.
		• The results showed that:
		  o The system architecture is in good condition based on the importance of the information system and the current performance of the system.
		  o All information systems are essential although the level of importance is diverse.
		  o Most information systems need minor changes.
		  o Some common information systems or tools greatly support both education-related and management-related activities.
		  o There is a need for a detailed analysis of the ICT environment.

(Olsen & Trelsgård, 2016)	Norwegian HE sector	Surveying the challenges and benefits of adopting EA in the Norwegian HE sector to examine the possibility to have common EA for HEIs.

		Goals achieved:
		• Identifying a number of challenging issues that hindered progress towards a common EA; these are:
		  o The lack of an overarching governing body.
		  o The lack of agreement about the vision and scope of the EA initiative.
		  o The lack of senior management involvement in describing the common IT engineering principles for the technical part of EA only.
		• Identifying the most important benefits of a common EA which are enhancing business agility, having better decision-making, and achieving economies of scale.

(Adwan & Al-Soufi, 2016)	An Educational Institution (IS-Dep) Information Systems Department in Bahrain	Developing a current and future EA models of the IS-Dep to assess its readiness for investing in a new Dashboard application.

		Goals achieved:
		• Providing the development of EA analysis for IS-Dept.
		• The Architecture Development Process (ADP) steps were followed and partly employed to work with Zachman framework to develop a baseline and targeted EA for IS-Dep.
		• The development process was limited at step 3 of the ADP and the project discontinued due to financial limitations.
		• Three issues were identified in which IS-Dep needs to resolve:
		  o Having difficulties in communicating and sharing information.
		  o Having centralized university data and information.
		  o Not using many services fully.

(Amalia & Supriadi, 2017)	The University of XYZ in Bandung	Using TOGAF and ADM to build appropriate EAF to produce a blueprint of IS/IT strategic planning for XYZ[2] University.

		Goals achieved:
		• The following stages of this study have been achieved:
		  o Creating a design using TOGAF and ADM for 9 functional areas of business.
		  o Establishing 11 principles for the development of the IT architecture.
		  o Establishing a future applications portfolio.
		  o Having the modeling of EA as a reference to build a blueprint for developing ISs and IT at the university.

[2] ‘XYZ’ is the terminology that Amalia and Supriadi (2017) use in the paper to keep it confidential

Related work	Context	Goal of a case study
(Czechowski, Padam, Anderson & Woodcock, 2011)	Coventry University in UK	Demonstrating how EA can be acting as a change agent when applied to large-scale projects to overcome cultural barriers, exploit all opportunities, and maximize business benefits.
		Goals achieved: • Providing a report on the use of EA for Coventry University and focusing on ArchiMate and TOGAF. • Providing details on the Smartcard project and why it was chosen to use EA. • Defining the tools used with EA. • Identifying three areas for improvement: process standardization, systems integration, and better use of technology for improving the efficiency of the process.
(JISC Flexible Service Delivery programme, 2014)	University of Bolton in UK	Using ArchiMate to build lightweight EA models of the functions of University of Bolton to help adapt to the new approaches needed for developing administrative processes and systems.
		Goals achieved: • The ArchiMate language and elements of the TOGAF framework were used in the project to develop EA at the university. The benefits achieved are: • Setting up the student record and reducing the administrative cost and effort around overseas campus enrolments and reducing the number of requests for assistance from the IT support office. • Improving knowledge and understanding across the business areas involved in applications, admissions, and enrolments, and creating reusable models to be used in new projects.

2.7.3 EA Journeys and Experiences

A group of universities adopted EA several years ago and published documents of their EA journeys. The Experiences of EA report (2014) provides a list of the EA journeys for a set of universities in UK that were captured during JISC Flexible Service Delivery program. It saw EA as a fundamental tool across the program in helping institutions become more effective, efficient and able to deliver core offerings. Besides these journeys, Charles Sturt University (CSU) has adopted EA and has provided several workshops to help others with using EA in HE sector by providing a set of reference models and templates (Bedwell, Cresswell, Sousa, Ireland & Percival, 2008).

These experiences should be studied and investigated to draw conclusions, whether positive or negative. They can provide guidance on the implementation of EA. Due to the similarities in the institutions of HE, these experiences may help to identify not only the most critical factors that contributed to the success of the implementation of EA but also the obstacles that hinder the implementation and how to resolve them. It is also possible to take advantage of the reference models and templates built in these experiences and adopted for the implementation of EA.

2.8 Agile Enterprise Architecture in the HE Context

Agile Enterprise Architecture (AEA) is one of the most important subject areas that have recently emerged. Despite the lack of studies about AEA (Kaddoumi & Watfa, 2016; Velumani, 2017), specifically in the HE context, it is an important topic for which more attention should be paid. At first, AEA is defined as a "flexible, easily extended, and easily evolved collection of structures and processes upon which your organization is built" (Ambler, 2015). Thus, it adds to traditional EA the notions of flexibility, extension, and evolution. This can be achieved by applying agile development principles and methods to EA (Velumani, 2017).

The goal of AEA is to incorporate the stakeholders in the process of EA by supporting communication between them and enterprise architects, in order to ensure their needs are understood. It also reinforces the collaboration between the enterprise architects and other teams to support them in their development efforts. In addition, it encourages applying agile practices and approach for EA modeling and documentation, which means applying the iterative and increment approach and ensuring that models are simple.

Ambler (2009, 2015) and Kaddoumi and Watfa (2016) identified the reasons for needing AEA from different perspectives. Ambler (2015) stated, "Enterprise architecture, when performed in a disciplined agile manner, is an important enabler of agile software delivery." The Disciplined AEA encourages using common architecture, common technical guidance, and a common infrastructure to enables agile teams to focus on value creation, and support consistency and continuous delivery (Ambler, 2015). It also allows scaling agile strategies horizontally through the enterprise (Ambler, 2015). Ambler (2009) emphasizes that in his opinion a particularly common issue occurring in enterprises is over-emphasis on tools and processes as opposed to people and relations. Certain problems commonly arise that can best be tackled by moving to AEA; these include outdated architecture, narrowly focused EA models, and issues in communication among enterprise architects and project teams (Ambler, 2009).

Kaddoumi and Watfa (2016) claim that the complexity and difficulty of EA frameworks is the first reason for needing AEA (Kaddoumi & Watfa, 2016). Most of EAF methodologies are designed based on waterfall methods (Kaddoumi & Watfa, 2016). This leads to problems such as slowness, slow return of investment, and difficulties in realizing the value of EA (Kaddoumi & Watfa, 2016). The EAFs based on waterfall do not address the agility needs of enterprises and the change adaptability. Also, they do not ensure early and periodical delivery of concrete EA deliverables and continuous adaptation to change (Kaddoumi & Watfa, 2016). A second reason is that enterprise architects spend their time and efforts on documenting the current state of enterprise more than developing innovative solutions, which impedes the achievement of EA goals and values. The third reason is the negative stakeholders' perceptions on EA (Kaddoumi & Watfa, 2016). Outdated EA deliverables make stakeholders think that EA is complicated, and it consumes time and resources without real value creation.

Hence, in order to adopt AEA successfully, Ambler (2009) defined five fundamental issues need to be addressed which are:

1. Agile enterprise architects should focus on stakeholders, customers, and project teams.
2. To increase the chance of understanding EA models and documents, agile enterprise architects should keep them simple ("good enough").
3. Agile enterprise architects should work iteratively and incrementally.
4. Agile enterprise architects should support project teams with the architecture process, and coach developers in the architecture and architecture skills.
5. Agile enterprise architects should ensure their technical ideas work before asking their teams to try them. This can be done be writing small codes to validate the ideas.
6. Agile enterprise architects should look at the whole picture of the enterprise to enhance their understanding and description of the architecture.
7. If the stakeholders and customers perceived value from the work of agile enterprise architecture, they would be attracted to AEA.

Ambler (2009) emphasizes that adopting AEA needs a change in the mindset of enterprise architects while working with other teams and with stakeholders. Thus, the AEA is all about people. Also, it is better to start small at first when adopting AEA in an organization

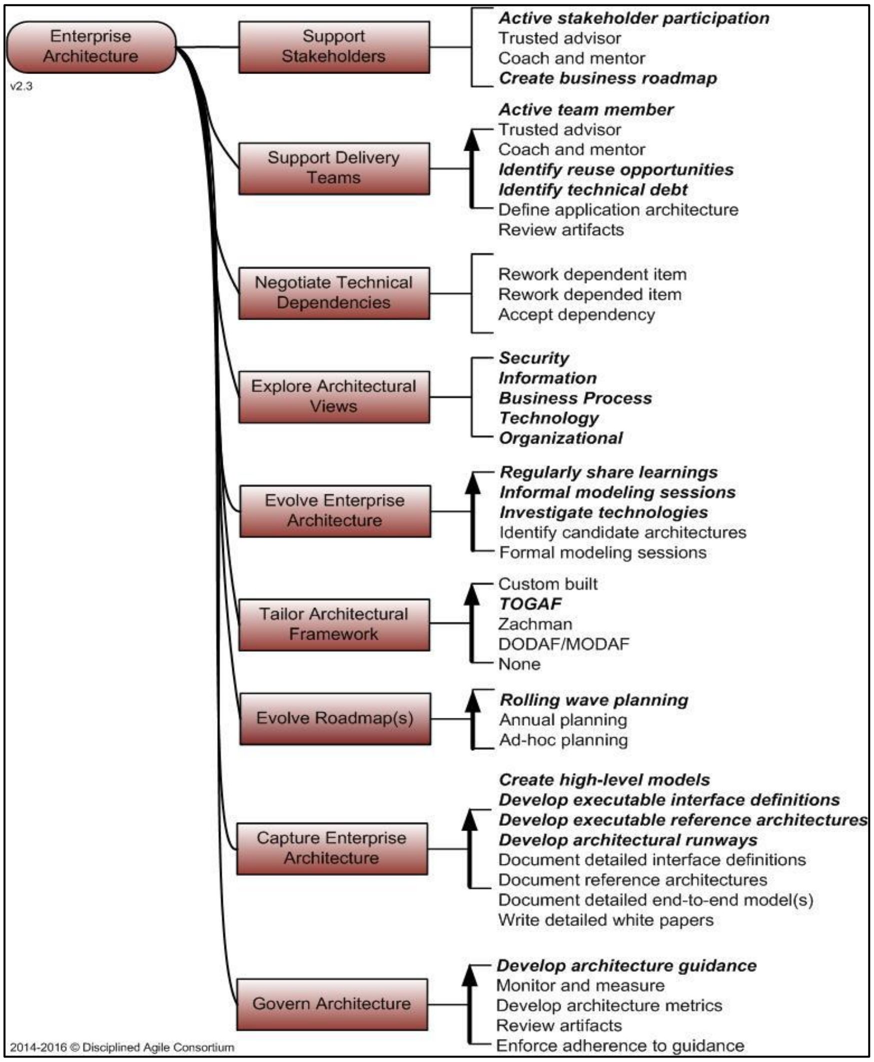

Figure 6 Agile Enterprise Architecture (AEA) goal diagram (Ambler, 2015)

in order to learn from experiences, evolve the adoption strategy based on what is learnt, and achieve some initial successes to boost confidence in the approach (Ambler, 2009).

AEA consists of several different activities. Ambler (2015) described these in a goal Diagram shown in Figure 6.

Ambler (2009) described the process of adopting the agile approach to EA in Figure 7. The idea is to get feedback and work iteratively and incrementally. The architecture work products will evolve over time.

Ambler (2015) provided a diagram to show more clearly the workflow of AEA within a disciplined AEA IT team in Figure 8.

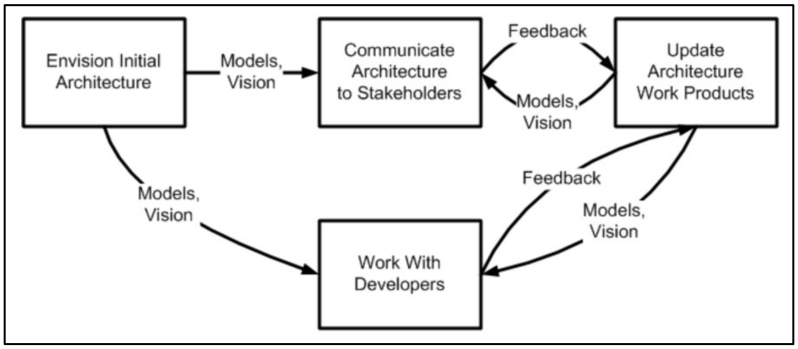

Figure 7 AEA adoption process (Ambler, 2009)

Ambler (2015) illustrated the workflow of AEA with other IT teams as shown in Figure 9. He described each process in the diagram and how it associates with AEA.

There have been several publications about AEA; however, none of them focused on the HE domain. The first two works of (Rouhani et al., 2008) and (Kaddoumi & Watfa, 2016) proposed an AEA framework from two different viewpoints. The third work of Velumani (2017) focused on the adoption method of AEA for large organizations that had already the traditional EA.

Rouhani et al. (2008) proposed Agile Enterprise Architecture Framework (AEAF) to enable the planning of enterprise's requirements using agile methods and practices. One of the most important benefits of this framework as stated by Rouhani et al. (2008) was that it enhanced the cooperation between the enterprise architects and other teams. It also increased the involvement of the stakeholders in the development of architecture by

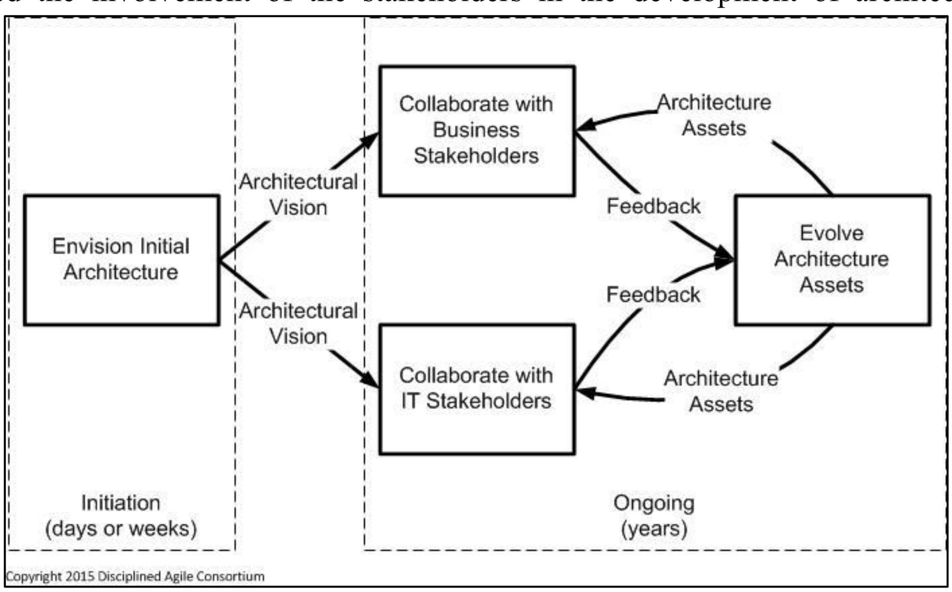

Figure 8 AEA adoption process within IT team (Ambler, 2015)

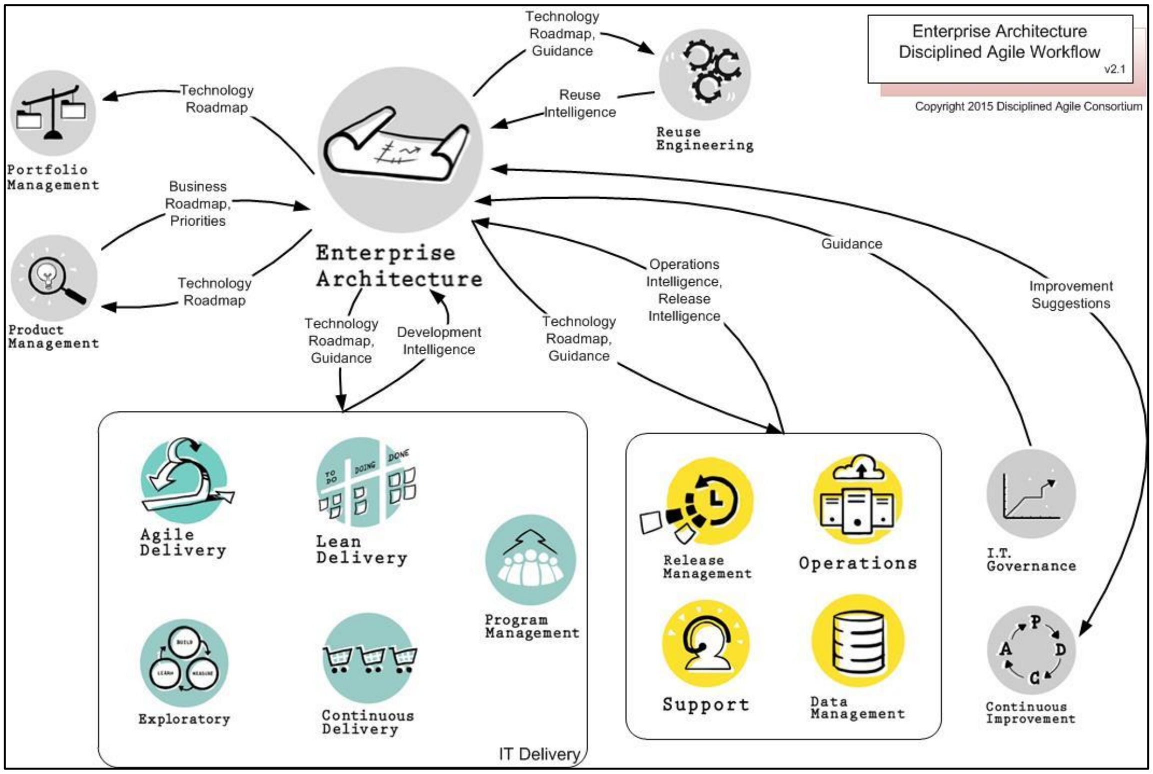

Figure 9 AEA adoption process with another IT team (Ambler, 2015)

determining their viewpoints and requirements. This framework consisted of 7 models and 11 relationships between them. The models and their interactions were built based on agile values and principles. This framework also covered five different viewpoints (planner,

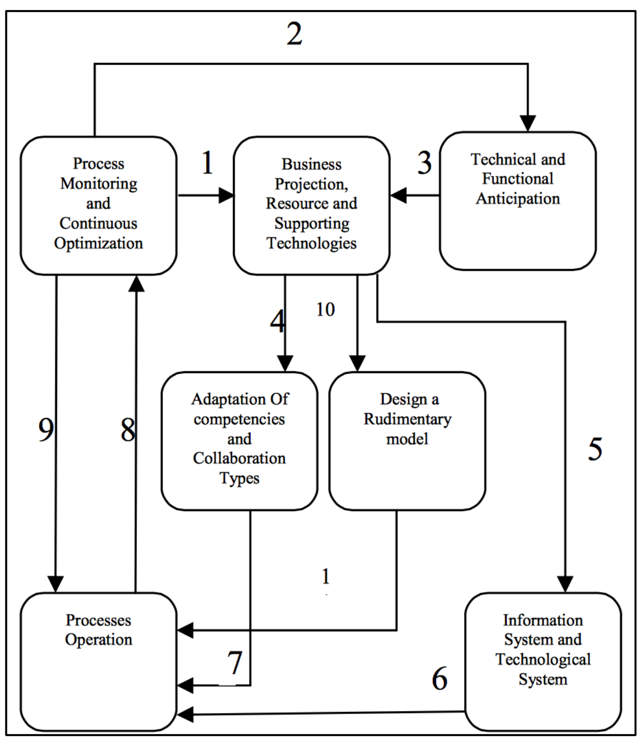

Figure 10 Agile Enterprise Architecture Framework (AEAF) (Rouhani et al., 2008)

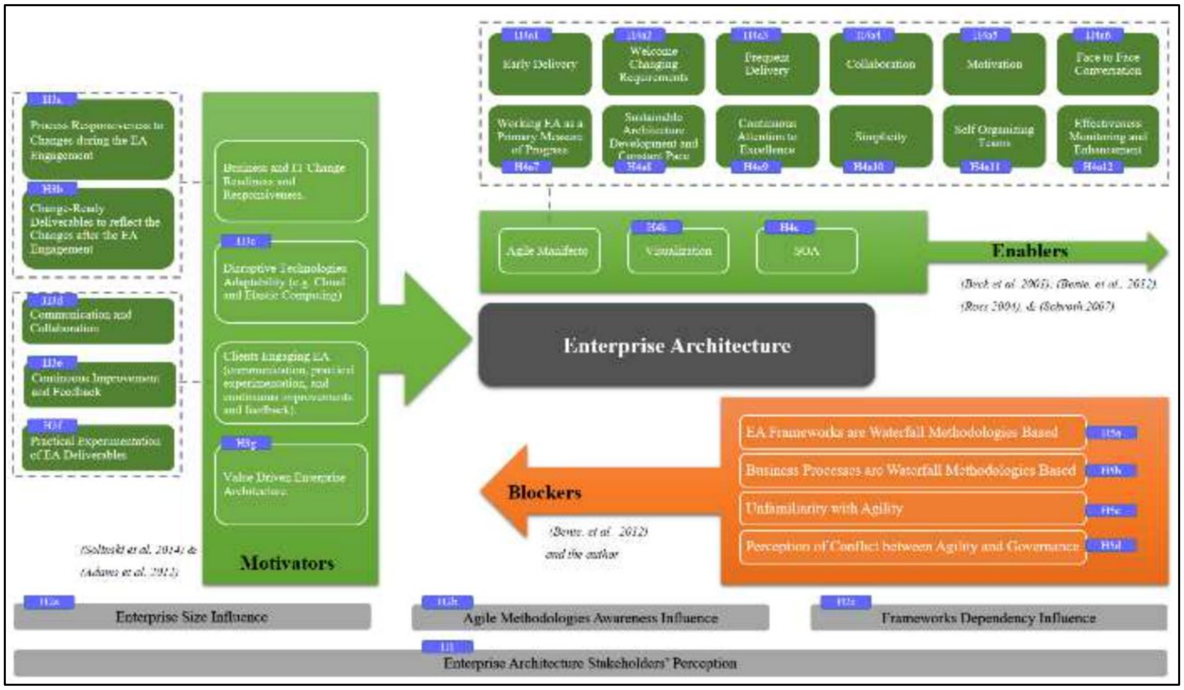

Figure 11 AEA Framework by Although Kaddoumi and Watfa (2016)

owner, designer, builder, and programmer) and six aspects of enterprise (data, function, network, people, time, motivation). This AEAF is shown in Figure 10. This framework was not validated. It has an aim to achieve agility by combining technical standards, which helped the enterprise to achieve its goal quickly. However, it lacks clarity on how the models are applied, how linkages between these models work, and how they communicate with the enterprise as a whole.

On the other hand, Kaddoumi and Watfa (2016) conducted a study to fill the gap in research of the perception of EA stakeholders regarding AEA. They investigated the elements that contribute to shaping the basis for the potential relationship between agility methodologies and EA. They proposed a framework for AEA consisting of a set of elements that constitute the foundation of this potential relation: EA, EA Motivators, EA Enablers, and EA Blockers as demonstrated in Figure 11.

Although Kaddoumi and Watfa (2016) used this framework to illustrate the relationship between EA and agile approach, their AEA framework was not validated; it depended only on what exists in the literature.

Velumani (2017) focused on studying the most important factors influencing the adoption of AEA in large organizations. To do this, Velumani (2017) studied the role that the

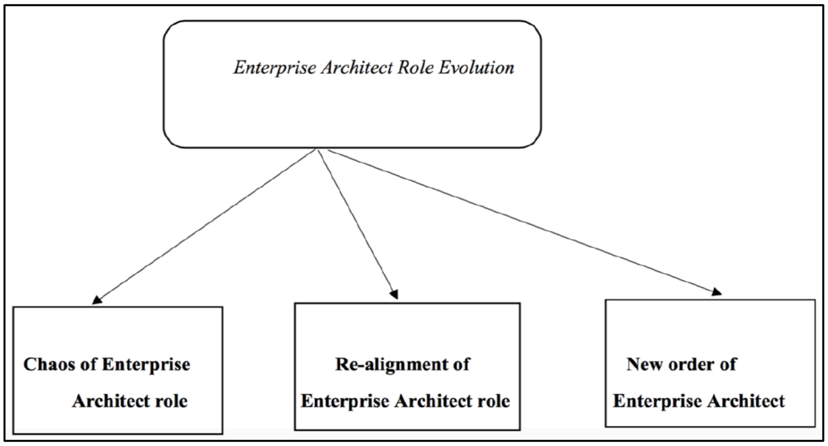

Figure 12 Enterprise Architects' role evolution during adopting AEA (Velumani, 2017)

enterprise architect plays in adopting the agile approach to EA, and how the role evolves when organizations transition from traditional EA to AEA.

Velumani (2017) illustrated the evolution of enterprise architecture's role during the adoption of AEA based on data gathered and analyzed from a case study conducted in Alpha Company in the transportation sector in North America. As a contribution to his study, Velumani (2017) illustrated how the role of enterprise architects is evolved through the adoption of AEA as shown in Figure 12. The study of Velumani (2017) was based on data gathered from a case study in the transportation sector. Therefore, it is not possible to generalize the result to other sectors such as the HE sector.

2.9 Summary

In this chapter, we present a review of the literature conducted on the adoption of EA in the HE sector. We reviewed 23 different sources on this subject area, the majority of which were not academic. The aim was to find out what was done in this area from different sources such as the websites of different universities and their documented EA work in addition to some theses.

The studies focused on two main areas namely the use of EA to align business needs and goals with IT, and the various aspects of EA adoption in HEIs. There has been some research that had been done on the development and use of EA frameworks in the HE context, the practical development of EA for HEIs, the challenges, benefits, and critical success factors for EA adoption n HEIs, the domain-Specific framework of EA for HEIs, the reasons for using EA by HEIs, the agility with EA in HEIs, as well as the previous HEI EA pilots, case studies, and experiences.

There are some aspects that were not discussed in this preliminary literature review, such as the tools and models used to develop EA for HEIs. In the next chapter, we present a Systematic Literature Review (SLR) and its findings to focus more on published academic research in the subject area of the thesis.

Chapter 3 Systematic Literature Review for EA in HE Sector

We conducted a Systematic Literature Review (SLR) to explore the use of EA in the HE sector. The review's steps are inspired by the guidelines of Kitchenham and Charters (2007). It was conducted through five main steps of the SLR process (Kitchenham & Charters, 2007). There were several iterations involving these phases until the final result was obtained.

The five major phases of this literature review are:

1. Identification of the need for a review and questions to be answered.
2. The selection criteria and the study quality assessment.
3. The search queries and electronic databases to be used.
4. The filters used to choose the relevant results.
5. The analysis and synthesis of returned results.

3.1 The Process of Using EA in HE Sector

The review methodology followed while conducting the literature review is as follows:

3.1.1 Objective of the Review

We investigate work being done in the HE sector that concerns the implementation and use of EA. We are interested in examining the long-term use of the EA in HEIs. We want to survey the diverse methods, tools, and frameworks used to implement EA in HEIs. Also, we want to investigate the models used to design the EA for HEIs. As well, we want to investigate if there is a domain-specific EA framework designed for HE institutions. Moreover, we want to survey the prominent challenges and critical success factors for the implementation of EA in HEIs. We also want to discover how the EA being adapted to suit the needs of the HE sector. This survey is an attempt to answer the following question:

How is EA being used in the HE sector?

3.1.2 Selection Criteria and Study Quality Assessment

The following set of criteria was inspired by the preliminary survey done in the previous chapter. We intended to investigate more the work done in this field. The selection criteria are:

1. Peer-reviewed papers.
2. English language.
3. Non-duplicated papers
4. The work shall be done in the HE context.
5. The work shall investigate the EA use in HE.

The results of the search queries are grouped into three categories:

1. *Relevant:* if the work satisfied all criteria (1 to 5).
2. *Not relevant:* if the work was not considering EA and was not done in the HE domain.

3.1.3 Search Query and Selected Electronic Databases

The main keywords to be used for creating the search query are: “Enterprise Architecture”, “Higher education,” “Postsecondary Education,” “Post-secondary education,” and “Third level education”.

The general query to be used to obtain the results is:

```
("Enterprise Architecture") AND ("higher education" OR "Postsecondary Education" OR "Post-secondary education" OR "Third level education")
```

The query was performed on ten general, large-scale databases: Google Scholar, Scopus, IEEE Xplore, Springer Link, Science Direct (Elsevier), EBSCOhost, ABI/Inform (ProQuest), Web of Science (ISI), JSTOR and ACM Digital Library (see Table 55 in Appendix A). We choose these e-databases to collect relevant papers.

3.1.4 Filter Process

After collecting the results, we did manual filtering based on the selection criteria in section 3.1.2. This filtering is composed of three sub-phases to choose the relevant papers resulting from the previous search queries.

1) *Abstract:* the filtering process starts by focusing on the abstracts. If a paper’s abstract seems to be relevant or partially relevant, the paper is transferred to the second phase; otherwise, it is excluded.
2) *Introduction, method, and conclusion:* the introduction, methods, and the conclusion of papers transferred from the previous step are read. Relevant papers

are transferred to the final step.

3) *Full paper:* in this step, all sections of the papers unfiltered by the previous steps are read. The relevant or partially relevant papers will be presented in this chapter as a result.

3.1.5 Results

Table 11 presents the returned results, from the selected databases, of the literature review process.

Table 11 Returned results from all databases of the related work on the use of EA in HEIs

Databases	Initial results	After 1st-iteration of filtering	After 2nd-iteration of filtering	After 3rd-iteration of filtering
Google Scholar	2443	84	49	40
Scopus	128	40	22	15
IEEE Xplore	94	20	12	10
Springer Link	130	8	6	5
Science Direct (Elsevier)	52	3	2	2
EBSCOhost	83	4	1	1
ACM Digital Library	148	11	4	4
Total	3073 (with duplicates)	170 (with duplicates)	96 (with duplicates)	75 (with duplicates) **53 (with no duplicates)**
Query: ("Enterprise Architecture") AND ("higher education" OR "Postsecondary Education" OR "Post-secondary education" OR "Third level education")				

We found a total of 53 peer-reviewed papers that discussed the use of EA in HE context from different perspectives. Conducting the SLR on this topic was hard due to two main reasons. Using the keyword “Higher Education” in the search query resulted in a considerable number of results that are unrelated this domain, instead, this keyword appeared in the address or description of the authors, their acknowledgment to specific institutions and so on. Therefore, we excluded a large number of studies. The other reason is that when we used the keyword “Higher Education” in Google Scholar we obtained a lot of irrelevant sources such as non-peer-reviewed papers and curricula. Also, books, book chapters, and non-English sources were retrieved. Sometimes websites that mention the use of EA were retrieved but they were not related to the scope of this study.

We analyzed and synthesized the relevant papers as shown in Table 12.

Table 12 Systematic literature review summary

Reference	Theme	Context	Date
(Ahmadi, Soltani & Gheitasi, 2007)	ICT Technical Reference Model of HEIs.	HEIs in Iran	2007
(Green, Beeson & Kamm, 2009)	Reusable process architectures and process models in HEIs.	HEIs worldwide - Two UK HEIs as case study	2009
(Oda, Fu & Zhu, 2009)	IT and business strategies alignment.	Corporations as well as HEIs- Oakland University as a case study	2009
(Yunis, Surendro & Telaumbanua, 2010a)	IT and business strategies alignment.	Indonesia HEIs	2010
(Syynimaa, 2010a)	Mergers of Higher Education Institutions (HEIs).	HEIs worldwide	2010
(Yunis, Surendro & Telaumbanua, 2010b)	IT and business strategies alignment.	HEIs worldwide	2010
(Oderinde, 2010)	IT and business strategies alignment.	HEIs worldwide	2010
(Carrillo, Cabrera, Román, Abad & Jaramillo, 2010)	Development of EA frameworks for HEIs -A roadmap for selecting and consolidating EA framework as a final product for HEIs.	HEIs of Ecuador	2010
(Clark, Barn & Oussena, 2011)	LEAP for expressing an EA model, including business motivation of HEIs and adding precision to EA technologies such as ArchiMate.	Organizations - University of Middle England (UME) as a case study	2011
(Doumi, Baïna & Baïna, 2011a)	IT and business strategies alignment.	Organizations – A real project at Rabat University in Morocco as case study	2011
(Doumi, Baïna & Baïna, 2011b)	IT and business strategies alignment.	Organizations – A real project at Rabat University in Morocco as case study	2011
(Goel, Tiwary & Schmidt, 2011)	Green Enterprise Architecture (EA) of campuses and academic institutions.	HEIs worldwide	2011
(Dongxing, Xulei, Qixin, Fang & Xiaolong, 2011)	A theoretical model -University Architecture (UA)- for the university-level information system construction at the stage of information integration.	HEIs worldwide	2011
(Syynimaa, 2012)	Implications of defining clear goals on the success of the EA implementation in HEIs.	HEIs worldwide - EA pilot conducted among eleven Finnish HEIs in 2011	2012
(Clark, Barn & Oussena, 2012a)	ICT and business strategies alignment.	HEIs worldwide - UK HEIs as case study	2012
(Clark, Barn & Oussena, 2012b)	ICT and business strategies alignment.	HEIs worldwide - UK HEIs as case study	2012
(Lu & Lin, 2012)	Study of competence of Enterprise Architects in HE.	HEIs worldwide - Taiwan Higher Education	2012
(Barn, Clark & Hearne, 2013)	ICT and business strategies alignment.	HEIs world-wide	2013
(Rychkova, Zdravkovic & Speckert, 2013)	EA methodologies challenges of decentralization organizations.	HEIs worldwide - HEIs in Sweden as a real case study	2013
(Beeson, Green & Kamm, 2013)	Reusable process architectures and process models in HEIs.	HEIs worldwide	2013
(Aserey & Alshawi, 2013)	A conceptual model for explaining outcomes of Enterprise Application Integration (EAI) adoption process in HE.	HEIs - King Abdulaziz University (KAU) a s case study	2013
(Araki, 2013)	IT and business strategies alignment.	HEIs worldwide - University of Lampung (Unila) as a case study	2013

Reference	Theme	Context	Date
(Doumi, Baïna & Baïna, 2013)	IT -IS and business strategies alignment.	HEIs world-wide - HEIs in Morocco as a case study	2013
(Kontio & Venho, 2013)	Development of EA for HEIs- creating a system architecture that serves EA for HEIs.	HEIs worldwide -Turku University of Applied Sciences as a case study	2013
(Golooba & Ahlan, 2013)	Improving collaboration and sharing of resources by organizations to create value for HEIs.	HEIs worldwide	2013
(Llamosa-Villalba, Delgado, Camacho, Paéz & Valdivieso, 2014)	Using the Agile School Architecture to enhance the Teaching-Learning process.	HEIs worldwide	2014
(Gama, Gaitan, Arteaga, Gomez, Gomez & Mena, 2014)	High Quality in Postsecondary Education in Colombia.	HEIs in Colombia	2014
(Ramadhan & Arman, 2014)	Measurement of EA adoption related to business process in HEIs.	HEIs worldwide	2014
(Zdravkovic, Rychkova & Speckert, 2014)	Development of EA frameworks - improving EAFs to overcoming decentralized organizations problems.	HEIs worldwide - HEIs in Sweden as a case study	2014
(Llamosa-Villalba, Carreño, Paez, Delgado, Barajas & Sneyder, 2015)	Development of EA frameworks for HEIs.	Colombian HEIs	2015
(Syynimaa, 2015b)	EA adoption challenges in HEIs.	HEIs worldwide	2015
(Ahmer, Demir, Tofallis & Asad, 2016)	Factors of enterprise resource planning systems (ERPS) in HEIs.	HEIs in Pakistan.	2016
(Syynimaa, 2016)	Solution for EA adoption challenges in HEIs - EA concepts misunderstanding.	HEIs worldwide	2016
(Chen, Tang & Li, 2016)	A Reference Model of IT Architecture of HEIs.	HEIs worldwide	2016
(Olsen & Trelsgård, 2016)	Challenges and benefits of common EA.	Norwegian HEIs	2016
(Adwan & Al-Soufi, 2016)	Practical development of EA Model for HEIs.	HEIS in Bahrain	2016
(Oktavia, Prabowo, Kosala & Supangkat, 2016)	A conceptual ontology model for social learning in HE.	HEIs worldwide	2016
(Sandkuhl & Lehmann, 2017)	Enterprise Architecture Management (EAM) for supporting digital transformation in HE.	HEIs worldwide - Rostock University as a case study	2017
(Bischof-dos-Santos, Takahashi, Giacomini, Rocha, Da Veiga & Duclós, 2017)	Implications of EA and Dynamic Capabilities in the study of higher education management.	HEIs worldwide - Brazilian Private HEIs as case study	2017
(Khumaidi & Ridhawati, 2017)	Using EAP for the development of information system strategies and information technology in HEIs.	HEIs worldwide – Private university in Pringsewu as a case study	2017
(Sanchez-Puchol, Pastor-Collado & Borrell, 2017)	Proposal for a unified IS RM for HEIs.	HEIs worldwide	2017
(Soares & Setyohady, 2017)	IT and business strategies alignment.	Oriental Timor Lorosa'e University is one of private universities in Timor Leste	2017
(de Fatima Gusmao & Setyohadi, 2017)	IT-IS and business strategies alignment.	Academic field - Instituto Profissional de Canossa (IPDC) Library	2017
(Amalia & Supriadi, 2017)	Development of EA frameworks - to create a blueprint of IS/IT strategic planning that is aligned with business needs.	HEIs - University in Bandung, West Java	2017
(Nama & Kurniawan, 2017)	The use of EAF for an EA planning for HE - design an adaptive IT infrastructure based on TOGAF ADM.	HEIs - University of Lampung (Indonesia) a s case study	2017

Reference	Theme	Context	Date
(Alamri, Abdullah & Albar, 2018a)	EA adoption for HEIs: HEI methodology used to adopt EA.	HEIs	2018
(Alamri, Abdullah & Albar, 2018b)	Development of EAF: Modeling and Simulation for EA on HEIs.	HEIs - Deanship of Graduate Studies (DGS) at King Abdulaziz University (KAU)	2018
(Searle, 2018)	Benefits of using EA for HEIS.	HEIs - Library Technology Management in an Australian university	2018
(Tjong, Adi, Kosala & Prabowo, 2018)	Exploring the existing EAFs used in HEIs and the reasons and implications of using them.	HEIs	2018
(Sanchez-Puchol, Pastor-Collado & Borrell, 2018)	Providing a unified, structured and comprehensive analysis process and catalogue of abstract EA artifacts (different ERAs and RMs	HEIs worldwide	2018
(Lethbridge & Alghamdi, 2019)	Frameworks, models and tools used in Higher Education Enterprise Architecture	HEIs worldwide	2019
(Bourmpoulias & Tarabanis, 2020)	EA approaches and challenges for the HE domain.	HEIs	2020
(dela Cruz, 2020)	Motivational antecedents influencing HEIs for adopting EA.	HEIs - Philippine HEIs	2020

In Table 12, it is clear that the context of the most studies is HE. Some of these studies were conducted in the domain of public organizations, but the validation of these studies involved using HEIs as case studies. Also, we recognized that the first publication in this area was in 2007 even though the Enterprise Architecture started in 1987 (Zachman, 1987). The other publications in this area were published from 2009 to 2020. Figure 13 shows the number of studies per year. It shows that there has been an increase in the number of studies interested in exploring and investigating the adoption of EA in HEIs for the last ten years.

Figure 14 showed the different themes discovered by returned studies. We categorize the relevant papers for each theme. In below, we discuss the different studies for each theme.

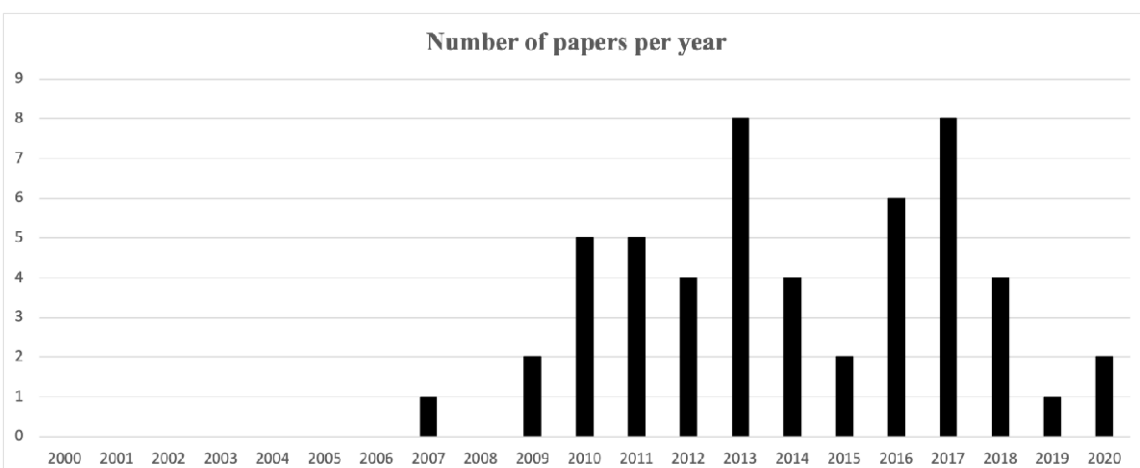

Figure 13 Number of papers per year

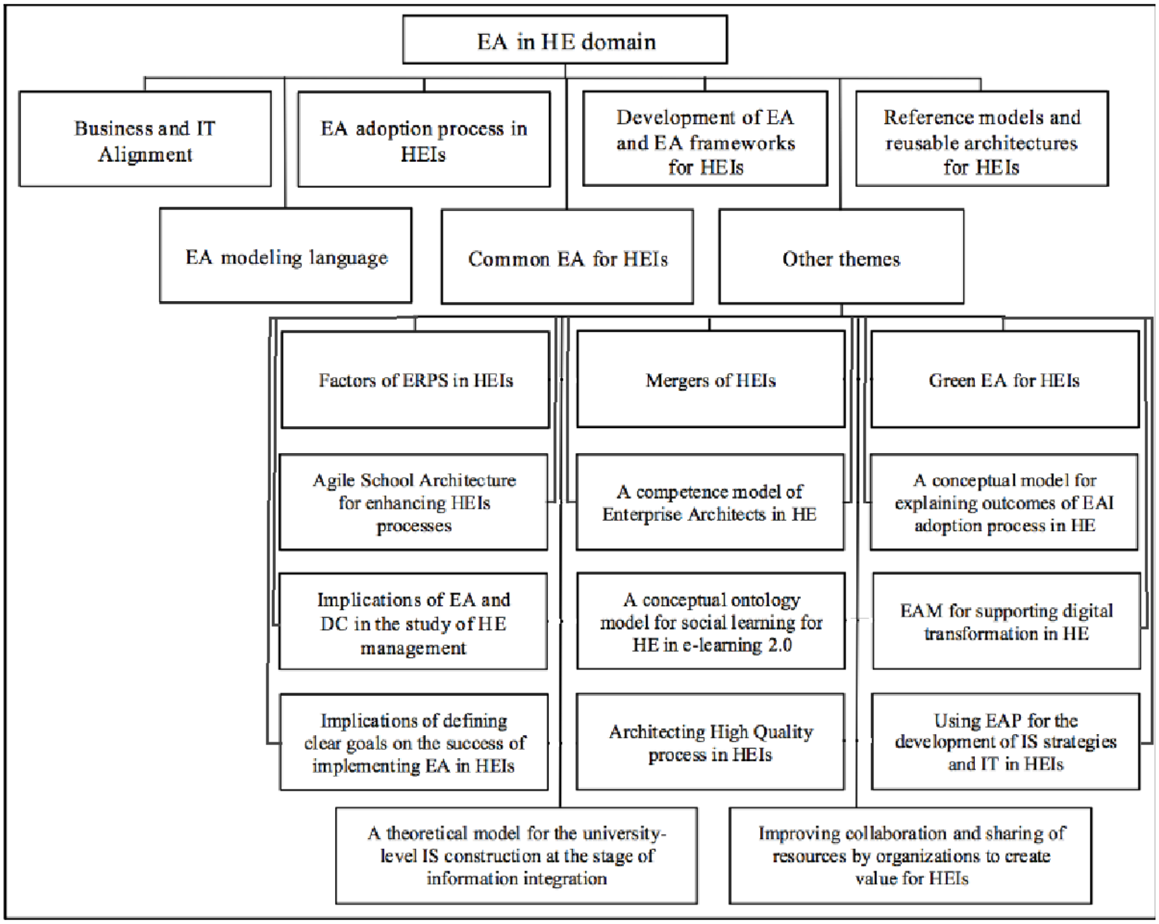

Figure 14 Different themes discovered in the SLR

3.1.5.1 Business-IT Alignment

A large number of returned studies (15 studies) in the SLR focused on the use of EA in HEIs as a tool for aligning their goals and vision with IT they used. The authors proposed different ways to use EA for this purpose. Most of the studies emphasized that using EA can help HEIs achieve the alignment of their business with IT either by using specific methods, methodologies or models.

Oda, Fu, and Zhu (2009) illustrated the importance of using an enterprise information security architecture (EISA) framework to incorporate security into all areas of EA to align security of HEIs with their business. In order to clarify the importance of EISA frameworks to HE institutions, Oda, Fu, and Zhu (2009) conducted a case study on Oakland University. They assessed its current security architecture compared to the existing industry security architecture frameworks and standards.

Yunis, Surendro, and Telaumbanua (2010a, 2010b) explained the use of EBA in HEIs to align their IT and business strategy. Oderinde (2010) indicated the need for using EA to help HEIs align their business strategy with their IT. Doumi, Baïna, and Baïna (2011a, 2011b) proposed a simple approach for modeling and evaluating the enterprise strategy-IT alignment using goal modeling and EA based on elements belonging to the two abstraction levels (strategic and functional).

Clark, Barn and Oussena (2012a, 2017b) built a lightweight domain-specific modeling language for EA called LEAP to model as-is and to-be EA models of HEIs with an aim to achieve the alignment of their business strategy and IT.

Araki (2013) proposed an EA-MDA model based on Web Information System (WIS) development to address the problems in HEIs in order to ensure that the planning, implementation, and control process of WIS are consistent with the business strategy of the enterprise.

Soares and Setyohady (2017) designed an enterprise architectural model that implements TOGAF by ADM stages to support the strategic plan of an integrated IS in HEIs to achieve their vision and mission efficiently and effectively.

Khumaidi and Ridhawati (2017) followed Enterprise Architecture Planning (EAP) methodology to develop a blueprint in the form of data architecture, application architecture and technology architecture as a whole on HEIs to support business turnover and achievement of their vision and mission and the goal of strategic development of IS and IT.

de Fatima Gusmao and Setyohadi (2017) created the EA models to be used as a guide of the Instituto Profissional de Canossa (IPDC) academic library to develop its ISs and IT services with a purpose to achieve the alignment of IS with business strategies.

Sanchez-Puchol, Pastor-Collado, and Borrell (2017) reviewed major existing developments of RAs and RMs to enable HE institutions to align their ISs and business strategies. Then they inductively proposed a unified IS RM tailored for HEIs.

Barn, Clark, and Hearne (2013) developed and used SICT toolkit for measuring the maturity of the extent of strategic alignment of an HEI’s needs and strategies with its ICT.

Doumi, Baïna, and Baïna (2013) created a BUSITAME (Business IT Alignment Modeling and Evaluation) model for strategic alignment of IS with business strategies in HEIs that covers the strategic and operational level. They also proposed a set of metrics to evaluate the strategic alignment.

3.1.5.2 Development of EA and EA Frameworks for HEIs

There are twelve studies among the returned studies of the SLR that discussed how to develop EA and EAFs for HEIs. For example, Carrillo, Cabrera, Román, Abad, and Jaramillo (2010) proposed a roadmap for selecting and consolidating EA framework as a final product for HEIs of Ecuador with the purpose of getting the best utilization of the IT resources.

Dongxing, Xulei, Qixin, Fang, and Xiaolong (2011) proposed a theoretical model called university architecture (UA) to construct the university-level IS at the stage of information integration and provide a unified planning for the overall process of IS development. This architecture consists of business architecture, ISs architecture, and technology architecture.

Rychkova, Zdravkovic, and Speckert (2013, 2014) identified conceptual problems of using EA methodologies in decentralization of organizations in the HE context and proposed a solution for these problems by identifying the concepts that link organizational structure, IT Governance and EA.

Zdravkovic, Rychkova, and Speckert (2014) indicated that some changes or additions to EAFs are necessary to enhance their support for decentralized business environments. Hence, they introduced two specific principles of peer-to-peer architectures (peer production and peer-to-peer trust management) to IT governance of EA frameworks. The idea was to offer more proper governance over current EA frameworks to support decentralized organizations because these EAFs can better match the decentralized components of the organizational structure of the university.

Kontio and Venho (2013) analyzed the system architecture of TUAS and discussed the future steps in creating a system architecture that serves EA for HEIs. They also provided an understanding of EA and its importance for HEIs.

Llamosa-Villalba, Carreño, Paez, Delgado, Barajas, and Sneyder (2015) created a CHE2A framework for managing the system-of-systems lifecycle of Higher Education Programs.

Adwan and Al-Soufi (2016) used Zachman Framework, ADP, and the ArchiMate modeling language to demonstrate the practical development of an EA (as-is and to-be effort) analysis that enabled the management of HEIs and assessed its readiness for investing in new systems, applications, or programs.

de Fatima Gusmao and Setyohadi (2017) develop IS and IT services for academic library IPDC by creating and designing the EA models following TOGAF, with the TOGAF ADM method for modeling its business architecture, information systems, and technology. This helps IPDC in achieving the alignment of its IS with business strategy.

Amalia and Supriadi (2017) established the concept of IS/IT strategic planning of the university based on the TOGAF framework and ADM. The aim was to produce a blueprint that aligning IS/IT with business needs of HEIs, optimizing the TOGAF ADM to design integrated systems to be more effective and building appropriate BEA model to perform their functions in which applying IT demand planning. As well, Soares and Setyohady (2017) implemented TOGAF methodology following ADM phases to design an enterprise architectural model that supported the strategic plan of an integrated IS of HEIs that helps in effectively achieving their vision and mission.

Nama and Kurniawan (2017) used a real case study to apply TOGAF ADM stages (from the preliminary phase to the opportunities and solutions) on the university to create an IT infrastructure architecture. As a result, they defined three core business activities: education activity, research activity, and community services, and they identified six supporting activities and proposed developing 12 new applications. All applications were designed to be modular and integrated. The aim was to design an adaptive and scalable IT infrastructure centrally managed by the IT unit to support the university business services and respond fast to business and application strategy changes (Nama & Kurniawan, 2017).

Tjong et al. (2018) followed the systematic mapping study approach to investigate the existing EAFs used in HEIs. The aim was to assist HEIs in choosing suitable EAF. The study concluded that TOGAF and Zachman were the common EAFS used in the HE domain, and the EAFs were often developed and designed at the governmental level. The reasons for adopting EA in HEIs, according to Tjong et al. (2018), are to solve the problem of data inconsistencies and the lack of interoperability systems, improve the teaching-learning process, and plan the IT infrastructure. Also, the most critical implications of adopting EA in HE are defining clear strategic objectives for institutions, having a precise transformation planning and integration plan, ensuring management support and stakeholder involvement, and finally, improving the EA experiences and knowledge of people in institutions (Tjong et al., 2018).

Tjong et al. (2018) showed that the number of studies on the EA adoption in HEIs is still limited because only 12 papers discussed this matter.

In 2019, we published research (Lethbridge & Alghamdi, 2019) on the EA frameworks, models, and tools used in HEIs that is discussed in this thesis as a part of our study results. We do not include it in the literature review.

3.1.5.3 Common EA for HEIs

Introducing domain-specific EA framework for HEIs has positive impacts on the performance of institutions, but there are some challenges in adopting it. Olsen and Trelsgård (2016) identified the challenges and benefits of common EA in HEIs. They explored how EA is implemented in various sectors, what benefits and challenges are realized, and investigated the efforts taken towards a common EA in the Norwegian HE sector.

3.1.5.4 Reference Models and Reusable Architectures for HEIs

There were several contributions related to RAs and RMs tailored for HE. In addition, there were a few additional contributions that described the ability to reuse process architectures for HEIs. Sanchez-Puchol, Pastor-Collado, and Borrell (2017) performed a preliminary literature review on existing RMs and RAs tailored for HE institutions. They identified a list of main contributions that emerged from the practitioners and the grey literature that were adapted for HEIs. Then, they inductively generalized and derived a unified IS RM for HEIs. The proposed model can be used as a support-tool of communication and decision-making for several HEIs practitioners or stakeholders (Sanchez-Puchol, Pastor-Collado & Borrell, 2017, 2018). It enables HEIs to align IS with their business strategy.

Moreover, Ahmadi, Soltani, and Gheitasi (2007) built ICT Technical Reference Model (TRM) that considers all technical aspects of developing and integrating ICT activities in HE industry, specifically Iran universities, to reach e-government goals.

Chen, Tang, and Li (2016) developed RM for IT Architecture of University called UNITA (University IT Architecture) that consists of six layers, including hardware infrastructure, data and information resource, software system, user service, cyber security and IT governance.

In the case of reusing architectures and models, Green, Beeson, and Kamm (2009, 2013) assessed the potential for reusing process architecture in HEIs. Green, Beeson, and Kamm (2009) suggested building repositories of process models and architectures for use by HEIs and organizations in the same business sector. The aim was to prove that process architectures of organizations in the same business could be reused either for new process development or for appraising an organization's existing architecture. Therefore, Green, Beeson, and Kamm (2009, 2013) applied the process architecture development method - Riva, which is used to identify the process architecture of an HE institution, to two UK HEIs. The aim was to study and compare the processes architectures created for one common area of activity, taught programs, to assess the potential for reusing the process architectures.

3.1.5.5 EA Adoption Process in HEIs

There were several studies that discussed the challenges, benefits, and CSFs of adopting EA in HEIs. Ramadhan and Arman (2014) developed a method for measuring the implementation of EA related to the business process in HEIs with a purpose of identifying the factors that affected the adoption of EA by evaluating business architecture in TOGAF framework with BPM theory with modifications.

Syynimaa (2015b) created a model called a Resistance during the EA adoption Process (REAP) to identify EA adoption challenges in HEIs. The REAP model shows the relationships between strategic levels of EA, organizational changes, and sources of the planning and execution phases' resistance of the EA adoption.

To resolve EA adoption challenges, Syynimaa (2016) created an Enterprise Architecture Adoption Method (EAAM) for HEIs to improve the traditional EA adoption method. As a result, EAAM contributes to increasing the EA maturity in Finnish HEIs through increasing the likelihood of successful EA adoption, and this can be achieved by:

- Addressing the resistance caused by the lack of understanding of EA concepts.
- Helping in acquiring the mandate for EA adoption from top management.
- Helping in supporting individual and organizational learning.

Searle (2018) conducted an exploratory case study documenting key components of 'is-as' enterprise architecture (EA) of a library to encourage other librarians to learn about the benefits of adopting EA methods in the library systems in favour of the institution as a whole. The short-term benefits of adopting EA in the library were identified, and the outputs of the EA process were determined that would assist institutions in the future to better plan for improving the library's IT planning and strategic procurement (Searle, 2018). Examples of short-term benefits include making the team proactive as they become able to identify architectural issues, increasing awareness of management groups about the integration methods commonly used in the library system, getting a better understanding of the complexities of the underlying application architecture, assisting library technology services in communicating, whether within the team or with other stakeholders, being able to upgrade the library management system, and increasing the trust of senior executives in the enterprise architects. The study did not identify the long-term benefits and risks because it was conducted on a single case only, so its applicability may be limited. Also, the study was limited regarding the resources as the adoption of EA may consume many resources.

Alamri, Abdullah & Albar (2018a, 2018b) described EA's composition, its different layers, its role in HEIs, and the used EAFs and tools to facilitate strategic decision-making. They used a multi-stage SWOT analysis to find the most appropriate EA for any education sector by effectively implementing an HEI methodology. They developed the HEI methodology based on the Architecture Development Method (ADM) and SWOT analysis to provide a unified, comprehensive, and easy methodology for building a suitable EA for any of HEIs in seven interdependent and main stages including developing EA plan, developing EA structure, building current and target architectures, and developing a transition plan, maintenance, and finally continuous activities.

Alamri, Abdullah & Albar (2018b) applied the EAF to model and simulate the Deanship of Graduate Studies (DGS) at King Abdulaziz University (KAU) to clarify its procedures and system applications by following the HEI methodology consisting of seven main stages and identifying the outputs from each stage. They also identified ten Key Performance Indicators (KPIs) for measuring the framework performance in strategic planning and investments and its impacts on HEI methodology's performance to DGS.

The above study had been done on one case study, and thus the possibility of generalizing the results of the feasibility of the framework to other HE institutions is limited (Al-Amiri, Abdullah & Al-Bar, 2018b). Al-Amiri, Abdullah & Al-Bar (2018b) concluded that identifying other KPIs is needed to measure EA's effectiveness in HE.

dela Cruz (2020) conducted a qualitative method complemented with an exploratory research design to provide a PHEI thematic map embodying the relationship between factors motivated HEIs in the Philippines to adopt EA in its long-term IT strategy and understand how institutions see EA and its impacts. The seven factors that impact the EA adoption process in HEIs are viewpoints, stakeholders, human traits, vision, revolutionary innovation, techniques and change components. The study revealed the importance of the human factor in the success of adopting EA in HEIs. dela Cruz (2020) then used a Venn diagram to show the relationship between the Chocolate Model (Dormant, 2011) of dimensions of change, the identified motivational factors and the adoption factors defined in the literature to support change in HEIs.

Bourmpoulias and Tarabanis (2020) followed a systematic mapping study to determine the major approaches and challenges of adopting EA at all educational levels. The study showed that although there is some research on adopting EA in the HE domain, it is still limited in primary and secondary education and lifelong learning, and it is also still very little in the field of adopting EA in educational systems in countries that are considered pioneers in this field. They identified the most important challenges facing educational institutions, including data inconsistency and redundancy, lack of interoperability, complex IT work, non-integrated information systems, lack of senior management commitment and institutional commitment, lack of EA knowledge and lack of training.

Despite the benefits of adopting EA for educational institutions, such as improving processes, enhancing IS interoperability, and integrating data, EA's maturity level remains low, according to Bourmpoulias and Tarabanis (2020).

The above study covers all research on educational levels for the last ten years, while our research focuses only on the scope of higher education. The study suggested doing more research in this area, especially from the pioneering countries in adopting EA in their educational institutions (Bourmpoulias & Tarabanis, 2020).

3.1.5.6 EA Technologies and Modeling Languages

EA technologies such as ArchiMate provide diagram-based models to express architectures, but they do not have precise semantics. Hence, managing the EA models is difficult especially when these models become large and complex (Clark, Barn & Oussena, 2011). The EA technologies provide varied views of an organization and also can be used to link business goals to their realization in technology (Clark, Barn & Oussena, 2011). In order to add precision to EA, model-driven approaches are used. These approaches use models to relate different views and define semantics for modeling languages (Clark, Barn & Oussena, 2011).

Clark, Barn, and Oussena (2011, 2012a, 2012b) created LEAP (Precise Lightweight Framework for EA) for expressing an EA model, including business motivation of HEIs and adding precision to EA technologies such as ArchiMate. LEAP can be mapped directly to leading EA technologies used to define a simple EA modeling language based on the Unified Modeling Language (UML) that addresses the problems of ArchiMate (Clark, Barn & Oussena, 2011). LEAP views an institution as hierarchically decomposed communicating components and allows all aspects of the architecture to be precisely defined using standard modeling notations (Clark, Barn & Oussena, 2011). It is used to represent EA components and model as-is and to-be EA of HEIs with an aim to providing a simulation environment that delivers an unambiguous description of the required changes and achieves the alignment of their business strategy and IT (Clark, Barn & Oussena, 2012a, 2012b). Clark, Barn, and Oussena (2012b) illustrated the use of LEAP by conducting a case study of business change currently being addressed by UK HEIs. This case study showed how to add business goals extension to ArchiMate, and how these can be expressed and formally analyzed in LEAP.

3.1.5.7 *Other Themes Related to the Use of EA in HEIs*

There are other themes discovered by about 15 studies. These themes are:

Mergers of HEIs: Syynimaa (2010a) introduced a framework called HMEF based on EA to evaluate the merger of HEIs and this framework focused on factors that affect the success of the mergers.

Green Enterprise Architecture (EA) for HEIs: Goel, Tiwary, and Schmidt (2011) proposed a strategic approach for implementing green EA of HEIs that is based on the Total Sustainability Framework (TSF) and the Total Sustainability Indicator (TSI). The purpose was to help HEIs achieve their goals and objectives of sustainability in a holistic and balanced way.

Competence models of Enterprise Architects in the HE sector: Lu and Lin (2012) created a practical competence model that identifies the core competencies of enterprise architects in HEIs.

Agile Architecture for enhancing HEI processes: Llamosa-Villalba, Delgado, Camacho, Paéz, and Valdivieso (2014) proposed using agile school architecture, which is an archetype of EA, for enhancing an organizational leadership process in HEIs. They illustrated that combining agile school and Processes of Organizational Leadership helps in leading and managing strategies, tactics, and operations of forming in HEIs. The Agile School model includes patterns that serve as a reference for organization and practices for a typical architecture of HEIs, and it is used to enhance the Teaching-Learning process.

EAM for supporting digital transformation in HE: Sandkuhl and Lehmann (2017) examined the role of Enterprise Architecture Management (EAM) for structuring digitization efforts of HEIs and supporting planning the transformation of the digitization strategies and the role of the portals for implementing the strategies and the transformation concerning educational services.

Implications of EA and DC in the study of HE management: Bischof-dos-Santos, Takahashi, Giacomini, Rocha, Da Veiga, and Duclós (2017) created a new causal model to relate enterprise architecture (EA) to the dynamic capabilities (DC) approach of HEIs by first positioning an HEI in an operating model.

<u>Conceptual ontology model for social learning for HE in e-learning 2.0:</u> Oktavia, Prabowo, Kosala, and Supangkat (2016) created an ontology that identifies social learning factors framework that can be mapped into Zachman Framework for enhancing collaboration and increasing responsiveness by leveraging social media channel in HE.

<u>Using EAP for the development of information system strategies and information technology in HEIs:</u> Khumaidi and Ridhawati (2017) used the Enterprise Architecture Planning (EAP) methodology as a guide for making a blueprint of the strategy development of IS/IT as a whole on HEIs to support business turnover and achievement of vision and mission and the goal of strategic development of IS /IT.

<u>ERPS in HEIs:</u> Ahmer, Demir, Tofallis, and Asad (2016) identified factors that contributed to the usage of enterprise resource planning systems (ERPS) at the organizational layer, the departmental layer and the end-user layer in HEIs in Pakistan.

<u>Implications of defining clear goals on the success of the EA implementation in HEIs:</u> Syynimaa (2012) investigated the type of goals set for the EA implementation (either clear or unclear), studied the evolving of these goals during the time, inspected if those goals are different or similar among stakeholders, and explored the effect of these goals on the success of EA implementation.

<u>Architecting high quality process in HEIs:</u> Gama, Gaitan, Arteaga, Gomez, Gomez, and Mena (2014) architected the process of High-Quality Accreditation of HEIs to verify the full compliance with the accreditation rules, policy, and quality assurance of entire academic programs. The architecture approach covers the whole processes of High-Quality Accreditation of a university and facilitates the strategic alignment of the different units of a university to the final strategy which is the High Quality.

<u>Models for the university-level information system construction at the stage of information integration:</u> Dongxing, Xulei, Qixin, Fang, and Xiaolong (2011) proposed a theoretical model called university architecture (UA) to construct the university-level IS at the stage of information integration.

Conceptual models for explaining outcomes of EAI adoption process in HE: Aserey and Alshawi (2013) analyzed the combination of the existing classification of Enterprise Application Integration (EAI) factors with the HE factors to enhance the implementation of EAI in HEI at both organizational and operational levels.

Improving collaboration and sharing of resources by organizations to create value for HEIs: Golooba and Ahlan (2013) proposed a framework of value creation to examine the use of a service-oriented enterprise architecture (SOEA) as an enabler in HEIs to co-create value between themselves in the context of research collaboration in HEIs through six key value drivers which are connectivity, automation, agility, service interactions, intelligence, and resource integration.

3.2 Discussion

3.2.1 The Use of EA in HE Beyond Planning Phase

A few studies reviewed the early stage of the adoption and planning of EA in HEIs that used EA for their very first time (Ramadhan & Arman, 2014; Syynimaa, 2015b; Syynimaa, 2016; Nama & Kurniawan, 2017; Searle, 2018; dela Cruz, 2020). However, the SLR we conducted did not show any study that discovered the stage of adopting EA in HEIs beyond the planning phase. There is even no study discussing the implication of full implementation of EA in HE. In fact, we could not find any research in the SLR that discusses the CSFs, challenges, and benefits of using EA in HE beyond the planning stage including the stages of implementation, evaluation, and adaptation to the changes. Therefore, there is a gap in the literature review in discovering these phases of work even though we found a reasonable number of experiences and pilot studies that illustrated the process of using EA in HEIs in the grey literature as explained in Sections 2.1.7.1, 2.1.7.2, and 2.1.7.3.

Indeed, there are five studies among the returned studies illustrated the attempts to develop EA for specific HE institutions. The first effort was made by Adwan and Al-Soufi (2016) to develop EA for the IS-Dep in an educational institution in Bahrain, but the development process was limited at step 3 of the ADP and the project discontinued due to financial limitations. The other attempt was the work of Amalia and Supriadi (2017) who used TOGAF to develop EA for the University of XYZ in Bandung, West Java. The two studies covered particular cases of two HEIs, and therefore it is hard to figure out if their experiences could be generalized to other HEIs. Also, these studies did not discuss the challenges they faced during their EA journey or the critical factors that contributed to the success of their projects. Nama and Kurniawan (2017) did not describe the implications of using an improved IT infrastructure developed based on the TOGAF ADM phases and whether the findings could be generalized to other cases in the HE domain.

Due to limited resources, and because the study was conducted on a single case study, Searle (2018) did not define any long-term benefits and risks. Searle (2018) adopted the EA process to improve library technology management in an Australian university, and the short-term benefits were identified. However, due to limited resources, and the study was conducted on a single case study, Searle (2018) did not define any long-term benefits and risks. dela Cruz (2020) identified the motivational antecedents influencing Philippine HEIs for adopting EA. The study included only Philippine HE institutions, so there is still a need to investigate more institutions that adopted EA to validate the study's feasibility.

3.2.2 EA Methodologies, Methods and Frameworks Used to Implement EA in HE

The SLR shows a gap in the evaluation of the suitable EAFs that could be used for developing and implementing EA in HEs. Carrillo, Cabrera, Román, Abad, and Jaramillo (2010) proposed a roadmap and a general scheme that helps in selecting the suitable EAFs for any HEIs, but the suggested scheme can be applied to any domain, and it is not tailored for HE context. There are also some other studies in this review suggested using Zachman and TOGAF to develop EA in HEIs. Yet, they do not provide concrete reasons for selecting these frameworks (Oda, Fu & Zhu, 2009; Ramadhan & Arman, 2014; Adwan & Al-Soufi, 2016; Oktavia, Prabowo, Kosala & Supangkat, 2016; Soares & Setyohady, 2017; de Fatima Gusmao & Setyohadi, 2017; Amalia & Supriadi, 2017). Tjong et al. (2018) investigated the reasons for and implications of adopting EAFs in HEIs. They concluded that the common EAFs used in the HE domain are TOGAF and Zachman. Bourmpoulias & Tarabanis (2020) investigated the approaches and challenges of adopting EA at all educational levels for the last ten years. However, their study did not focus on the HE domain. Alamri, Abdullah & Albar (2018a, 2018b) developed the HEI methodology based on ADM and SWOT analysis to provide a unified and comprehensive methodology for building a suitable EA for HEIs in seven main stages. Their study was conducted on one case study, DGS at King Abdulaziz University, and thus the applicability of the results to other HE institutions is limited (Al-Amiri, Abdullah & Al-Bar, 2018b). Drawing on this result, further research is needed to find out which EA framework, methodologies and methods are appropriate for use in the development of EA in HEIs. Also, exploring this area is more likely to help reach an EA framework and methodology that fits the scope of HE.

3.2.3 EA Tools Used to Support EA in HE

Gartner (2017) defines Enterprise architecture (EA) tools as, "software applications targeted primarily at supporting participants and stakeholders of the EA discipline in their strategically driven planning through to execution. Support for strategic decision making is provided through capturing vital enterprise context background, along with content development and analysis capabilities across the business, information, technology and solution architectures."

EA tools and technologies are essential in developing EA for HEIs. Unfortunately, there is a gap in the literature that covered this area. There are four studies suggesting using LEAP because it resolves the problems experienced with ArchiMate, and it enables adding extensions such as businesses motivators (Clark, Barn & Oussena, 2011, 2012a. 2012b). Hence, it used to add a precise semantics to the produced EA models.

Alamri, Abdullah and Albar (2018a) made a comparison between four EA tools: dragon 1, ArchiMate, Sparx Systems, and Corso. They did comparison-based points which are automation capabilities, customization and extendibility, operation capabilities, and vendor credibility and quality of client support. However, they did not provide a thorough analysis of the tools that best suit HEIs. However, there are no other studies that reviewed other EA tools used in the development and use of EA in the HE context.

3.2.4 EA Models Built for HEIs and the Modeling Notations Used

There are a few studies showing reference models for HEIs (Ahmadi, Soltani & Gheitasi, 2007; Green, Beeson & Kamm, 2009; Beeson, Green & Kamm, 2013; Chen, Tang & Li, 2016; Sanchez-Puchol, Pastor-Collado & Borrell, 2017). They discuss the importance of having these models for HEIs. Some other studies discuss the use of UML but to a limited extent. More research in this area is required to review the modeling notations used by HEIs to model and develop EA.

3.3 Gaps Identified in the Systematic Literature Review

The gaps that we found after conducting the systematic review can be summarized as follows:

- We found a reasonable number of experiences and pilot studies that illustrated the process of using EA in HEIs in the grey literature, as explained in Sections 2.3.1, 2.3.2, and 2.3.3. A few studies also reviewed the early stage of the EA adoption and planning in HE institutions, which have used EA for their very first time (Ramadhan & Arman, 2014; Syynimaa, 2015b; Syynimaa, 2016; Nama & Kurniawan, 2017; Searle, 2018; dela Cruz, 2020). However, there is a lack of studies that discussed the implication of full implementation of EA in HE, including the benefits of using EA in the HEIs, the critical factors that have contributed to their projects' success, and the challenges beyond the planning stage.
- The systematic review shows a gap in evaluating the suitable EAFs that could be used to develop and implement EA in HEIs. Few studies suggested using specific EAFs, but they did not provide concrete reasons for selecting them (Oda, Fu & Zhu, 2009; Ramadhan & Arman, 2014; Adwan & Al-Soufi, 2016; Oktavia, Prabowo, Kosala & Supangkat, 2016; Soares & Setyohady, 2017; de Fatima Gusmao & Setyohadi, 2017; Amalia & Supriadi, 2017). Another study by Carrillo et al. (2010) suggested considering five familiar EAFs and selecting the appropriate EAF, based on the framework selection criteria provided by Sessions (2007). Also, Tjong et al. (2018), Bourmpoulias and Tarabanis (2020) and Alamri, Abdullah and Albar (2018a, 2018b) made some contributions to this topic. We are not including research (Lethbridge & Alghamdi, 2019) that we did ourselves that is discussed in this thesis and was published in 2019. That research covered our findings on the EA frameworks, models and tools used in HEIs.
- There have been some attempts to build a domain-specific EA framework tailored for HEIs to simplify creating and developing EA for such institutions. These attempts have experienced various shortcomings due to limited research in using

EA in HEIs, particularly with respect to the longer-term evolution of such EA implementations. However, there is still a lack of research investigating using a common EA for the HE sector (Olsen and Trelsgård, 2016; Kondeth, 2016). There is a need for more research on how these frameworks are used and what benefits or struggles they have after fully implementing EA in the HE context.

- There is a gap in the literature discussing the suitable tools to support EA in HEIs, whether specialized or general. Some studies explained the analysis of the five EA tools or suggested using LEAP (Lightweight domain-specific modelling language for EA) as it resolves the problems experienced with ArchiMate (Clark, Barn & Oussena, 2011, 2012a. 2012b; Carrillo et al. (2010). Besides, Alamri, Abdullah and Albar (2018a) made a comparison between four EA tools used in this field which are dragon 1, ArchiMate, Sparx Systems, and Corso; yet they did not provide a thorough analysis of what tools are the best suit HEIs. However, no other studies reviewed other EA tools used in the development and use of EA in the HE context.
- A few studies showed and discussed the reference models and reusable architectures tailored for HE institutions and explained its importance (Sanchez-Puchol, Pastor-Collado, and Borrell, 2017). More research in this area is required to review the modelling notations used by HEIs to model and develop EA.
- There is limited research discussing the use of EA as a tool to resolve the issues of HEIs. A few of them discussed the importance of using an expert advisor in aligning the business strategy of higher education institutions with information technology. However, there is almost no research addressing the importance of using EA in aligning the business strategy of HEIs with IT, but there is almost no research that addresses the importance of using EA to support decision making at universities or improve their business processes. Besides, a few studies and dissertations reviewed the EA adoption challenges facing public organizations, including HE institutions and also investigated the critical factors that led to the successful adoption of EA (Oderinde, 2011, 2012; Syynimaa, 2015a; Bourmpoulias & Tarabanis, 2020).
- A few publications discussed the need and benefits of using Agile EA; however, none of them focused on the HE domain (Rouhani et al., 2008; Kaddoumi & Watfa, 2016; Velumani, 2017).

In Chapter 10, we provide a synthesis of the conceptualization of EA adoption in HEIs with respect to motivations, key success factors, and best practices based on this literature review, and also the grounded theory and survey research we present in coming chapters.

3.4 Limitations and Threats to validity

Threats to the validity of the systematic literature review results should be considered and deliberated (Kitchenham & Charters, 2007). Some threats can limit the internal and external validity of this research. We discuss these threats and illustrate how they can be mitigated in this section.

3.4.1 Internal Validity

Internal validity in a literature review involves bias in selecting and reviewing the publications. We used various strategies to mitigate this threat by using multiple electronic databases to search for relevant papers, doing backward reference searches, and using proper inclusion and exclusion criteria to select the appropriate papers. Secondly, two authors (the student and the supervisor) reviewed the selected papers and extracted data.

Another threat is that we selected only English peer-reviewed papers. Using other languages to search for papers on adopting EA in HEIs may be useful since the EA has been used in different countries. As well, accessing other sources such as working papers or white papers, trade magazines, organization websites, and experts' blogs may have provided other significant contributions. Therefore, we devoted the second chapter of this thesis to review some of these sources.

3.4.2 External Validity

External validity involves the ability to generalize the results of the review outside the scope of the study. This review's results were validated as we attempted to bridge the literature gap by conducting and analyzing a set of interviews with the experts and constructing a survey based on the grounded theory results and distributing it to many participants from countries worldwide.

Chapter 4 Research Methodology

In this chapter, we explain the research methodology we followed in this study and clarify the rationale behind our choices. We also describe in detail the two phases of the research methodology we undertook to conduct our research.

The purpose of our study is to gain an in-depth understanding of how HE institutions are using and implementing EA. Our objectives are to explore what motivates HE institutions to develop and employ EA, the frameworks and tools they use, the principles they apply, the challenges they face, what they have found to be critical success factors (CSFs), and how they respond to changes they face after ultimately adopting EA. Based on the information gathered, our final goal is to recommend how the EA process can be improved in the higher education context.

To achieve this goal, we first conducted an initial literature review (presented earlier in Chapter 2) to discover what has been done in this area. This initial research helped us review the concepts used to describe EA in the context of higher education. It shows how the EA had been used to overcome the various issues that HE institutions might face and the benefits they might obtain by applying EA. It also stated the different reasons for using EA in the HE context. The initial review also identified a list of previous pilot projects, case studies, and experiences of adopting EA by some HE institutions.

Then we conducted a systematic literature review (Chapter 3) to investigate in-depth the existing research performed in this context. The outcome of our systematic literature review shows that there is very little research about the use of EA in the HE domain. We also identified the gaps in the literature that need to be filled.

To fill these gaps and gain in-depth knowledge of this area, we decided to follow an exploratory sequential mixed-methods research design. It consists of an initial qualitative phase of data collection and analysis, followed by a quantitative phase, and finally a phase to integrate the two forms of data (Creswell & Plano Clark, 2011). The mixed-methods design is defined as “those that include at least one quantitative method (designed to collect numbers) and one qualitative method (designed to collect words)” to analyze both qualitative and quantitative data (Creswell & Plano Clark, 2011). The researchers should organize these methods into specific research designs and integrate or mix the two forms of data and their findings (Creswell & Plano Clark, 2011). Hence, our research approach consisted of the qualitative and quantitative phases, respectively.

In the first phase, we followed the grounded theory approach inspired by Birks and Mills's approach (2011) for the data collection and analysis. We used semi-structured interviews with university enterprise architects (or people responsible for EA at the HE institutions) as a primary research method in this phase. The goal was to help us obtain a better understanding of the topic and uncover new themes about it. Our interview questions were informed by our literature reviews from Chapter 2 and Chapter 3, and also progressively by issues raised in earlier interviews.

In the second phase, we developed a survey and deployed it to a much larger group of enterprise architects to evaluate the findings of the grounded theory and help explore more aspects. We constructed the survey based on the responses to the questions asked in the interviews, refined by the grounded theory analysis process.

After conducting the qualitative phase and then the quantitative phase, the integration phase of qualitative and quantitative data can be implemented at multiple levels of research: design, methods, or interpretation level (Creswell & Plano Clark 2011). In this study, the first integration took place at the design-level through the use of exploratory sequential design, where the findings from the first qualitative phase were used to construct the second quantitative stage of the research design. The second integration happened at the interpretation level using integration through a narrative in the research report. We followed the weaving approach, where both qualitative and quantitative results were written together on a theme-by-theme or concept-by-concept basis.

The entire research project received ethical approval from the Research Ethics Board (REB) of the University of Ottawa. We obtained the participants' consent before conducting the interviews and survey. As part of our ethical commitment, we made sure to protect the confidentiality of participants' data.

In the following sub-sections, we explain in detail these two phases of the research methodology: what tools we used, what samples we studied, and what steps and procedures we followed to collect and analyze data.

4.1 First Phase: Grounded Theory

Grounded theory is an explorative and qualitative research approach (Glaser, 2005). Corbin and Strauss (2008) defined grounded theory as a systematic process that is used to analyze qualitative data to build a theory that provides an explanation of a specific phenomenon or proposes a solution to a specific problem. Grounded theory depends on the researcher's creativity and innovation, and it emphasizes avoiding making assumptions before obtaining results (Simmons, 2006; Engward, 2013).

The grounded theory method was introduced by Glaser and Strauss in 1967 (Glaser & Strauss, 1967). Starting in the 1990s, several different variations appeared: emerging design (Glaser, 1992), constructivist approach (Charmaz, 2006), and systematic designs (Strauss & Corbin, 1998).

Grounded theory is useful when current theories about a phenomenon are either inadequate or non-existent (Creswell, 2008) or when a broad theory or explanation of something is needed. It aims to describe the phenomena, understand their context and influences, and draw meaning from participants' viewpoints (Corbin & Strauss, 2008). The result of this approach is a theory constructed through the connections among categories that will have been uncovered, as well as hypotheses that explain the theory (Glaser, 1992; Glaser & Strauss, 1967).

Since the research on the process of using EA in HE institutions is limited, and further exploration is required, we used the grounded analysis method to guide our data collection, analysis, and formulation of the emergent theory to facilitate a better understanding of this process. This methodology helped us to understand the participants' perspectives, as well as to explore the emergent descriptions of why HE institutions use EA, what frameworks, tools, and practices they follow, and how EA helps improve different aspects of the institutions.

4.1.1 Grounded Theory Phases and Components

In general, the grounded theory approach should consist of the following phases:

1. Openness and problem identification: identifying the phenomenon or problem that needs to be solved by reading a lot about it and setting up the main research question(s).
2. Data collection: using interviews, observations, or documents and writing notes to collect data about the area under study.
3. Data analysis: analyzing the data collected and notes and tagging concepts discovered with various codes (phrases of keywords) in order to compare the concepts with each other and to extract the primary themes or categories.
4. Development of the emergent theory: constructing the new theory based mostly on the themes and classifications that the researcher reached and writing up the report.

Birks and Mills (2011) illustrated the essential grounded theory methods in Figure 15, involving the phases mentioned above in more detail. They defined these components as "three wheels that can drive a machine (you) to generate grounded theory."

Each of these three wheels includes a set of essential grounded theory methods that fit together during the process of grounded analysis. All these wheels contribute to the development of grounded theory going from the largest wheel (more general) to the smaller

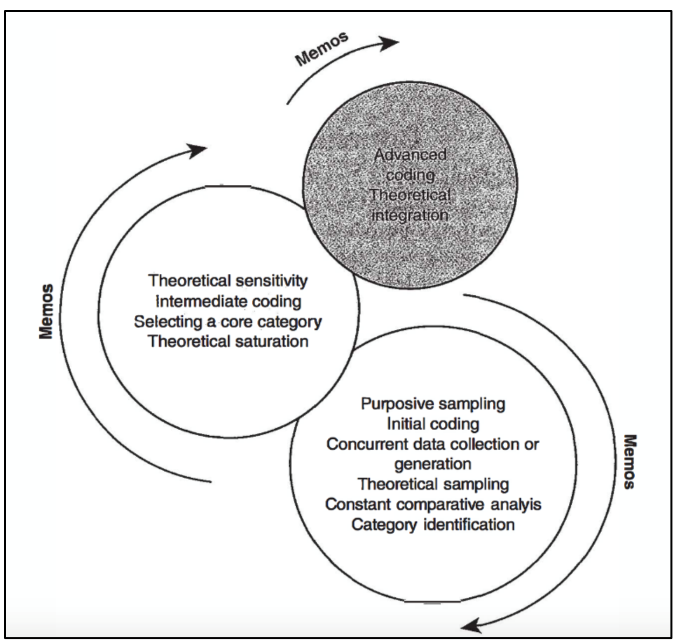

Figure 15 Essential grounded theory methods (Birks, & Mills, 2011)

wheels (more specific and advanced). Writing high-quality memos during data collection and analysis is crucial because it helps formulate patterns and emerging links between codes (Glaser & Strauss, 1967; Charmaz, 2006; Engward, 2013).

The largest wheel includes the straightforward methods that allow for generating and refining data as follows:

- **Initial purposive sample:** A technique in which members of a population are selected to participate in the study based on the researcher's judgment (Birks & Mills, 2011).
- **Initial coding:** The first major stage of data analysis that involves identifying important words or groups of words, in the collected data and labeling them accordingly (Birks & Mills, 2011).
- **Concurrent data generation, collection, and analysis:** An iterative and incremental method in which some data is collected and generated with an initially purposive sample. Then the data is coded before collecting or generating more data, and the analysis process is repeated (Birks & Mills, 2011).
- **Theoretical sampling:** Since the grounded analysis process is iterative, the researcher needs to decide on what sources can provide rich information to *saturate* the generated theory. The aim is to find out more about the properties of a category, conditions that a particular category may exist under, the dimensions of a category, or the relationship between categories (Strauss & Corbin, 1998).
- **Constant comparative analysis and category identification:** This is conducted as part of the concurrent data collection and analysis process that performs, "the constant comparison of the incident to incident, incident to codes, codes to codes, codes to categories, and categories to categories" (Birks & Mills, 2011). The constant comparative analysis continues until fully integrating the grounded theory (Birks & Mills, 2011).

The smaller wheel in the middle increases the comprehensiveness of grounded theory by enabling for further refining of the analysis as follows:

- **Theoretical sensitivity:** This reflects the level of insight of researchers in the area of study as well as their intellectual history (Birks & Mills, 2011). The theoretical sensitivity level of researchers to analytical possibilities increases as they become engaged in the data (Birks & Mills, 2011).

- **Intermediate coding:** This is the second major stage of data analysis. Coding is the core of the data analysis process that is defined as, "a process of breaking data down into smaller components and labeling these components" (Charmaz, 2006; Engward, 2013). Coding appears in three stages: open coding, selective coding, and theoretical coding (Charmaz, 2006; Engward, 2013). It includes developing fully individual categories and their properties and dimensions by connecting the sub-categories. It also includes creating a relationship between the categories. The two stages of data analysis are repetitive processes (Birks & Mills, 2011).
- **Identifying a core category and theoretical saturation:** This process involves creating a core category that describes the grounded theory as a whole. When reaching the full theoretical saturation of the core category, further theoretical sampling, and selective coding focus on actualizing the core category in a highly abstract conceptual manner (Birks & Mills, 2011).

The smallest wheel contains complex method that helps integrate grounded theory as follows:

- **Advanced coding and theoretical integration:** using advanced coding procedures such as storyline technique to integrate and formulate the emergent-grounded theory (Birks & Mills, 2011).

4.1.2 Designing the Grounded Theory Process for Our Study

The specific and detailed grounded analysis process we undertook in this study is provided in Figure 16, inspired by Birks and Mills (2011). We used semi-structured interviews, discussed later, to collect and analyze responses from participants across the HE industry. We avoided imposing pre-existing assumptions on the data we collected and analyzed. The findings and discussions are provided in the next chapters.

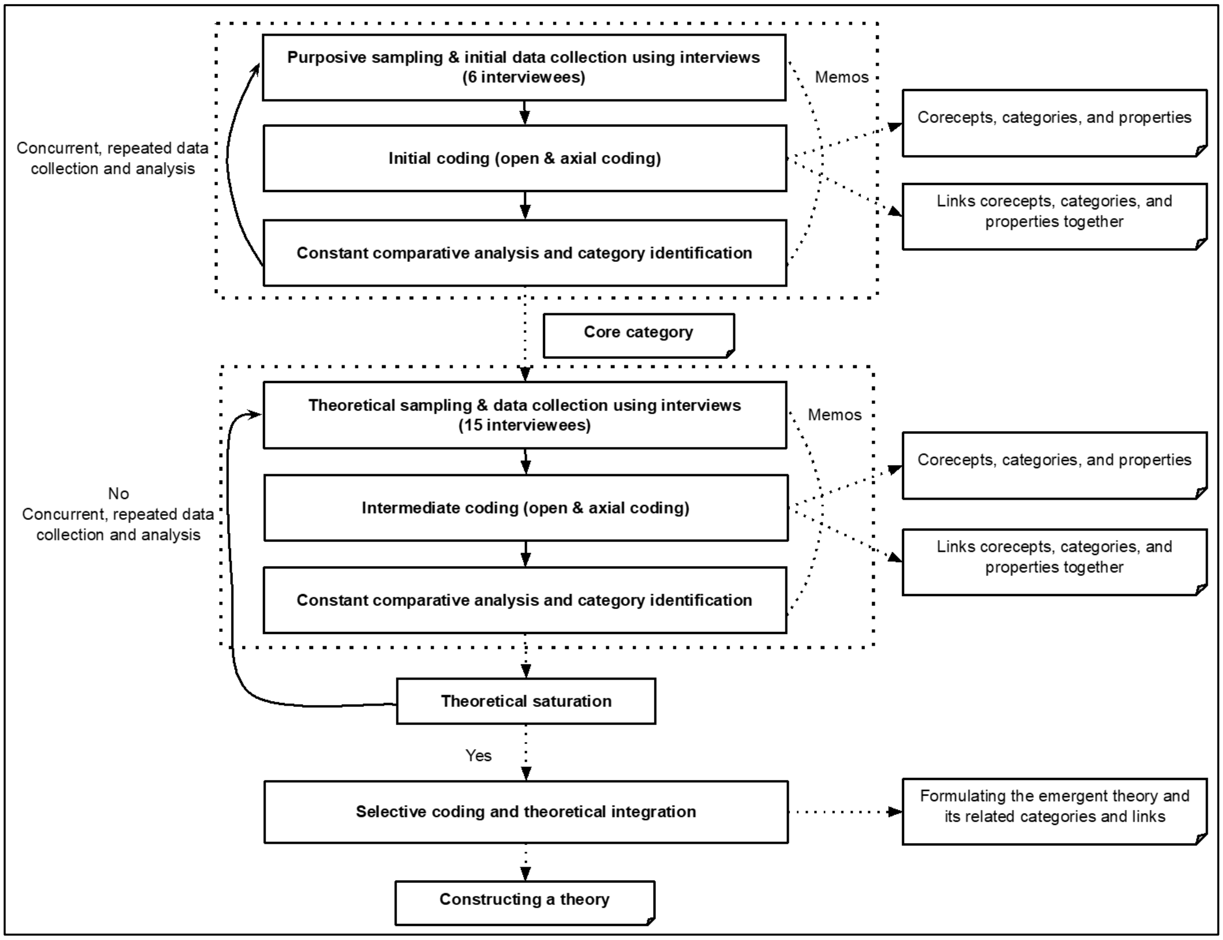

Figure 16 Grounded analysis process as adapted from (Birks & Mills, 2011)

The Interviews

We used in-depth semi-structured interviews as the primary method to collect data during this process. The objective of the interviews was to ask questions exploring many aspects of EA in higher education. Clark-Carter (2004) suggested using a semi-structured approach, where a few pre-structured questions are asked at the beginning of the interview, to help focus on the topic by allowing free-flowing conversations and guiding the course of the interview. The semi-structured interview approach becomes more effective as an interviewer has a clear idea of the questions needed to be asked (Clark-Carter, 2004).

Our interviews consisted of questions that covered a range of themes related to the adoption and implementation of EA in the institutions, including:

- An overview of when EA was adopted at the university, the motivations and objectives of adopting it, the people responsible for the implementation of EA, and the roles they play during this process.
- The principles of EA employed (or planned to be employed) at the university.
- The EA stakeholders, and team organization.
- The EA frameworks used for implementing EA, and whether they are followed closely or not.
- The tools used to support EA and what they like and dislike about them.
- The modeling notations and models used in the institution's EA.
- The milestones and breadth of organizational use of the EA process
- The impacts of using EA on the different aspects of the university.
- The management of changes made to the EA since its establishment.
- The process or criteria used for evaluating EA at the university.
- The critical success factors for EA at the university, including success of EA itself, and success of EA team members.
- The challenges encountered during the implementation of EA at the university.
- The adoption of agile approaches (if any) to the EA process.

We also asked follow-up or clarification questions between any of these questions during each interview. In some cases, we skipped certain questions if they had already been answered in the context of earlier questions.

The interviews were conducted during normal business hours, at the convenience of the participants. We individually asked the participants a set of questions, and each interview took between 30 minutes and one hour. In one case, the interview took more than one hour and 30 minutes because the interviewee talked extensively. All the interviews were audio-recorded using a phone recorder and/or QuickTime. We also sometimes used the audio or video recorder built into Skype and Zoom. We transcribed the interviews with the help of tools such as Express Scribe and Apple's Dictation.

Interview Participants

All the interview participants were male (this was not as a result of any selection bias on our part), and all worked directly or indirectly on EA in their institutions. We recruited people with the title Enterprise Architect (or similar roles) in higher education institutions (primarily universities). We focused on Canada, Saudi Arabia, Australia, New Zealand, the UK, and the USA.

The approach to finding and recruiting participants was opportunistic. In most cases, we found the email address of the person who is in charge of the EA from the university website. That connected us in many cases to the administrative assistant of that person; we talked to him or her to arrange the interview, sending the information sheet by email. In other cases, we reached the people who know the person who is responsible for the EA at their university, and they forwarded the emails to that person and informed us to contact him. In some cases, an email reached the enterprise architects directly, and hence we arranged interviews directly with them. We also asked the enterprise architects at one institution to give us the contacts of their colleagues at other institutions. We also looked for the information of potential participants on some of the networks and meetings of university enterprise architects. We also used social media such as Twitter and LinkedIn to search for people who have a role in implementing EA at their institutions, although we do not believe we made any new contacts through such media.

Examples of the roles filled by the recruited participants are Enterprise Architects, CIOs, IT managers, and directors (any person who responsible for adopting EA in HEIs). We performed the interviews in person in the offices of some participants (6 interviews). We interviewed the remaining participants through Skype (5 interviews), Zoom (9 interviews) and across a specific communications platform (one interview) (see Table 14). We interviewed only one person in most of the universities. However, we interviewed three persons with EA-related roles in one university (the former EA who had moved to the private sector, the newly hired EA with EA experience outside higher education and the CIO who had held the EA role for a period between the other two interviewees).

4.1.2.1 The Steps We Followed During the First Phase of Our Research

First Step: Purposive Sampling and Gathering Data Using Semi-Structured Interviews

In any qualitative study, the purposive sampling phase involves selecting the candidate interviewees based on their ability to provide information about the emerging concepts and answer the research questions (Leedy & Ormrod, 2005; Maxwell, 2005; Corbin & Strauss, 2008; Birks & Mills, 2011). Nassiff (2012) surveyed 25 papers in grounded theory and concluded that the range of interviewees involved in the grounded theory methodology would typically be in a range between 2 and 159 participants.

We performed our initial interviews with four participants from Canadian universities (U1 and U2) and two participants from Saudi universities (U10 and U11) (see Table 13). They were in charge of adopting EA in their institutions. They had the following roles: former enterprise architect, former CIO and the current senior director of Network Infrastructure Services and acting and current CIO. These people were our initial purposive sample.

We interviewed each of these four face-to-face, with our set of pre-prepared questions guiding us to make sure we covered all relevant issues. We freely deviated from the questions, however, allowing the interviewees to express their thoughts in an unconstrained manner. The initial interview questions for this group are presented in Appendix C. In addition to digitally recording the interviews, we took notes during the interviews. We then transcribed each interview and wrote memos with the important information obtained.

Second Step: Initial Coding and Constant Comparative Analysis

As the interviewing process progressed, we continued to transfer the audio records of interviews to a textual form. Sometimes we transcribed the whole audio file manually, and sometimes we employed software. We iteratively analyzed and reviewed the transcribed data to enable the constant comparative analysis and to help us focus on specific questions in the next iteration of collecting data.

To analyze transcribed data, we performed a coding procedure. Coding is about analyzing the textual form of the interview as well as notes taken during the interview to discover in a bottom-up manner the categories, themes, concepts, properties, and dimensions of the phenomenon under investigation (Charmaz, 2006; Corbin & Strauss, 2008). As is recommended, we wrote memos about the properties found from the new theoretical categories after inspecting the data (Glaser & Strauss, 1967).

We used constant comparison (Creswell, 1998) in which, with each subsequent interview, we compared each emerging category with previous categories (from initial interviews) and examined it for similarities and differences in order to determine whether this emerging category is a separate category, a property or representative of an existing category. We had revised the previously coded transcripts and relabeled some of the categories to produce more conceptually refined codes. The goal of this process was to make the properties of all categories and the relationships between categories clear.

Thus, in the initial coding step, we used open coding to analyze the transcribed data line-by-line and identify key points and assigned codes to them. We wrote memos about the important points and observations discussed during the interviews. After that, we used constant comparison to compare the emerged code with the previous open codes in the same and previous transcripts that helped find concepts (Glaser, 1978). The next step was to find categories by applying iterative constant comparison on the emerging concepts (Glaser, 1978). Each category consisted of a group of concepts that relate to the same phenomenon (Glaser, 1978). This process is performed immediately after the collection of each interview data to determine the merging categories (Corbin & Strauss, 2008).

We then used axial coding to identify the links between concepts, categories, and properties (Corbin & Strauss, 2008). The axial coding started after the completion of each open coding session. It was repetitive and continued throughout the coding process. Discovering the emergent categories and their relationships using constant comparison technique helped find a core category (Glaser, 1992).

We changed some of the interview questions and added other questions based on our analysis and notes of the initial interviews. The edited interview questions are provided in Appendix D.

Third Step: Collect More Data through Theoretical Sampling

Corbin and Strauss (2008) described theoretical sampling as, "the frequently used method of gathering data for grounded theory studies." The findings produced by analyzing the initial data collection were used to direct the collection of data onwards.

In this study, we used theoretical sampling where the population consisted of people in charge of adopting EA in HEIs. After the collection and analysis of initial data, we decided to make our study international by covering more countries instead of focusing only on Canada and Saudi Arabia. We sent invitation emails to people from 56 universities in Canada, Saudi Arabia, the USA, the UK, New Zealand, and Australia. We also sent follow-up emails to those who did not respond within one to two weeks. And we then sent the final reminder email to people who did not respond to our follow-up email within two weeks. We ended up with a total of 27 responses (including the participants from our initial purposive sample) from 23 universities: 12 responses from Canadian universities, five responses from Saudi universities, three responses from Australian universities, two responses from universities in New Zealand, two responses from universities in the UK, and three responses from universities in the USA. Three of those who responded eventually declined to participate because they either did not actually perform EA or said they were not allowed by their institution to participate in external research. One person agreed to do the interview, but he did not show up at the interview time; we sent him an email to reschedule the meeting time, but he did not reply. Two persons agreed to have the interview, but they did not respond when we asked them to schedule an appointment with them.

We ended up with a total of 21 interviews out of these 27 responses, as shown in Table 13 and Table 14. We changed the names of the universities and participants to protect their identities (we use the participant IDs and university IDs in the later chapters).

All universities where we interviewed their enterprise architects are public; 8 in Canada, 3 in Saudi Arabia, 3 in Australia, 2 in New Zealand, 2 in the UK, and one in the USA. Ten of these universities are very large universities (> 40K students), six are large universities (15K-40K), and three medium-size universities (<15K). All of them have multiple campuses except two universities, which has a single campus. We did not give the exact sizes of the universities in Table 13, to avoid revealing their identities.

Table 13 Summary of universities whose staff were interviewed

University ID	Public or Private	Single or Multi Campus	Size	No. of Students	Country	Participants
U1	Public university	Multi-campus	Very Large	> 40,000	Canada	P1, P2, P3
U2	Public university	Single-campus	Large	> 30,000	Canada	P4
U3	Public university	Multi-campus	Very Large	> 40,000	Canada	P5
U4	Public university	Multi-campus	Large	> 30,000	Canada	P6
U5	Public university	Multi-campus	Large	> 35,000	Canada	P7
U6	Public university	Multi-campus	Large	> 25,000	Canada	P8
U7	Public university	Multi-campus	Medium	> 10,000	Canada	P9
U8	Public university	Multi-campus	Very Large	> 90,000	Canada	P10
U9	Public university	Single-campus	Medium	> 5,000	Saudi Arabia	P11
U10	Public university	Multi-campus	Very large	> 55,000	Saudi Arabia	P12
U11	Public university	Multi-campus	Very large	> 40,000	Saudi Arabia	P13
U12	Public university	Multi-campus	Very Large	> 50,000	Australia	P14
U13	Public university	Multi-campus	Very Large	> 50,000	Australia	P15
U14	Public university	Multi-campus	Large	> 20,000	Australia	P16
U15	Public university	Multi-campus	Very Large	> 40,000	New Zealand	P17
U16	Public university	Multi-campus	Large	> 20,000	New Zealand	P18
U17	Public university	Multi-campus	Very Large	> 40,000	United Kingdom	P19
U18	Public university	Multi-campus	Medium	> 10,000	United Kingdom	P20
U19	Public university	Multi-campus	Very Large	> 50,000	United States of America	P21

All participants in the interviews were male, and their job title varied widely. For example, we interviewed former and acting enterprise architects, former, acting, and current CIOs, directors and senior directors, IT managers and senior managers, assistant vice-presidents, academics, senior architects and one person with the title Dean if IT. A description of the participants and their universities is provided in Table 14.

Table 14 Summary of interviewees

Participant ID	Role of Participant	Date	Duration	Meeting place	University ID	Country	Adoption of EA
P1	Former Enterprise Architect	10-May-18	00h:53m	In person	U1	Canada	Long-term adoption (2011): (2011: EA was formally adopted. EA roles were set up. Time and money have been invested in building up the EA practice)
P2	Current Chief Information Officer	31-May-18	00h:56m	In person	U1	Canada	Long-term adoption (2011): (2011: EA was formally adopted. 2013: a review of EA work had been done, and an external consultant for EA had been hired. 2015-2016: the EA program was set up,

Participant ID	Role of Participant	Date	Duration	Meeting place	University ID	Country	Adoption of EA
							and the EA position was filled)
P3	Senior Director of Network Infrastructure Services (Former Chief Information Officer)	31-May-18	00h:58m	In person	U1	Canada	Long-term adoption (2011)
P4	Assistant Vice-President (ITS) and Chief Information Officer	11-May-18	00h:54m	In person	U2	Canada	The university does not have an official EA adoption (2014): (2014: There has been a focus on the architecture of the university since three and half years ago)
P5	Enterprise Architect and Professor	04-Jun-18	00h:40m	Skype	U3	Canada	Long-term adoption (2012)
P6	Strategic Architect; responsible for the EA activities	25-Jul-18	00h:54m	Skype	U5	Canada	Short-term adoption (2017): (2017: the core EA team was created & some changes have happened since 2017)
P7	Director of Planning and Governance	27-Jul-18	00h:41m	Skype	U6	Canada	Short-term adoption (2015)
P8	Director of IT Architecture	02-Aug-18	00h:32m	Skype	U7	Canada	Short-term adoption (2014): (Late 2014: the EA role had been filled in 2014.The EA capability was built)
P9	Manager of Servers, Storage and Architecture	17-Aug-18	00h:54m	University's meeting platform	U4	Canada	Organization as a whole does not have EA officially yet (2013: EA head and three other persons started got TOGAF training and certification and tried to apply it. 2013: EA head and three other persons tried to push the need forward to EA)
P10	Senior Manager of Technical Solutions and Architecture	21-Nov-18	01h:08m	Skype	U8	Canada	Long-term adoption (2008): (2008: an official enterprise architect position was filled)
P11	General Directorate of Information Technology	22-Sep-18	00h:55m	In person	U10	Saudi Arabia	Short-term adoption (2017)
P12	Deanship of Information Technology	09-Oct-18	00h:45m	In person	U11	Saudi Arabia	Long-term adoption (2011)

Participant ID	Role of Participant	Date	Duration	Meeting place	University ID	Country	Adoption of EA
P13	Chief Information Officer	03-Jan-19	00h:53m	Zoom	U9	Saudi Arabia	Short-term adoption (2018): (2018: the EA unit was established to take over the responsibilities of EA)
P14	Associate Director of IT Governance	18-Dec-18	01h:02m	Zoom	U12	Australia	Long-term adoption (2011): (2011: the team did some key artifacts for EA on the application landscape. 2013: There were not any roles associated with EA. 2015: IT architecture group did not add much value. 2016: EA had a gap; the team did re-structure. Early 2017: different architect roles were created under the director of IT governance; one individuality IT organization was managed; the team defined what EA services are and what to do for the university as part of EA)
P15	Former Enterprise Architect	20-Dec-18	01h:42m	Zoom	U14	Australia	Short-term adoption (2015): (2015: EA was adopted about three years ago)
P16	Director of Enterprise Architecture	11-Jan-19	00h:41m	Zoom	U13	Australia	Short-term adoption (2017): (2017: the team was formed. EA function was there before but had chosen to remove it before 2017)
P17	Solutions Architect/Architecture and Security Manager	11-Dec-18	00h:41m	Zoom	U16	New Zealand	Long-term adoption (2007): (about 11 years ago. 2007: the EA team was built)
P18	Enterprise Architecture Manager	07-Feb-19	00h:58m	Zoom	U15	New Zealand	Long-term adoption (2002): (2002: the university had someone in a position called an architect. 2002: Enterprise architect role was filled)
P19	Enterprise Architect/Senior Systems Architect	18-Dec-18	00h:44m	Zoom	U18	UK	Long term adoption (2012): (2012: EA was officially adopted)
P20	Enterprise Architect	11-Jan-19	00h:51m	Zoom	U17	UK	Long-term adoption (2009): (2009: EA started. 2009: IT became entirely centralized. 2011: new enterprise architect interviewee joined the team)
P21	Director of Enterprise Architecture and Strategy	08-Jan-19	00h:37m	Zoom	U19	USA	Medium-term adoption (2013): (2013: established the EA group (5 years ago))

Fourth Step: Intermediate Coding and Constant Comparative Analysis

We had coded and analyzed data every time we conducted a new interview. We constantly compared the produced concepts and categories with the core category. We iteratively continued the processes of conducting theoretical sampling, and performing interviews, open coding, and axial coding until we reached the point of theoretical saturation.

Theoretical saturation is reached when further analysis does not result in any new concepts, and all categories of a generated theory are fully developed (Creswell, 2008; Corbin & Strauss, 2008). We believed that the number of participants (21) here is sufficient. Creswell and Plano Clark (2011) suggest that between 20 and 30 participants would be typical for grounded theory. We then proceeded to the selective coding for the core category and its closely related categories (Glaser, 1978).

Fifth Step: Selective Coding and Theoretical Integration

Selective coding is about explaining the interconnected categories (Creswell, 1998). It is also called integration (Corbin & Strauss, 2008). It results in an analytic story that explains the phenomenon under study using the categories and subcategories, and relations among them (Corbin & Strauss, 2008). After identifying the codes and relationships between them, we started to define the core variable to include all data related to it.

Sixth Step: Building Theory and Writing-up

The last step of the grounded analysis is to build theory through the connections between the core category and other emerged categories and form the hypotheses that explain the theory (Glaser, 1992; Glaser and Strauss, 1967). The findings of our analysis are discussed in the following chapters.

4.2 Second Phase: Constructing a Survey

In the second phase, we developed a survey to test the findings of the grounded analysis on a larger group of participants working on EA in HE institutions in different countries. We used the survey approach as opposed to further quantitative techniques because we had a sufficient set of concepts to move forward with quantitative analysis.

4.2.1 The Sampling Process

Sample: We designed a purposive sample that covered the HE institutions in many different countries. The sample was geographically diverse and covered campus types, and thus this helped reduce bias. We obtained data from many different countries, but our focus was on Canada, the USA, Australia, New Zealand, the European Union (mainly the UK), and Saudi Arabia. Our goal was to obtain as much participation as possible from the above 6 countries which would enable us to make comparisons.

The survey targeted three groups of participants: Those who already have adopted EA at their institutions; those who did not adopt EA yet but have a plan to do that, and finally those who do not want to adopt EA at all.

Sample selection: We used two methods, primary and secondary, to search for the right people to participate in our survey.

For the primary method, we first searched the institution's website to ensure that it had already applied EA. Then we searched the staff directory on the websites for people with the title Enterprise Architect. Second, if there was no person with this title or the university's website did not have information about adopting EA, we searched the staff directory for other titles such as CIO, IT director, IT Manager, and so forth. We created a list of all potential participants and their emails. Then we sent them an email containing a personalized invitation with a separate URL for each university so that we could only remind people who did not complete the survey and identify multiple responses from the same institution. We sent a final reminder to participants 7 to 14 days after the initial invitation if they did not use their URL. For a few universities, when we could not find email addresses, we used LinkedIn or Twitter accounts to contact people and asked them to send the invitation to relevant EA staff.

Our secondary method to generate responses was to request specific enterprise architects to send the survey invitations to the mailing lists of EA organizations they belong to or to people whom they know that work in the same field. Two of the people we asked were ones with whom we had conducted grounded theory interviews, and three others, who completed the survey, also volunteered to do so.

Using the primary method, we emailed invitations to 229 institutions worldwide, in total. The total number of responses we received was 115, including 17 responses using our secondary method from May 22, 2019, to July 15, 2019. Not all 115 responses were complete, as there were a large number of them, for example, who only completed demographic questions, sometimes one or two of the required questions, and then they did not complete the rest of the survey. However, we received a 50.2% response rate to our direct contacts, which is considered good for such a study.

We anonymized all the participants' data to protect them from potential risks such as an employee or institution being embarrassed, although we tracked responses by using a separate URL for each invitation.

Survey procedure: We used SurveyMonkey, on which the University of Ottawa has a corporate account, to conduct the survey. The participants were asked to consent to participate before they filled out the surveys. It took an average of 33 minutes to complete the survey.

4.2.2 The Survey Questions

The survey questions were designed based on the results we got from the analysis of the different interviews we conducted. The survey consisted of 47 questions, varying from multiple-choice and ratings-scale questions to checkboxes and comment box questions (see Appendix E). The survey consisted of the following sections:

- Consent and background information on the participants' institutions including demographic information and general overview of how deploy EA at their institutions (Q1-4).
- The extent of implementing EA (Q5).
- In cases where EA was not implemented or was being wound down, the participants were directed to Q6, which asked about reasons for not adopting EA.
- In cases where there was a plan to adopt EA at their institutions, participants were directed to answer questions from Q7 to Q18.
    - Centralization of the university (Q7-8).
    - Definition of EA from the participants' perspective (Q9).
    - Motivations and objectives for EA (Q10).
    - Models used in EA (Q11).
    - EA Principles (Q12 -15).
    - Success factors and challenges in EA (Q16-18).

- The remaining questions were for people who had already adopted EA at their institutions:
    - Questions about how EA is conducted, the process of adopting EA, and the organizational model of EA that best fits the institution (Q19-21).
    - EA team size and management (Q22-23).
    - Centralization of the institution (Q24-25).
    - Definition of EA from the participants' perspective (Q26).
    - Motivations and objectives for using EA at institutions (Q27).
    - Use of EA Frameworks and reasons for using them (all frameworks were encountered during our grounded theory study) (Q28-29).
    - Models and tools used in EA and pros and cons of using specific tools (items listed had been identified during the grounded theory) (Q30-33).
    - EA Principles (Q34-39).
    - Success factors and challenges in EA (Q40-42).
    - Impact of using EA on different aspects of institutions (Q43).
    - The most prominent changes made to EA at institutions since its establishment (Q44).
    - The agility of the EA process at institutions and the factors that affect the agility (Q45-46).

4.3 Summary

In this chapter, we explained the two phases of the research methodology that we followed in this study. The first phase was the grounded theory approach in which we conducted 21 interviews with multiple enterprise architects (or people responsible for EA) in HE institutions from different countries. In the second phase, we developed a survey based on the results of grounded theory. We distributed the survey to a larger group of enterprise architects from 229 HE institutions around the world, and we received 115 responses from various countries.

In Chapter 7, we provide a detailed description of how we performed the coding, together with examples. We described how sampling evolved over time earlier in this chapter in Section 4.1.2.1.

In the following chapters, we present the results from the grounded theory and survey approaches on a theme-by-theme basis. We also discuss the analysis and integration of these two forms of results, and we provide lessons and recommendations based on the final results.

Chapter 5 Demographics, Motivations, and Objectives of the Enterprise Architects

In this chapter, we discuss the results of our grounded analysis and survey* related to demographics of the participants and of their institutions, the motivations for performing enterprise architecture, how they define enterprise architecture, and related issues.

5.1 Grounded Theory Analysis

As discussed in Chapter 4, the first phase in our overall research approach was qualitative, following the grounded theory approach. To recap, we conducted 21 interviews with enterprise architects (or people responsible for architecture) in 6 different countries. We transcribed these interviews and analyzed them using the coding procedures adapted from the work of Birks and Mills (2011). We used the grounded theory results to construct the survey questions. The results of the grounded theory research are discussed below.

5.1.1 Results of the Grounded Theory

The HE sector differs from other industries in several aspects, including its culture, terminology, structure and environment, as stated by our interviewees. In particular, our interviewees emphasized that HE institutions follow common approaches to governance, organizational structure and decision-making. Decision-making by consensus is widely practiced, unlike in most other industries.

We asked our interviewees a set of questions about the adoption of EA at their institutions. This resulted in a collection of a massive amount of data covering different themes from multiple perspectives. We classified the collected data and created the initial set of categories of themes, as shown in Figure 17 – a view of a board on which we helped arrange our data. We subsequently refined this set of themes as the research progressed.

In this chapter, we focus on the questions related to the participants' demographic information (their countries, the centralization of their universities, the size of their institutions, the year the EA was established in their institutions), and the motivations for undertaking EA in their institutions.

* Some of the materials are adapted from (Lethbridge & Alghamdi, 2019)

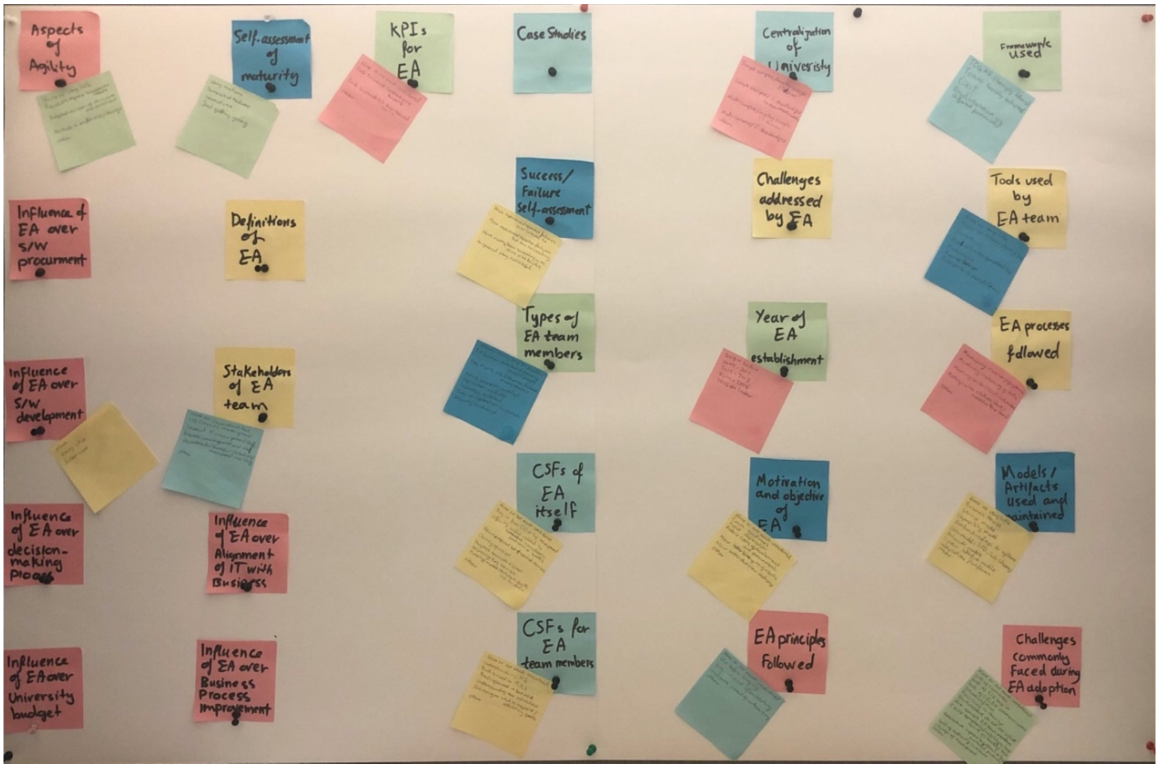

Figure 17 The initial themes from grounded theory results

In the following chapters, we present the analysis and discussion of other results. The interview questions that we cover in this chapter are as follows:

> *Could you explain your role in the EA team you work with? Who are the other team members and how was the team formed and chosen?*
>
> *What are the reasons or motivations behind the use of EA?*
>
> *What are the objectives, goals or vision set by your university or institute for using EA?*
>
> *When did you start adopting EA? Did you complete the adoption/ implementation of EA?*
>
> *Has the EA been implemented in all faculties or services of the university or implemented in specific ones only?*
>
> *To what extent has EA been successful or failed? What goals have you met or not met?*
>
> *Do you plan to continue the EA process, or do you think the organization might*

wind it down or ignore it? (If you wind it down, what would be the reasons for this decision?)

The 21 participants (all are male) are from 19 institutions (as shown in Table 13): 8 from Canada (3 interviewees from one university and one for each other university), 3 from Saudi Arabia, 3 from Australia, 2 from New Zealand, 2 from the UK, and one from the USA. Later and in the following chapters, we compare the survey results of these same six countries.

All 19 institutions were public (which we define as institutions that obtain core funding from a government and are subject to government regulation); 17 of them were multi-campus, and 2 were single-campus.

We found that our sample is biased towards the larger universities, as shown in Table 13. It is due to the fact that there are only 9 universities out of 94 in Canada that have more than 40,000 students (Universities Canada, 2019), and only 3 universities in the UK (Higher Education Statistics Agency, 2018-2019). 10 of institutions were very large (>40K students), and 6 were large (20K-40K). Only 3 institutions were medium (>5K). We did not interview anyone from small-size institutions.

Table 14 shows the role of each interviewee, the duration and place of the interview and for how long they had adopted EA. The sample also shows diversity in the interviewees' responses regarding when EA was established in their institutions. The responses ranged from long-term adoption from 2012 or earlier (e.g. 2002, 2007, 2008, 2011, and 2012), medium-term adoption from 2013-2016 (e.g. 2013, 2014, 2015, and 2016), to short-term adoption from 2017 or later (e.g. 2017 and 2018). Also, one of the interviewees said that his institution did not have an official EA adoption, but there had been a focus on the architecture of the university. Another interviewee mentioned that his university as a whole did not have EA officially yet.

5.1.1.1 Self-Assessment of EA Maturity at HE Institutions

We asked our interviewees *"Did you complete the adoption / implementation of EA?"* The answers of the interviewees were varied regarding the implementation of EA at their institutions. Some of the interviewees stated that the adoption of EA at their institutions was completed. Others said that they were on the early stage of the EA implementation.

One of the interviewees said that they created a self-sustaining model for EA to bring stakeholders and staff together to understand EA and its work. Other interviewees said that the adoption of EA in their institutions was not totally complete. They had done some activities some of which were of value, and some were not of value.

Based on the information above, we decide to categorize the implementation of EA at the HE institutions into the following categories:

- Very mature: EA is mature and has a significant impact.
- Somewhat mature: EA is established and has had a positive impact, but it is still actively developed.
- Immature: EA is established but has not had much impact on the institution or has not been successful yet.
- Just getting going: EA is on a very early development stage, and it is relatively immature.
- Unsuccessful: EA was established but is winding down or is having less impact.

5.1.1.2 *Success/Failure Self-Assessment with EA at HE Institutions*

We asked our interviewees to what extent they succeeded or failed to implement EA in their institutions. We obtained diverse responses to this question. Generally, they had some

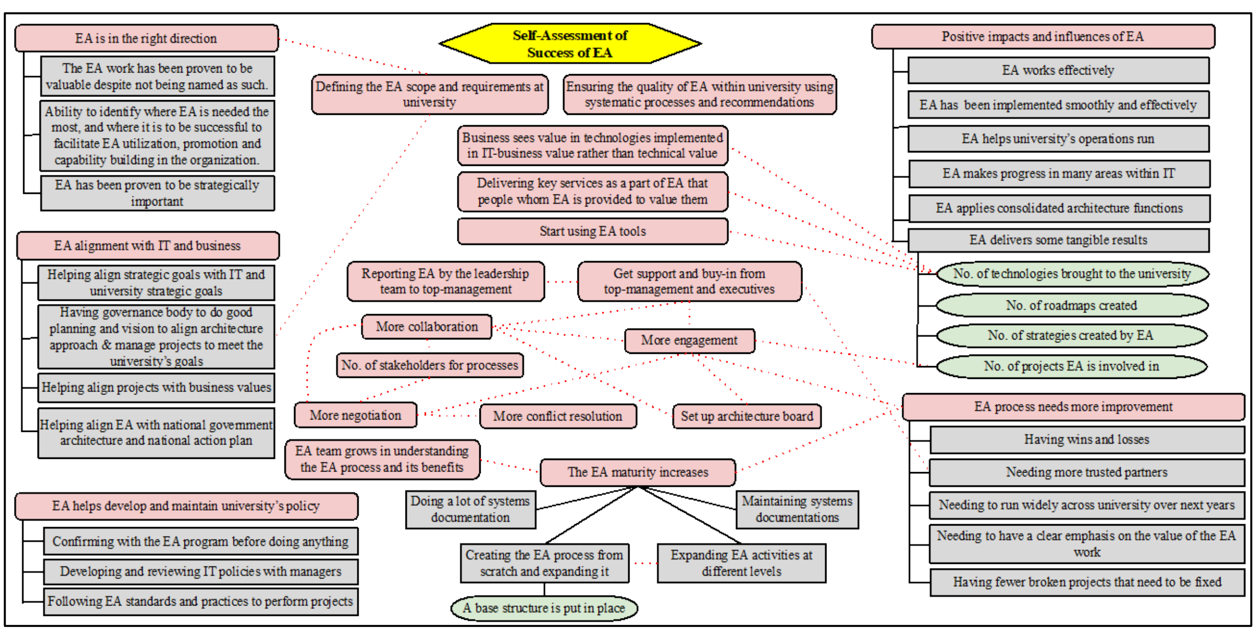

Figure 18 Success self-assessment with EA at HE institutions (GT results)

successes and some failures with EA. The participants reported some signs of success and failure in implementing EA in their institutions.

Figure 18 shows some of the successes described by our interviewees. Pink boxes indicate the main categories illustrating the successes with EA; gray boxes indicate the sub-categories, and the green boxes are the concepts related to the sub-categories. Dotted lines group the similar categories together while black lines indicate the relationship between the category and its related concepts.

For example, according to some interviewees, getting more support from top management was one of the most important signs indicating the EA implementation's success and the consequent improvement in communication, negotiation, and collaboration between the different groups and the EA team. One of our interviewees said:

> *"... We have been successful lately in getting some support and buy-in from top management and executives within the central unit. And we are making some progress in many areas within IST. And we are kind of started to look for expanding our activities at different levels and... We see that the EA maturity has been increasing and getting some tangible results…"*

Some participants also mentioned that the maturity of EA had increased. Others said that there were some positive impacts and tangible results from the EA implementation, such as improving the university's operations and making effective use of technology and related IT-services in universities. EA also had the advantage of bringing appropriate technology to the institutions, according to one interviewee.

On the other hand, Figure 19 illustrates the failures that some of our interviewees experienced for implementing EA at their institutions, although this did not stop them from seeking to improve the use of EA and solve the issues.

For example, some interviewees said that the limitations of time and resources were among the most critical obstacles that led to the EA implementation failure at their institutions. Also, according to some participants, the inability to communicate with stakeholders and other parties made it challenging to implement EA successfully.

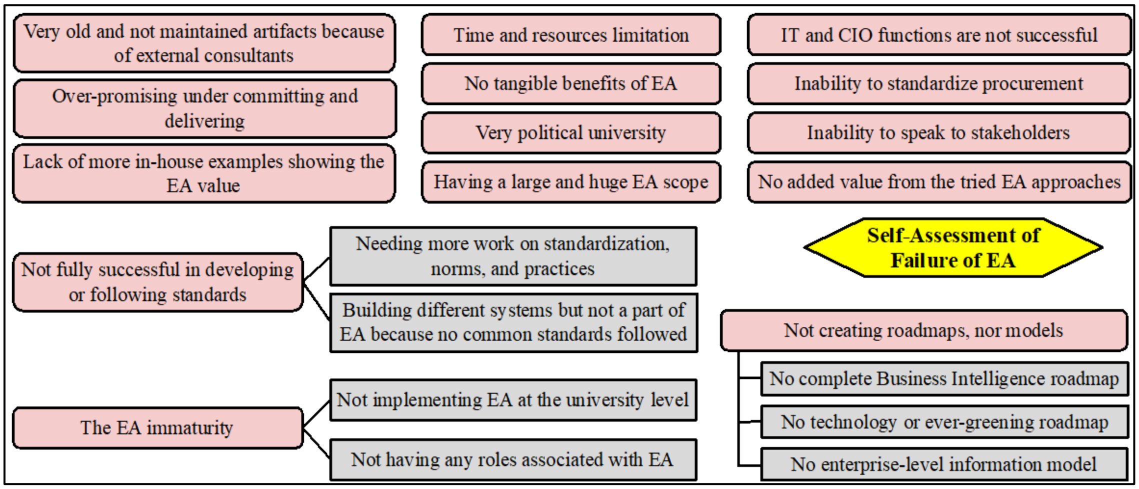

Figure 19 Failure self-assessment with EA at HE institutions (GT results)

Some participants also described some of the obstacles that led to the EA implementation failure, such as having a large EA scope, being a very political university, and lacking in-house examples to illustrate EA's value, as one of our interviewees indicated:

> *"… we still need to demonstrate values, but to do this we need to have in-house examples of where we provide value, …. This needs strong support from, you know, top-level management, which we currently have. Also having the intake process helps us in identifying where we are needed as EA, where we are needed the most, and we also look at where we will be successful. If a project does not require EA participation, that is fine, we just go for the next project where EA is required and can show value…"*

Some interviewees also mentioned other signs of the failed implementation of EA, such as EA immaturity, out-of-date and not-maintained artifacts and roadmaps, as well as the inability to follow or develop standards.

From the above, we built a list of categories to describe the success/failure self-assessment of EA at HE institutions:

- Have experienced repeated failures and continue to do so.
- Have experienced repeated failures but now succeeding.
- Have mostly been succeeding with some obstacles.
- In general, successful.

5.1.1.3 Plan to Continue EA Work at HE Institutions

We asked our interviewees if they would continue their EA work or intended to implement EA in their institutions formally, and their answers were in general yes. The following are some examples of what they would do to continue the implementation of EA in the future.

Some interviewees said they were at an early stage of implementing EA, but the development process was ongoing.

Other interviewees said they would either create an EA team, fill an EA position if it was vacant, or continue to implement EA without having an official EA role.

One interviewee said they would change the EA flavour. One interviewee said that choosing the architecture to work on was driven by the chief information officer's personality, while another interviewee said they would try a new approach to add value. Another participant said that they would do a high-level architecture design as opposed to solution-based design, as he said:

> *"…The eventual plan is to have an EA team that has…that is more than just me… doing high-level architecture design as opposed to the solution-based design that we are currently doing…"*

Other participants indicated that they would expand and increase the EA maturity and expand the scope of practice of EA, saying:

> *"…we are definitely continuing to expand and increase our EA maturity…and expand the scope of EA practice as we go…"*

Others said that they would maintain the EA process and keep everything on track. For example, some participants stated that they would follow the architects' continuous changes and plan for each specific year cycle. Other interviewees mentioned that they would hold more meetings with their stakeholders and communicate with them more. Others stated that they would keep their architecture boards with minor changes (either locations or memberships).

Others said that they would formally adopt EA, since they would formally establish roles related to EA and increase EA investment in terms of time or money.

On the other hand, one response made it clear that there were no signs of adopting EA in the short or medium term, while others established and developed a governance organization to address the challenges that EA intended to address and fill a lot of the gaps in EA.

Based on the interviews, we built a list of categories that described this aspect as follows:

- Planning to put increasing effort into EA.
- Keeping effort at current levels.
- Expecting to reduce it.
- Expecting to wind EA work down.

5.1.1.4 EA Team and the Head of EA Team

We asked our interviewees about their role in the EA team and the roles of other team members. We received different answers covering different themes such as the size of the EA team, the type of the team, the role of the EA team, the head of the EA team, and the reasons for selecting and hiring enterprise architects.

The roles of each interviewee are presented in Table 14. They all were responsible for applying EA either directly or indirectly.

For the size of the EA team, we classify the result into four main categories: very small (part-time person only or 1 person), small (2-3 people), medium (4-6 people), and large (more than 6 people).

According to our interviewees, the EA team could be virtual architecture team, distributed team, dedicated and partially-dedicated members, more centralized team, or small-and-lean EA team.

The roles of EA team members are presented in Figure 20. Some interviewees said they did not have an EA team, official EA position, or official EA function. As for those who said that they had an EA team, the roles played by each member of their team varied. For example, one of the interviewees said that there was someone in his team doing the EA but with a different job title.

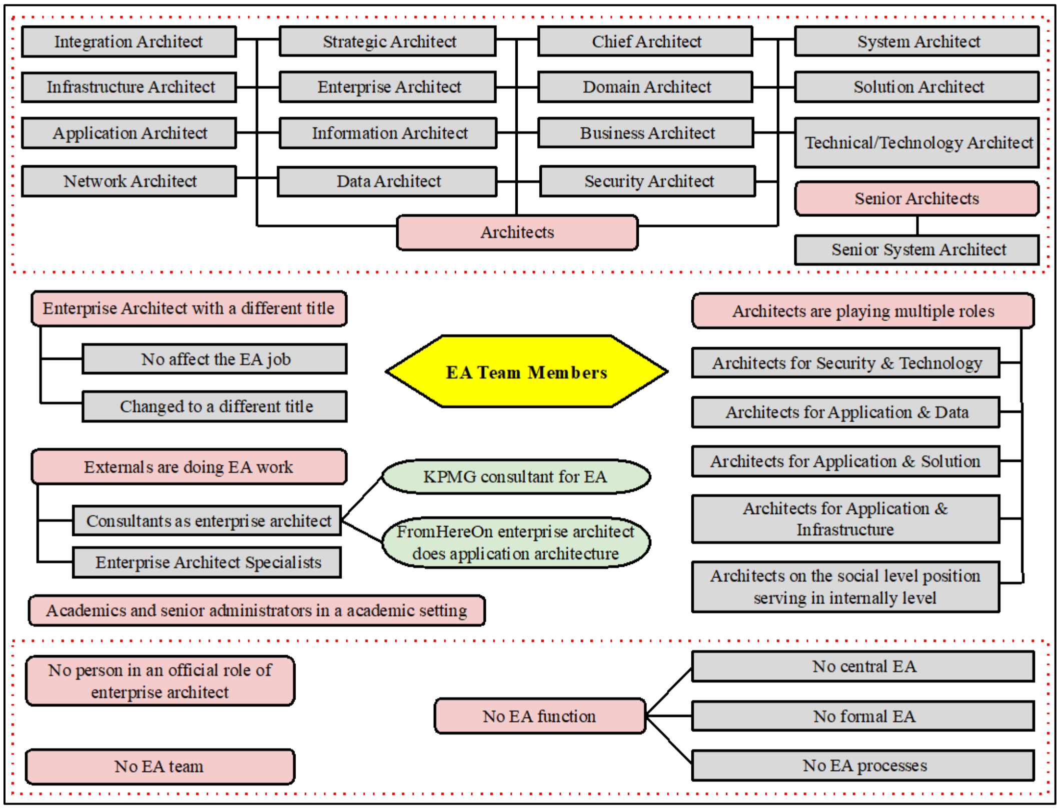

Figure 20 EA team members (GT results)

Most of the interviewees said that they had architects or senior/chief architects in their teams such as a business architect, enterprise architect, data/information architect, domain architect, infrastructure architect, network architect, technology architect, application architect, strategic architect system architect, security architect or solution architect. Some of these architects played multiple roles, such as being responsible for technology and security architectures.

Some universities hired external consultants or enterprise architects to do their EA work. There were also some academics and senior administrators who did the EA work.

We also identified a list of who could be the head of the EA team in Figure 21. They could be directors, CIOs, managers, or other senior/chef architects.

The interviewees provided information about the role of their EA teams from different perspectives.

One of the important roles of the EA team is was to promote to others the need for EA and to help stakeholders understand the value of EA, as emphasized by some of our

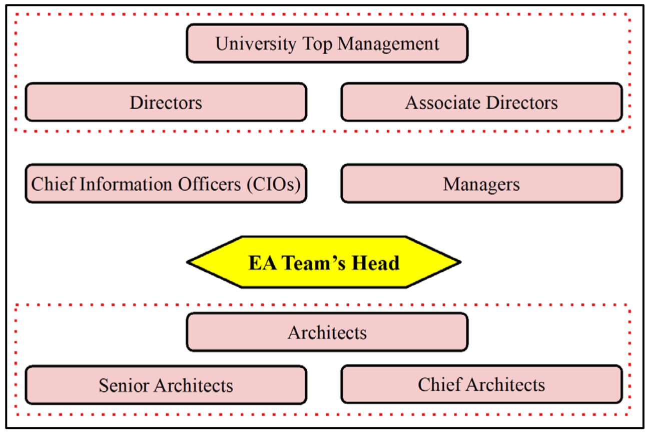

Figure 21 The head of EA team (GT results)

interviewees. A few interviewees told us that their team worked with other IT and business subject-matter experts at different levels. They focused on how to use technology and technical roadmap and strategy to achieve the organization's goals. Some other interviewees also told us that they worked on aligning overall IT strategies with business strategies and translating these business strategies into terms that could be used to form the IT strategies. Another interviewee told us that his team was responsible for creating and developing current and future state of architecture and roadmaps of business processes, application and technology as a part of the EA.

Some of other interviewees said that one member of the team might take care of multiple architectures such as business, information, technology and data architecture. Others said that their team members worked on a part-time basis. There were many overlaps within the EA team, as all of them did some work on each area more than when they did specialize in a specific area.

One of our interviewees said that they were thinking of architecture as the solution focus. They thus worked on an operational solutions-oriented project basis. While another interviewee said that they focused on infrastructure architecture and expanding it to enable development shops. Another said that their focus was to manage a business capability planning process across different domain levels across the university.

The other role played by the EA team was to work with different stakeholders and understand their needs. They enabled strategic leadership up to the senior leadership team and helped them think of how to communicate with campus stakeholders and other partners. The team drove the strategic management practice; that is, getting people to re-

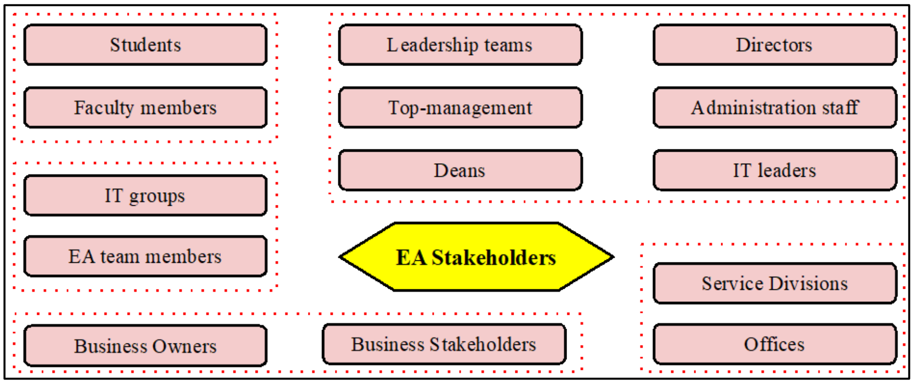

Figure 22 EA stakeholders (GT results)

do their strategies and re-facilitate sessions for people to help them define what their strategies are.

The EA team had a technical authority on the projects. They helped govern the process of selecting and implementing the different applications, so they fitted well with the university's overall technology suite. They had general policies regarding handling private information and the storage policy on document lifecycle or information lifecycle.

The other theme discovered in the interviews is the reasons or factors for hiring and selecting enterprise architects. The main factor is that enterprise architects should take responsibility for EA. Another factor is that the architects should have a long time of service in the university because they would then be familiar with the university's environment. They should also have a deep understanding of the different areas of architecture such as data, applications and networks. In addition, they should be able to flex and evolve with the university's changing needs. Also, they should have general and technical expertise, such as getting basic TOGAF training or certification.

Some universities hired a consultant to work as an enterprise architect who should create the reference models to use in EA, build up the architecture practice as a whole, and bring in some of the EA tools.

5.1.1.5 EA Stakeholders

When we asked our interviewees about their stakeholders, they provided us with different responses. The main categories extracted from our transcribed interviews are illustrated in Figure 22.

We summarize these answers in the following list:

- Have not considered this.
- CIO / Senior management: directors, managers, etc.
- Central IT management staff: EA managers, IT directors, etc.
- Business management and staff.
- Department/Service/Distributed management and staff.
- Executive directors within university services and Chancellor.
- Different members of the academic community.
- Students.
- Strategic partners.
- Individual stakeholders in projects.
- Other EA team members.
- Other stakeholders: boards, committees, and offices (Architecture Board, Architecture Committee, Design Authority, Offices for BP improvement, Organizational Excellence).

5.1.1.6 Centralization

We asked our interviewees if they applied EA at the whole university or for specific departments or units. We received different responses ranging from a single campus with mostly single IT team, a single campus with IT decentralized to departments/units, multi-campus with mostly single IT team, and multi-campus with IT decentralized, and other forms of centralization. We classify the responses as follows.

Some participants said that they had campuses that were isolated and very small. They did not have EA practice, nor had enterprise architects, nor ask for EA team help, and built and ran ad-hoc architecture.

Other interviewees said that EA was implemented as a holistic view of the whole university. They stated that they applied one EA across all campuses or had one architecture program across all campuses. They also defined network standards and technology standards for full university regardless of campus.

Alternatively, some of our interviewees stated that they applied EA as a localized activity within the central IT unit. They had centralized IT and EA for multiple campuses, which indirectly works with other business units in terms of application, integration, and system integration and the relationship between them. In other words, EA was part of IT and part of the CIO's office that served all faculties. Some universities had only one campus, and they implemented EA within the IT department, but it provided services across the whole university.

In further cases, some interviewees indicated that EA was only applied to main departments and specific faculties. For example, one of the interviewees said that their EA team worked on the university's main campus and provided guidance and assistance to other campuses and departments that co-operated with them. As for faculties that had their own IT support teams out of EA scope, they used EA to align with the latest EA standards, according to some participants.

In some universities, certain staff were distributed and did architecture intake tasks, but they were not architects, according to one interviewee. In certain universities with multiple campuses, each campus had its EA team or its own IT department, where EA was a part of it. Other universities had remote campuses, so the EA team was organized partially in several different ways but not in terms of architecture treatment. The architectural-minded people tried to follow what the EA team had come up with even though they did not have the architects' title.

5.1.1.7 Motivations for Undertaking EA in HE Institutions

We first identify some issues that drove the need for EA from the transcribed interviews. These issues are summarized in the following list:

- A need for authorization to access data and information.
- Silos between different portfolios.
- Overlaps of systems, duplication and triplication in IT assets and services.
- Difficulty in maintaining inventories of technologies and capabilities.
- Difficulty in maintaining the storage policy on the document lifecycle.
- No professional development plan for technical staff.
- Gaps in formalizing IT policy.
- Not recognizing the benefits of systems or having system and software defects.

- Considering the systems as key drivers for architecture.

Implementing EA at the HE institutions helped address these issues or at least some of them, as stated by our interviewees. Hence, we asked the participants to define their motivations for using EA in their institutions:

> *What are the reasons or motivations behind the use of EA?*
>
> *What are the objectives, goals or vision set by your university or institute for using EA?*

We received a good number of comprehensive answers to this question. Some of the interviewees explained that they had an official list of motivations and goals for using EA at their institutions, while others indicated that their motivations and goals were more based on the needs and issues that led to the use of EA.

For example, in terms of aligning projects with university's goals, and aligning business and IT sectors, one of our interviewees said:

> *"…one of the goals is to try to focus on how we line up the technology we got, to the business goals and business capabilities…"*

Another participant said:

> *"…create a clear direction and vision for many of the business owners, with respect to technology and their needs…"*

We first identified a list of concepts that identify and represent the motivations for using EA at HE institutions. Then, we identified the similarities and differences between these concepts, and the links between them to create subcategories of similar concepts, as shown in Table 58 in Appendix G. From this table, we identified the similarities and relationships between these subcategories, and we created a preliminary list of the main categories as shown in Table 59 in Appendix G. We decided to shorten this list of main categories of motivations. We focused on the essential and prioritized motivations (as shown in Table 15) to use them in the survey later (the long list of the motivations could have been overlooked by the participants, and the survey contained many other questions in addition to the question about the motivations).

Table 15 List of main categories for the motivations of using EA at HE institutions from GT results

Motivation ID	Main Categories
1	Align projects with university's goals.
2	Align business and IT sectors.
3	Rationalize and simplify, including reducing duplication.
4	Enable digital transformation and improve automation.
5	Better leverage assets.
6	Enable institution to be more adaptable.
7	Enable decision making to be data driven.
8	Reduce costs.
9	EA mandated by government.

5.2 Survey

As discussed in the last chapter, the second phase of our research was to develop a survey based on the grounded theory and deploy it to a much larger group of people responsible for EA in their institutions.

The following is an overview of the questions whose answers we discuss in this chapter. Those marked * are the ones that were required to be filled out by the participants:

Q1*. Asked participants whether they consent to participate.

Q2-4*. Demographic questions: Country, type of university, campus size. In the results section, we will divide the survey by country to show some comparisons.

Q5*. To what extent is EA implemented.

Q6. In cases where EA is not implemented or is being discontinued, the participants were directed to question Q6, which asked about the reasons for not adopting EA in their institution.

Q7-Q18. In cases where the participants did not adopt EA at their institutions but plan to do, they were directed to Q7 to Q18, which were demographic questions and other EA-related questions. In this chapter, we focus on Q7-10; we will cover the other questions in the subsequent chapters.

Q19-21*. How EA is conducted, and the organizational model of EA that best fits the institution.

Q22. The EA team size.

Q23. To whom the head of the EA team reports to.

Q24-25*. Centralization of the institutions.

Q26. Definition of EA from the participants' perspective.

Q27*. Motivations for the use of EA.

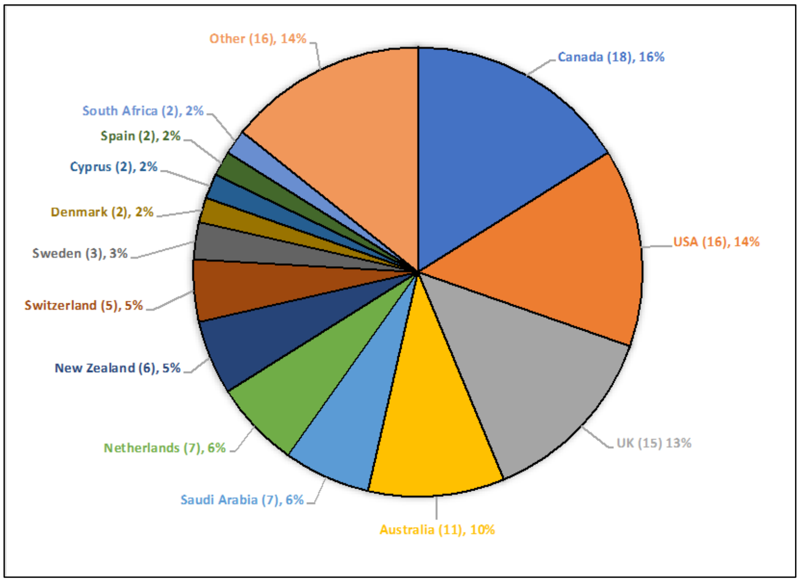

Figure 23 Countries of participants in the survey (Q2)

We received 115 responses to our survey. Three participants dropped out of the survey after consenting to participate. We hence received 112 responses from 30 countries to the initial questions (including the demographic data, and one or two of the core questions) which is a 48.9% response rate to our direct contacts. We subsequently anonymized the data to guard against risks such as an institution or enterprise architect being embarrassed.

5.2.1 Results

This section discusses the results of the survey and the statistical analysis of the results. As we present each type of data, we discuss the implications of particularly interesting aspects.

5.2.1.1 Demographic Questions Q2-4

Figure 23 presents the coverage of countries in the survey from Question 2. Countries not explicitly listed, with one response each, are Finland, Germany, Ireland, India, Iceland, Qatar, Bahrain, Jordan, Lebanon, Singapore, Pakistan, Malaysia, Philippines, Hong Kong, South Korea, and Brazil. The fact that we have covered many countries should improve the general applicability of analysis of other questions. In some of the later analysis, we compare the results from the top six countries where we received 6 or more responses.

Some other relevant data to characterize the sample are the following:

91.1% of institutions indicated they were public (from Question 3), and 8.9% were private.

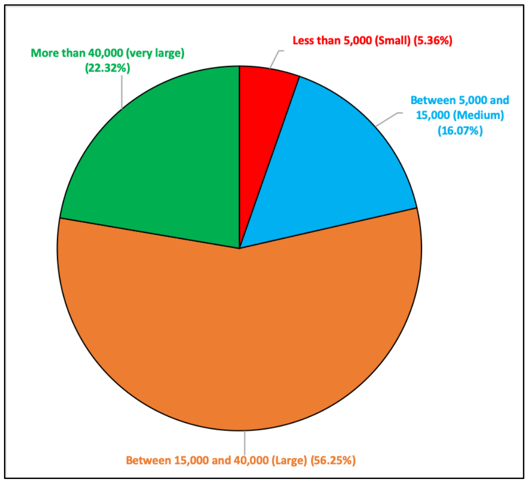

Figure 24 The size of HE institutions (Q4)

The results also show diversity in the size of participants' institutions, as shown in Figure 24. 22.3% of institutions reported they had more than 40,000 students (from Question 4); 56.3% had between 15,000 and 40,000 students; 16.1% had between 5000 and 15,000 students, and the remainder (5.4%) had fewer than 5000 students.

This suggests that the sample is biased towards the larger universities: In Canada, only 9 (out of 94) (9.6%) actually have more than 40,000 students (Universities Canada, 2019), and in the UK only 3 universities do (less than 2%) (Higher Education Statistics Agency, 2018-2019). Also, there are about 20 institutions in the USA with more than 40,000 students (U.S. Department of Education-National Center for Education Statistics, 2019).

So, in the end, we received data from 34% of all the very large universities in the top six countries we surveyed. This over-sampling of larger universities is a result of them more likely needing and having an EA program, so it is a sign of our survey's quality, rather than a threat.

5.2.1.2 The Extent of the EA Implementation (Q5)

In Question 5, we asked participants if they had an EA program and to what extent it is implemented. As shown in Figure 25, 50.9% of the respondents indicated that they had an EA program; 30.4% said that only aspects of EA were in place. 13.4% of the participants said they did not have EA but planned to adopt it, and only 5.4% said they did not implement EA in their institutions.

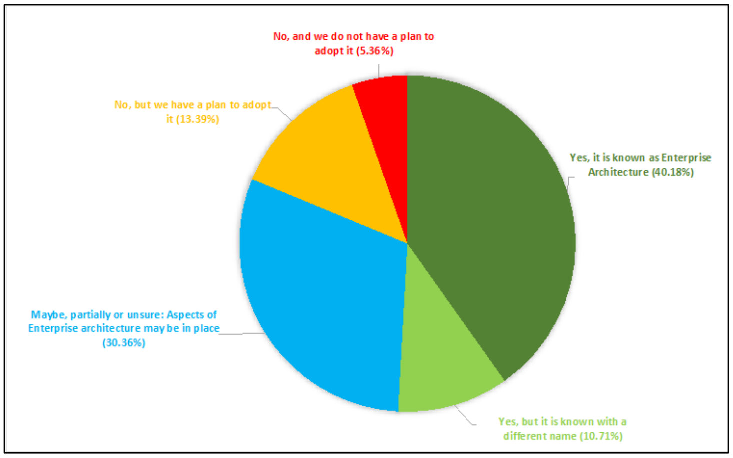

Figure 25 The extent of the EA implementation (Q5)

We received 59 responses from the top six countries to this question. The countries with the highest percentage of institutions having a full EA program are Saudi Arabia (100%), New Zealand (83.4%) and Australia (81.8%). In Canada, only 36.4% had a full EA program so far. In the USA, 53.8% had a full EA program.

5.2.1.3 The State of Implementation of EA (Q19)

For Question 19 to Question 27, the number of responses decreased to 83 for those adopting EA in their institutions. In Question 19, 32.5% of the participant said that the implementation of EA at their institutions was at a very early development stage, and it was relatively immature. 53.0% of the participants indicated that EA was established and had had a positive impact, but it was still actively developed.

On the other hand, 7.2% of the participants said that EA was established but had not had much impact on the institution or had not been successful yet. Only 3.6% of the respondents said that EA was mature and had a significant impact. 3.6% of the participants said EA was established but was winding down or was having less impact.

Only institutions in Saudi Arabia and Australia generally indicated that their EA was mature and had a significant impact, with 16.7% and 9.1% doing so, respectively. New Zealand and Saudi Arabia have the highest percentage of participants who said that their EA was established and had a positive impact on their institutions, with 66.7% for both. A percentage of participants from Saudi Arabia, Australia, and the USA (with 16.7%, 9.1%, and 7.7%, respectively) stated that they established the EA program, but they would wind it down. 50% of the participants in the UK said that their EA was at a very early development stage and was relatively immature.

5.2.1.4 How EA Is Conducted in HE Institutions (Q20)

In Question 20, we asked the participants if they would continue their EA work. 68.7% of the participants planned to put increasing effort into EA; 25.3% would keep effort at current levels while 1.2% expected to reduce it, and 4.8% expected to wind their EA work down. Saudi Arabia stood out with 100% of institutions planning to increase effort.

5.2.1.5 Organizational Model of EA that Best Fits HE Institution (Q21)

In Question 21, we asked the participants about the organizational model of EA that best fitted their institutions. The highest percentage of the participants, with 28.9%, indicated that they had a limited central architecture group, while 16.9% said that they had a central architecture group that reviewed all projects in the institution. We also obtained a balanced result with 13.3% of participants who had an informal architecture group acting as ad hoc architects in their areas and 13.3% who had a more formal, isolated architecture group focusing on one or two departments. 10.8% of the participants had a central lead architect(s) orchestrating the federation with domain architects. Only 7.2% of the participants had federated architecture with architecture groups or individuals around campus or campuses working together to form an 'EA' group.

We also received responses from 9.6% of participants who provided other forms of organizational models as follows:

1. One EA and no architecture team or other identified architects.
2. Federated Architecture Review Committee and a central EA function in which not all projects flow through EA, but all enterprise-level efforts do.
3. Limited central architecture (the team was disbanded in a reshuffle and scoped back).
4. A combination of central architecture (in terms of synchronizing ideas to existing) and distributed architecture (in terms of getting ideas).
5. Isolated architecture or even informal/ad hoc architecture group, but some elements of the central effort remain in place.

6. "Isolated" as they are mostly IT Architecture, "informal" as to EA (beyond IT), and not universal and not just in their own areas (i.e., IT talks to others, no others consider "enterprise").
7. Combination of a head architect with domain architects evolved from a Central Architecture function that still exists virtually to review all projects.
8. EA practice within the IT service area, working on a lot of significant initiatives, but with some level of federation with business architects in various areas.

Among our top six countries, the USA has the highest percentage of participants (53.8%) who had a limited central architecture group. All listed organizational models of EA were selected by the participants from the UK and Canada, with very close results.

5.2.1.6 Size of the EA Team (Q22)

The size of the EA team (Question 22) was well-distributed: more than 6 people (10.8%), 4-6 people (16.9%), 2-3 people (36.1%), 1 person (14.5%), and a part-time person only (21.7%). Our top six countries had roughly similar distributions of team sizes, but only Australia (18.2%), Canada (27.3%) and Saudi Arabia (33.3%) had any teams with more than 6 people. New Zealand stood out, with 66.7% who had between 2 and 3 team members.

5.2.1.7 To Whom EA Team Head Reports (Q23)

For Question 23, 55.4% of EA team heads reported to a CIO and 26.5% reported to an IT manager below the CIO level. Surprisingly, only one reported to a manager of a business-focused group such as a director of planning. Direct report to the CIO was most common in Saudi Arabia (66.7%) and the USA (69.2%).

We also received other responses from 10.8% of the participants as follows:

1. There is no head of the EA team because either there is no such position or there is no longer a clear EA team leader. There could someone trying to coordinate previous EA efforts part-time or the team is informally led by superiors who understand the benefit of EA (and may not be recognized as EA).

2. There are one or more directors, such as a director in a central IT Office, IT directors across the institution who report to the COO, or a director of Enterprise Systems Strategy who reports to the CIO.
3. There is a manager of the project management office (PMO).
4. The role is undertaken by an associate Vice-President (AVP), who reports to the CIO.

5.2.1.8 Centralization (Q24-25)

73.5% of the institutions were multi-campus (Q24). This likely over-samples the real proportion of multi-campus universities. We received more single-campus data from the UK and USA (33.4% and 30.8%, respectively) than the other top six countries.

In Question 25, we asked the participants about how centralized their institutions were with regarding to its Information Technology (IT) team. 50.6% of the participants indicated that there was a central IT team, but some of the work was distributed to departments, units, colleges or campuses, and 42.2% had a central IT team that did most of the IT work. On the other hand, only 7.2% said they had a central IT team, but most IT work was distributed.

Among our top six countries, only Canada and the USA had a central IT team that did most of the IT work with 18.2% and 15.4%, respectively. None of these six countries had almost all their IT work distributed.

5.2.1.9 What Enterprise Architecture Means to the Participants (Q26)

In Question 26, we asked our participants to give us their opinion about the extent to which 6 definitions applied to EA in their institutions. These definitions were derived either from the literature or from our interviews with enterprise architects. The 6 definitions of EA are listed in Table 16. We gave them a semantic difference scale from ‘Does not apply at all’ rated 0, ‘Somewhat applies’ rated 1, to ‘Strongly applies’ rated 2. In the literature, there have historically been people arguing against using semantic difference scales with parametric statistics, however with our sample size of 83 and backed up by recent statistical literature (Harpe, 2015), we feel confident that it is now considered legitimate to perform this sort of analysis.

The result of this question is shown in Table 16 and Figure 26. As Table 16 shows, none of the definitions strongly applied to EA, on average (i.e., close to 2.0), but most somewhat applied to EA (close to 1.0).

In Table 16, we have applied some keywords, which we call 'tags', to various definitions. These help us to distinguish the definitions. We have applied the same tags later on to the responses of other questions, in order to enable us to draw connections among various categories and answers. We have used some colour coding to help the reader make visual connections. In particular, the tags appear when we discuss processes (Table 51 and Table 52).

The definition that received the highest percentage of participants who thought it strongly applied to EA at their institutions is Def. (1) 'A process of understanding the different enterprise elements' (The Open Group, 2011) with 30.1%.

On the other hand, Def. (6) 'A discipline for proactively and holistically leading enterprise responses to disruptive forces' (Gartner. IT Glossary, 2017) was statistically less than the other definitions with a 0.86 average. It received the highest percentage of participants who thought it did not apply to EA in their institutions, with 32.5%.

The Saudi participants' answers to this question indicated that all of these definitions somewhat or strongly applied to EA at their institutions - all definitions from this list applied.

Table 16 Basic statistics for definitions of EA in the HE context (Q26); n=83 (Q26)

ID	Definition	Origin	Mean	Std. Dev	Tags
Def. (1)	A process of understanding the different elements that go to make up the enterprise and how those elements are inter-related.	(The Open Group, 2011)	1.20	0.60	[Process], **[Learning], [Institution-Wide], [Recognizing-Interdependence]**
Def. (2)	A digital representation of the organization's business and information technology landscape	By an interviewee	1.11	0.61	**[Automation], [Strategic-Information-Base]**
Def. (3)	A formal description of the current and future state(s) of an organization, and of managed change between these states to meet organization's stakeholders' goals and to create value in the organization.	(Syynimaa, 2015a).	1.02	0.72	**[Formalizing],** [Change-Management], [Value-Delivery], **[Stakeholder-Collaboration], [Roadmap]**
Def. (4)	A strategic information asset base, which defines the mission, the information necessary to	(CIO Council, 2001).	0.98	0.63	**[Strategic-Information-Base], [Automation],**

ID	Definition	Origin	Mean	Std. Dev	Tags
	perform the mission, the technologies necessary to perform the mission, and the transitional processes for implementing new technologies in response to changing mission needs.				[Change-Management], [Roadmap] [Management]
Def. (5)	A master plan that "acts as a collaboration force" between aspects of business planning, business operations, automation, and enabling technological infrastructure.	(Schekkerman, 2004).	0.90	0.69	[Stakeholder-Collaboration], [Automation], [Roadmap], [Business-Plan], [Business-Operation], [Technology-Infrastructure]
Def. (6)	A discipline for proactively and holistically leading enterprise responses to disruptive forces by identifying and analyzing the execution of change toward desired business vision and outcomes.	(Gartner, 2017).	0.86	0.70	[Process], [Leadership], [Institution-Wide], [Change-Management], [Value-Delivery], [Proactiveness]

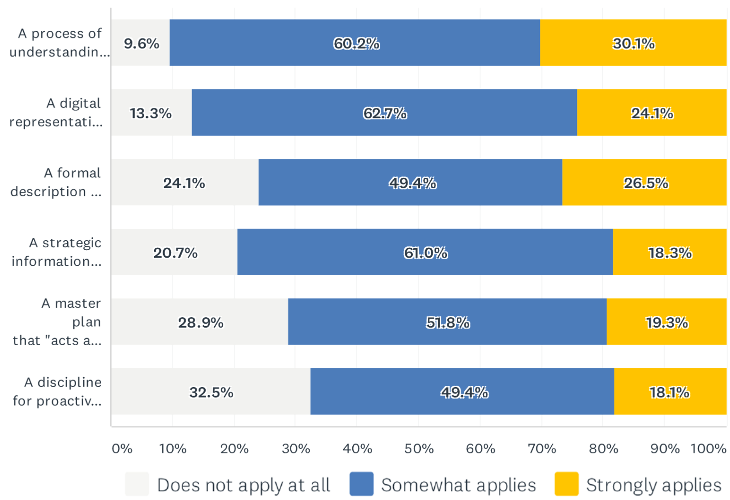

Figure 26 Definitions of EA in the HE context (Q26)

5.2.1.10 *Motivations for Undertaking EA in HE Institutions (Q27)*

For Question 27, we asked our participants to rate 9 motivations for EA on a scale: 'Not important at all' rated 0, 'Slightly important' rated 1, 'Moderately important' rated 2, 'Very important' rated 3, and 'Absolutely essential' rated 4. The motivations are listed in Table 17. We have also used tags in this table; most of the tags differ from the ones in the previous table, indicating that the motivations and definitions are not entirely in alignment. For example, the notions of alignment, simplification and cost reduction appear prominently in the motivations, but do not appear in the definitions. And the notion of change management, which is prominent in the definitions only weakly appears in the motivations.

Table 17 Motivations for undertaking EA in HE institutions (Q27)

Motivation	Tag
<u>Align</u> projects with university's goals.	[Alignment] **[Institution-Wide]**
<u>Align</u> business and IT sectors.	[Alignment] **[Business-Plan]**
<u>Rationalize</u> and <u>simplify</u>, including reducing duplication.	[Rationalization], [Simplification], [Cost-Reduction]
Enable <u>digital transformation</u> and improve <u>automation</u>.	[Digital Transformation], **[Automation]**
Better <u>leverage</u> assets.	[Leverage]
Enable institution to be more <u>adaptable</u>.	**[Adapting and agility]** [Change-Management]
Enable decision making to be <u>data driven</u>.	[Data-driven], **[Better-Decision-Making]**
<u>Reduce</u> costs.	[Cost-Reduction]
EA <u>mandated</u> by government.	[Mandated]

The result is presented in Table 18 and Figure 27 (row labels have been abbreviated to reduce clutter).

Table 18 shows that none of the motivations are regarded, on average, as absolutely essential (i.e. close to 4.0), but most are very important (close to 3.0). Two motivations stood out with 74.7% for 'Align projects with university's goals', and 73.5% for 'Align business and IT sectors,' as elucidated in Figure 27.

'Reduce costs' is moderately important, and this is statistically significantly less than the top 5 motivations. Only 40.9% of respondents considered it very important or higher.

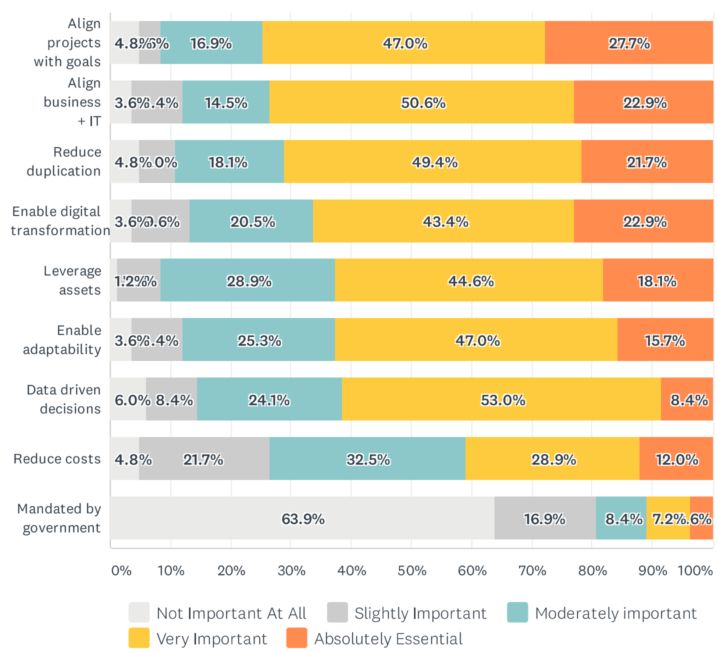

Figure 27 Motivations for undertaking EA in HE institutions (Q27)

Table 18 Basic statistics regarding motivations of EA in HE institutions; n=83 (Q27)

Motivation	Mean	Std. Dev	95% Confidence Interval of mean	
Align projects with university's goals.	2.89	1.01	2.67	3.11
Align business and IT sectors.	2.81	1.01	2.59	3.03
Rationalize and simplify, including reducing duplication.	2.77	1.02	2.55	2.99
Enable digital transformation and improve automation.	2.72	1.04	2.50	2.95
Better leverage assets.	2.71	0.89	2.52	2.91
Enable institution to be more adaptable.	2.63	0.97	2.41	2.84
Enable decision making to be data driven.	2.49	0.98	2.28	2.71
Reduce costs.	2.22	1.07	1.98	2.45
EA mandated by government.	0.70	1.12	0.45	0.94

Hardly any of the institutions had EA mandated by the government; the only exception to this was in Saudi Arabia, where 66.7% said this motivation was very important or absolutely essential. In Canada, only one (9.1%) said this was a very important motivation.

Saudi Arabia stood out in several other answers to this question too. For example, its respondents rated 'Rationalize and simplify, including reducing duplication,' 'Better leverage assets,' 'Reduce costs' and 'Enable digital transformation and improve automation' much higher (50.0-66.7% absolutely essential) than did respondents from other countries (on average 27 % absolutely essential). 'Align projects with university's goals' and 'Align business and IT sectors' were the most essential motivations in the USA and New Zealand (38.5% and 33.3% absolutely essential respectively).

We also received seven additional survey responses to identify motivations other than what we provided (that had been determined from the grounded theory). Interestingly, one participant indicated that it was difficult to identify the motivations for EA from an institutional perspective because "there is no written strategy in these areas, history of interest has been spotty," and because of the newness of their current administration. Another said that they did not have EA motivations because their institution believed that EA did not provide practical outcomes and did not add value to the business.

On the other hand, a few participants provided some motivation for using EA in their institutions, including improving decision-making by promoting the adoption of architecture principles and best practices and providing analysis and options for decision-makers to make the best decisions. Another essential motivation was to reduce the risk of project failure due to a lack of insight and careful and persistent effort. The participant defined the project failure as "over budget, over schedule, or delivery of incomplete functionality." Also, having an EA department was one of the motivations given by one of our participants. Finally, another participant added a motivation that was not on our list: "facilitating security and privacy by design."

5.2.1.11 Reasons of not Adopting EA in HE Institutions (Q6)

We asked those who indicated that they did not adopt EA in their institution why they did not tend to use it (Question 6). We received only 5 responses to this question. Although this is not enough for statistical inference, the small sample could give us an idea about why people do not tend to adopt EA at their institutions.

We list 13 factors for not using EA and provide a scale as follows: 'Not a factor' rated 1, 'A minor factor' rated 2, 'A significant factor' rated 3, and 'A major factor' rated 4. The result is presented in Table 19.

Key results are highlighted in grey in the table. The results show that 'Nobody has seriously thought about it' was the factor with the highest percentage of participants (40%) who stated it was major reason to not use or implement EA. However, 'Staff are too busy with other tasks' was overall more important with 20% of respondents believing it was a major factor and 80% believing it was an important factor.

In contrast, 100% of respondents believed that 'We have heard about failures of EA (or experienced them)' was not a factor in not implementing EA. Another interesting finding is that 25% of the respondents believed that 'Relevant people have not yet learned enough about it' was not a factor in not adopting EA, while 75% believed it was a significant factor.

Table 19 Factors of not implementing EA in HE institutions; n=5 (Q6) *

Factors	Not a factor	Minor factor	Significant factor	Major factor
Nobody has seriously thought about it	20%	20%	20%	40%
Staff are too busy with other tasks	0%	0%	80%	20%
We are unable to hire sufficiently knowledgeable staff	40%	20%	20%	20%
University finances are too limited	40%	40%	0%	20%
Relevant people have not yet learned enough about it	25%	0%	75%	0%
The university has other processes in place to manage its assets, information and processes	40%	20%	40%	0%
Senior management does not support it	60%	0%	40%	0%
IT team(s) do not support it	60%	0%	40%	0%
Other potential stakeholders do not support it	60%	0%	40%	0%
There is a desire to keep the amount of administrative work as small as possible	60%	0%	40%	0%
The university is too decentralized	50%	25%	25%	0%

Factors	Not a factor	Minor factor	Significant factor	Major factor
The university is too small, so it is considered unnecessary	60%	40%	0%	0%
We have heard about failures of EA (or experienced them)	100%	0%	0%	0%

* The light-grey shaded cells indicate important or most interesting data

5.2.1.12 *Participants Who Have a Plan for EA Implementation (Q7-10)*

Questions 7 to 9 were directed to those who had a plan to implement EA but had not yet done so. We received 15 responses to Q7-9. As with Question 6, this was not a good sample, but still it gave us an insight into the perspective of people who had a plan and interest in implementing EA in their institutions. 60% of these institutions were single-campus (from Q7), while 40% of them were multiple-campus.

40% of the participants of this question series indicated that they had a central IT team that did most of the IT work (from Q8), whereas 60% of the participants said that they had a central IT team, but some of the work was distributed to departments, units, colleges or campuses.

For Question 9, we asked the same question regarding definitions as for those already doing EA as discussed in Section 5.2.1.9. There is consistency among the responses, but Definition (2) ‘A digital representation of the organization’s landscapes’ stood out, with 42.9% of the participants believing that this definition strongly applied to EA. In contrast, Definition (3) ‘A formal description of the current and future states of an organization’ has the lowest percentage, with only 6.7% of the participants stating it strongly applied to EA. Definition (6) ‘A discipline for proactively and holistically leading enterprise responses to disruptive forces’ has the highest percentage of the participants who indicated it did not apply to EA (35.7%). These results share many similarities with the earlier results from Section 5.2.1.9.

For Question 10, we asked about the motivation of the future EA adopters, just like we asked about those who had already adopted EA ad discussed in Section 5.2.1.10. We received 12 responses to this question. 100% of participants believed that ‘Align business and IT sectors’ was very important or higher, consistent with our earlier analysis. On the other hand, 66.7% of participants believed that ‘EA mandated by government’ was not important at all. ‘Reduce costs’ is almost at the bottom of ranking, where only 27.3% of participants stated that it was very important or higher. Again, this is consistent with results from institutions who had already adopted EA.

5.3 Lessons Learned and Recommendations

The most important lessons learned from the elements of the study reported in this chapter are:

- Enterprise Architecture is widely used in higher education, especially on larger campuses and in countries where it is mandated (Saudi Arabia).
- Higher Education enterprise architects are motivated by a desire to facilitate the alignment of business and IT and associated projects. They also want to enable digital transformation, reduce duplication and leverage assets.
- Enterprise architects in HEIs are advised to use EA to reduce the complexity of digital transformation and facilitate aligning business and IT.
- There is a lot of consistency among countries regarding the motivations for adopting EA.
- Most of the survey responses were from public institutions; specifically, 34% were from very large universities in the top six countries, indicating that they likely needed and had an EA program.
- In general, most of our respondents had an EA program or adopted only some aspects of EA, which indicated the need to have EA in the HE institutions.
- More than half of our participants said they had a positive impact from adopting EA and it was still actively developed. Most of them planned to put increasing effort into EA.
- None of institutions from the six key countries had almost all their IT work distributed.
- Four main EA team size categories range from very small (part-time person only or one person), small, medium, and large.
- An EA team can be a virtual architecture team, a distributed team, a team with dedicated and partial members, a more centralized team, and a small and lean team.

- The roles played by each member of the EA team were varied. In some cases, a member of the EA team had a different job title but was doing EA work. Other members were architects or senior architects. Some of the architects were playing multiple roles. External consultants or external enterprise architects in some cases did the EA work. Academics or senior administrators also did certain EA work.
- Some examples of the EA team's leaders are directors, CIOs, managers, or other senior/chief architects.
- EA stakeholders in HE institutions include CIOs and senior managers, EA managers, IT directors, EA team members, business managers and staff, academic community members, students, strategic partners, individual stakeholders in projects, and members of boards, committees, and offices.
- The EA definition from The Open Group (2011) received the highest percentage of participants who agreed that it strongly applied to what EA is in HE institutions.
- Having better communication between different parties in a university, increasing EA maturity, and getting tangible benefits from implementing EA, such as reducing the cost and increasing the number of projects that EA is involved in, are some of the indications of the successful implementation of EA in higher education institutions according to our study results.
- To avoid rejection by management, enterprise architects need to increase awareness of EA, demonstrate EA value and outcomes and have a good team.
- Having outdated roadmaps and models, having an immature EA, and not developing or following standards are signs that the implementation of EA in higher education institutions has failed according to our study results.
- Not thinking seriously about EA and having staff busy with other tasks were among the most important reasons not to implement EA in HE institutions. On the other hand, the failures of EA or experiencing them were never a reason for not using or implementing EA.
- Enterprise architects need to be aware of indicators of failed implementation of EA in HEIs and work on them before continuing EA implementation.

Chapter 6 Frameworks, Models and Tools

In this chapter, we provide a brief background of the main frameworks and tools used in EA. Also, we review and identify the gaps in the literature relevant to the use of EA frameworks, models and tools in the HE context*. Then, in Section 6.2 and Section 6.3 respectively, we present the analysis of the results from our grounded theory and survey regarding the EA frameworks (EAFs), models and tools used in the HE community around the world. We conclude with lessons and recommendations.

6.1 Introduction and Background

Over the last several decades, several frameworks have been developed to guide enterprise architects. We asked practitioners about their use of these frameworks, so we briefly highlight them here.

One of the earliest frameworks used to guide enterprises in their information systems architecture was the Zachman Framework (Zachman, 1987). This is considered the seminal framework, although it is not as comprehensive as later work and focuses more on IT and less on other aspects of the business. Zachman (1987) described the notion of architecture at the enterprise level and suggested some modeling types.

Since 1995, the Open Group has been developing the most-used EA framework called TOGAF (The Open Group, 2018). This is a comprehensive guide that considers business, data, applications and technical architecture as well as process, governance, change management and similar issues. The current version of TOGAF is version 9.2, published in 2018.

In some world regions and industries, specialized frameworks have been developed. Of particular note is the framework developed by the Council of Australian University Directors of Information Technology (CAUDIT) (CAUDIT, 2013). This has as objectives to, "increase the value and efficiency of their architecture teams, facilitate the exchange of architectural knowledge and good practice in the sector, support interoperability and

* Some of the materials are adapted from (Lethbridge & Alghamdi, 2019)

collaboration between member organizations, and improve engagement with industry in major projects and initiatives."

In Saudi Arabia, the National Overall Reference Architecture (NORA) is prescribed for public sector organizations (E-Government Program (Yesser), 2017). It focuses on the continuous governance of both architectures and projects.

The ITANA Learning Working Group (ITANA Working Group, 2013) provides educational institutions with a set of resources, skills and tools to help with their enterprise, business and technical architectural needs. ITANA was formed in 2007 and is supported by EDUCAUSE and Internet2. It was expanded to include enterprise architects and business architects in Academia in 2012. It has contributed to this field by developing a reference architecture for teaching and learning enterprises called Reference Architecture for Teaching and Learning (RATL) (ITANA Working Group, 2013). RATL is primarily used to map the business functions, processes, and application systems of the institutions. Besides, it is used to assess their maturity, and make a plan for proposed changes, and model the impact of new objectives (ITANA Working Group, 2013).

The American Productivity & Quality Center (APQC) was founded in 1977 in the US by Jack Grayson, and it has members from 45 industries from around the world. In 1992, the APQC developed a process framework called APQC's Process Classification Framework (PCF) for organizations of different domains (APQC, 1992). APQC developed industry specific PCFs; one of them is for the education industry (APQC, 1992). Organizations can leverage the PCF for better EA outcomes by using it as a taxonomy of their business processes, and to organize and map them. The PCF also allows organizations to track their performance by providing definitions and key performance indicators for the process elements in the framework (APQC, 1992).

As for the tools specifically targeted to EA, there are relatively few tools in this regard. One of them is the ArchiMate language (Lankhorst, Proper & Jonkers, 2009) and the associated Archi tool (Beauvoir & Sarrodie, 2019), which are most widely used. ArchiMate provides an extensive palette of graphical symbols for modeling aspects of the business, applications and technical infrastructure, as well as numerous types of relations among them.

In summary, we discovered a gap in the literature regarding this topic. For example, some studies suggested using Zachman and TOGAF to develop EA in the HE institutions. Yet, they did not provide concrete reasons for selecting these specific frameworks (Adwan & Al-Soufi, 2016; Amalia & Supriadi, 2017; de Fatima Gusmao & Setyohadi, 2017; Oda, Fu & Zhu, 2009; Oktavia, Prabowo, Kosala & Supangkat, 2016; Ramadhan & Arman, 2014; Soares & Setyohady, 2017). There is a need to conduct further research to evaluate the EA frameworks used in higher education and propose a systematic method for selecting the best of them, or the ones most suitable to particular educational institutions.

A few studies have suggested using the lightweight domain-specific modeling language LEAP for expressing EA models in higher education because it resolves certain problems experienced with ArchiMate (Clark, Barn & Oussena, 2011; Clark, Barn & Oussena, 2012a; Clark, Barn, & Oussena, 2012b).

A few studies developed reference models for HE institutions (Sanchez-Puchol, Pastor-Collado & Borrell, 2017; Ahmadi, Soltani & Gheitasi, 2007; Beeson, Green & Kamm, 2013; Chen, Tang & Li, 2016; Green, Beeson & Kamm, 2009) and explained their importance. Other studies discussed the use of UML for defining EA models but to a limited extent.

EA frameworks such as TOGAF, ITIL, or NORA have been developed or customized to be used for the HE sector or other public sectors. In particular, NORA has five types of reference models. These are:

- Performance Reference Model (PRM), which sets the performance standards for the government agencies through the measurement indicators, and thus provides a set of performance standards for the other below four reference models from an architectural point of view.
- Business Reference Model (BRM), which has a set of business architecture models such as business processes model, business functions diagram, and business areas diagram.
- Application Reference Model (ARM), which has a set of application architecture models such as application systems structured diagram, application components structured diagram, and application interfaces structured diagram.

- Data Reference Model (DRM), which has a set of data architecture models such as data model, conceptual data model, logical data model, and data flow diagrams
- Technology Reference Model (TRM), which has a set of technology architecture models such as service area diagram, service category diagram, and infrastructure overview diagram.

The NORA framework has been used by the public sectors in Saudi Arabia, including the HE sector. It has also been adapted by other organizations.

In addition, the TOGAF framework has also been used or adapted by some universities as highlighted in our literature and mentioned by some of our interviewees. TOGAF has a set of architecture models including:

- Business Architecture models. Including business motivation model (BMM), business footprint diagram, and business process model.
- Data Architecture models: Including logical data model, data management process model, conceptual data diagram, and business data model.
- Application Architecture models: Including application communication diagram, application and user location diagram, and application use-case diagram.
- Technology Architecture models: Including, technical interoperability, networked computing/hardware diagram, and network and communications diagram.

TOGAF also has several reference models (RM) (e.g., The TOGAF Technical Reference Model (TRM)) as well as maturity models (e.g., Capability Maturity Models (CMMs)).

However, more research in this area is required to review the tools, models and modeling notations used by the HE institutions to model and develop EA.

6.2 Grounded Theory Results

In this section, we discuss the results of the grounded theory process regarding the frameworks, tools and models that enterprise architects used, as well as what they liked and disliked about them. We asked our 21 interviewees a set of questions as follows:

What were the EA frameworks and methods you used if any?

Did you use any specialized EA framework for higher education? If yes, what is it?

If you used a framework, did you follow it closely? If not, why not, and what changes or adaptations did you make?

What were the EA tools that you used to support EA?

What do you like about these tools? To what extent have these tools supported the EA frameworks and methods you chose?

What did not you like about these tools? (What problems did they have?) What improvements would you like to see?

What modeling notations/standards did you use? Why did you choose them?

What models did you build (e.g., enterprise models, business process models, data models, system models, etc.)?

To what extent are these models being used? E.g., are they being used for structuring the organization, procurement, software development, etc.?

We followed the grounded theory process described in Chapter 4 to code and analyze our interviewees' answers. In the following sections, we review and discuss the results.

6.2.1 EA Frameworks Used by HE institutions

We asked our interviewees whether they used any of the existing EA frameworks or if they developed their own frameworks. We analyzed and coded the responses and discovered different themes regarding this topic. The interviewees talked about the frameworks they used, to what extent they used them, the advantages and disadvantages of the frameworks, and for what they used the frameworks.

Some interviewees indicated that they used some of the existing frameworks that were developed for EA. We classified the frameworks used by the interviewees into:

- TOGAF framework.
- NORA framework (National Overall Reference Architecture).
- KPMG framework.
- Zachman Framework.
- DODAF (Department of Defense Architecture Framework).
- ITANA methods and architectural values change steps.

- ITSG framework for network zoning (ITSG22).
- COBIT by ISACA (Control Objectives for Information and related Technology).
- CAUDIT HE reference models by EDUCAUSE.
- Gartner approach to EA.

One of the interesting answers was that some of the interviewees said they used customizable frameworks adapted from various existing frameworks.

Other participants said they adapted some frameworks or used specific frameworks to complement their major frameworks. For example, one of our interviewees said:

> *"The entire development is mostly aligned to NORA framework and TOGAF to complement the missing components from NORA framework…"*

Other interviewees said:

> *"…we use part of TOGAF, if you will. We do not use the entire TOGAF framework. We use part of its structure … on the ADM side…"*

> *"…In terms of the frameworks, we have looked at various frameworks like Zachman, TOGAF, DODAF, and others. These kinds of frameworks are kind of useful for defining and guiding the development of detailed architecture. They provide guidelines, modeling techniques and methods for EA development. But we did not follow like particular framework or... like we did not say this is a framework we are going to follow from kind of start to end whether we follow Zachman or TOGAF to the book. Rather we tend to adopt what could work for us from various frameworks. We use certain methods and approaches, and we have adjusted them to our own environment…"*

Other interviewees said they aligned with a basic infrastructure framework. Others said they worked based on business capability planning.

On the other hand, some of the interviewees did not follow specific frameworks for EA. For example, they said that they used a blueprint that based on prior to EA experience from other HEIs. They stressed that this blueprint helped them communicate change, ideas and concepts, about generating artifacts that can become reference architectures, which then everything was measured against, with people in their institutions. Others said that they used frameworks or reference architecture known from corporate experience.

In addition, some of the interviewees said that they worked off their own roadmaps, while others had an engagement practice to follow. Some said that they had a way of thinking and working that applied to different situations.

We also asked our interviewees, who used the frameworks, to what extent they followed or used these frameworks. We classified the answers as:

1. Using the EAF extensively.
2. Not following the EAF closely:
   - They tailored or adapted the EAF to meet their university's needs.
   - They use only specific parts of the EAF's processes or methodologies.
   - They have adopted various aspects of the EAF driven by the IT department or what adds value to the university.
   - They have adapted the EAF to work with more agile methodologies.
3. Borrowing or adapting from various existing EAFs and reference models (Customized EAF):
   - Based on TOGAF or any other existing EAF but adds a few things.
   - Driven by an institution's function.
   - Driven by problems facing the institution.
4. Depending on the previous experiences of the use of EAFs in HE or another industry.
5. Not following the EAF at all:
   - Not following the EAF rigorously.
   - Not prescribing a particular process of EAF to follow.
   - They do not like following one or a specific EAF.

The interviewees also talked about the advantages of the frameworks they used, such as being general, being very organic, being complete and covering different aspects, being a very good reference, and being able to complement missing components from other frameworks. Yet, others talked about some of the disadvantages of the frameworks such as the difficulty to implement as a whole, being too big and overwhelming, and posing a steep-learning curve.

The frameworks were used by the interviewees for different purposes. The main reasons that motivated them to choose their frameworks were:

- Modeling and creating artifacts for modeling the solutions.
- Organizing the EA team.
- Managing risk.
- Guiding the development of their own methods and processes.
- Creating an architecture overview and the processing models.
- Better understanding solutions to problems.
- Mapping all real applications and infrastructure.
- Defining and guide the development of detailed architecture.
- Providing guidelines, modeling techniques and methods for EA development.
- Suiting the university's needs.
- Very complete, general and covering different aspects.
- Complement with other frameworks.
- Very good reference.

6.2.2 Models and Modeling Notations or Standards

We also asked our interviewees about the models they built and to what extent they were being used. We classified the answers into various themes, including the set of models built, the reasons for using the models, the obstacles of building the models, and the basis on which the models were built.

We defined a large number of codes from the answers to this question. We classified the set of models used by our interviewees into a group of main categories, as shown in Figure 28.

The first group of codes represents the different types of models used in EA by HE institutions. Some examples of different models used by our interviewees are technology models, service models, security models, enterprise models, infrastructure models, application models, data models, and system models.

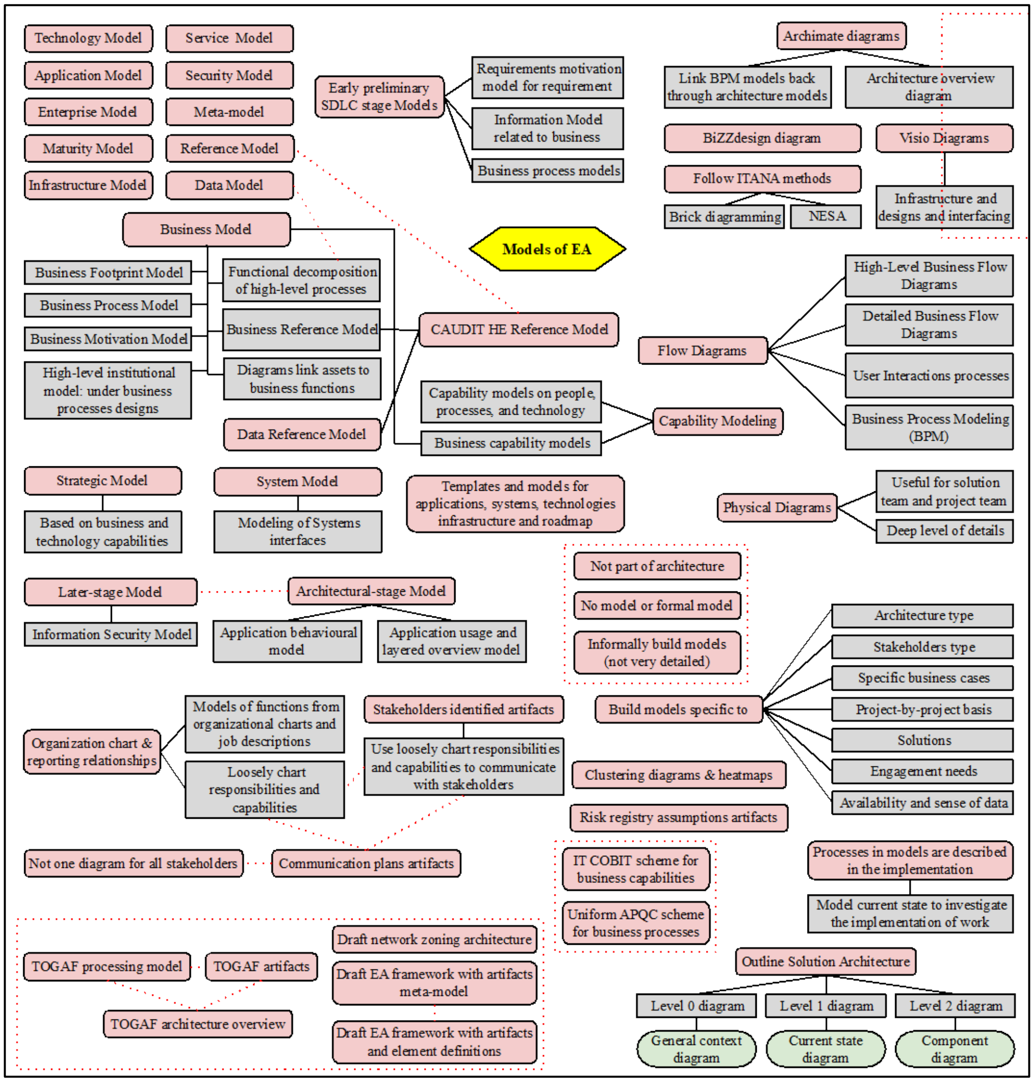

Figure 28 Models used by HE institutions (GT results)

Business models were used by some of our interviewees, such as the business process models, business motivation models, business footprint models, and functional decomposition of high-level processes. Related models used were the strategic models to develop strategic goals and express the overall strategy of the institutions at the enterprise level. Maturity models, which are a survey-based framework, were also used to assess IT capabilities. Some interviewees also mentioned that they used reference models such as CAUDIT HE business and data reference models.

Other interviewees said they used capability models regarding people, processes, and technology. They are created to understand or describe the capabilities of the enterprise, which in turn helps to deliver the purpose, mission, and contribution of the institutions.

Examples include business capability models, process capability models, and data capability models.

Models of functions from organizational charts and job descriptions and loosely charted responsibilities and capabilities were used by some of the interviewees. These models were used for communication plans. Also, stakeholders identified artifacts that were created to communicate with stakeholders, according to a few interviewees. Some interviewees also mentioned that they used metamodels, which are descriptions or classifications of the types of things and rules between them that are used to express models.

Some of the interviewees talked about the uses of the models during certain stages of the implementation. For example, some participants talked about models created at the early preliminary stage of the software development life cycle (SDLC) such as requirements motivation model for requirements, information models related to business, and business process models. Other interviewees said that they created models at the architectural-stage such as application behavioral model, and application usage and layered overview models, as well as models at later-stage such as information and security models.

The other group of codes is about the artifacts or models used by some interviewees that were related to specific frameworks such as IT COBIT scheme for business capabilities, uniform APQC scheme for business processes, TOGAF artifacts and processing model, draft EA framework with artifacts and element definitions and risk registry assumptions artifacts.

The third set of codes is about diagrams they were used by some interviewees. Diagrams are defined as a specific view of all or part of a model in a specific context. Some of the interviewees used specific modeling tools to draw the diagrams such as ArchiMate diagrams, BiZZdesign diagrams, Visio, and following ITANA methods for creating Brick diagramming and NESA. Others mentioned the creation of various types of flow diagrams such as high-level business flow diagrams, detailed business flow diagrams, user interaction processes, business process modeling (BPM). Additionally, the physical diagrams were used because they were useful for the solution team and project team and provided a deep level of detail, according to one of our interviewees. Finally, diagrams used for outline solution architecture were used such as context diagrams, current state diagrams, and component diagrams.

The final group of codes is the templates used for applications, systems, technologies infrastructure and roadmaps, according to one of our interviewees.

Although most of our interviewees emphasized that they used or built the models, few believed that the models were not important. One interviewee said that the models were not a focus for them. They focused more on resolving the issues their institution faced and building models based on the cases they faced. He said that often those who build models were the staff in the IT department. One of the interviewees indicated that the models were built with enterprise architects and/or network data analysts.

The interviewees also explained that the models were built based on one or more of the following:

- Architecture.
- Stakeholders.
- Business cases.
- Project-by-project basis.
- Solutions.
- Engagement needs.
- Availability of data.
- Different SDLC stages.

We also asked the interviewees about the reasons for creating and using the models. Their answers were varied. They provided a range of reasons for using models either in general or according to a specific type of model. Here are some samples of what the participants said about the reasons for using the models:

- Helping **understand roadmaps** on describing what the EA team does and how they need to think and act (e.g., Brick diagramming and NESA from ITANA methods).

- Demonstrating the **current situation** and maturity of the university and using different viewpoints to say how to invest in current capability or new capability, and in operations and efficiency (e.g., reference models).
- Helping **deliver business value**.
- **Getting everyone on board** by adopting enterprise models in the university.
- **Identifying the security zones** and the main components which helps avoid any redundancy.
- Identifying **return on investment** (ROI).
- Identifying **risks** involved.
- Creating a **deep level of detail** of the systems' after they are built, and they are in a stable operational state, which is useful for the solution and project teams (e.g. physical diagram).
- Diagramming business processes from the student perspective to understand what the **user experience** would be and get a better idea of what the potential implications are (e.g., business process model).
- Diagramming business process models when the requirements are **in conflict with each other** (e.g., business process model).
- **Linking** detailed business flaws with high-level models of services within the business side (e.g., models in ArchiMate).

The uses of models depended on the self-sufficiency of the faculties, as highlighted by one of our interviewees. He said that the large faculties used fewer models and services from central IT, and they developed their own capabilities. In contrast, smaller faculties used more models and services from central IT.

Another topic that was raised by some of our interviewees was the obstacles or issues experienced by our interviewees with building and using their models. One of our interviewees mentioned that there was a gap between their models and implementation. Another interviewee highlighted that they were slow in building models at their institutions, and they did not have an inventory for their models. They had a large set of models, but it was hard to keep them up to date (the models became out of date and useless).

6.2.2.1 *Modeling Notations Used by HE Institutions*

We asked our interviewees about the modeling notations/standards they used or followed and why they used them. The answers were coded into themes, including the set of modeling notations or standards used, and the reasons for using them, as well as what prevented them from using them.

Some examples of modeling notations or standards used by some of our interviewees were:

- Business Process Model and Notation (BPMN): simple standards for business process modeling.
- Unified Modeling Language (UML): context diagrams and use cases used for architectures.
- Simple standards for conceptual data modeling.
- ArchiMate standards: model and architecture definitions, internal standards, and business architecture.
- The CAUDIT Higher Education EA Reference Architecture designed in Australia: Business Reference Model and Data Reference Model.
- NEA Framework Standards.
- TOGAF Standards.
- Technology Assessment Standards (YEFI).
- IT Governance Standards.
- IT Service Management Standards.
- Quality Standards.
- Use whatever is fit-for-purpose for the EA team.

The interviewees gave us some reasons for using modeling notations and standards. One of these was because they were familiar and comprehensive (e.g., UML) or widely used in EA development (e.g., ArchiMate, BPMN, and UML). Some also used specific modelling notations because they were tailored to fit the needs of their institutions. Another reason was that they had used a specific modeling tool because it had additional features other than UML for modeling and business architecture (e.g., ArchiMate). Another reason to use modeling notations and standards was to map applications against models.

Although some interviewees confirmed using modeling notations, others said they did not use or follow any modeling notations or standards because they either did not care about having artifacts or models, wanted to keep everything simple for the EA team, or were immature in regard to modeling notations.

6.2.3 Tools

We asked our interviewees about the tools they used to develop and support EA at their institutions, and what they liked and disliked about these tools. Some interviewees said that they were at an early stage in the adoption of EA tools, and some never had the maturity needed to use specialized tools. Others said that they re-evaluated their tools as EA activity expanded and matured.

We categorized the answers about the tools used to support EA into groups of codes, as shown in Figure 29.

The first category is the basic tools that were used by most of our interviewees, including word processors, presentation tools, and spreadsheets such as MS Word, Google Docs, PowerPoint and Excel.

Second, the specialized or EA-specific tools were used by some of our interviewees to support the strategically driven planning of EA through to the execution. Examples of such tools are iServer For Enterprise Architecture by Orbus Software, Enterprise Architect by Sparx Systems and other tools presented in Figure 29.

One of our interviewees said:

> *"... we used the traditional common Microsoft Office tools like Visio, Excel, Word, and so on. But recently we have adopted a specialized EA tool. The name of the tool is called Erwin EA agile. It is a lightweight EA tool for capturing and storing architectural information and serves as central repository for the EA information..."*

Also, ArchiMate is another EA modeling tool that was mentioned by most of our interviewees.

For example, one of our participants said:

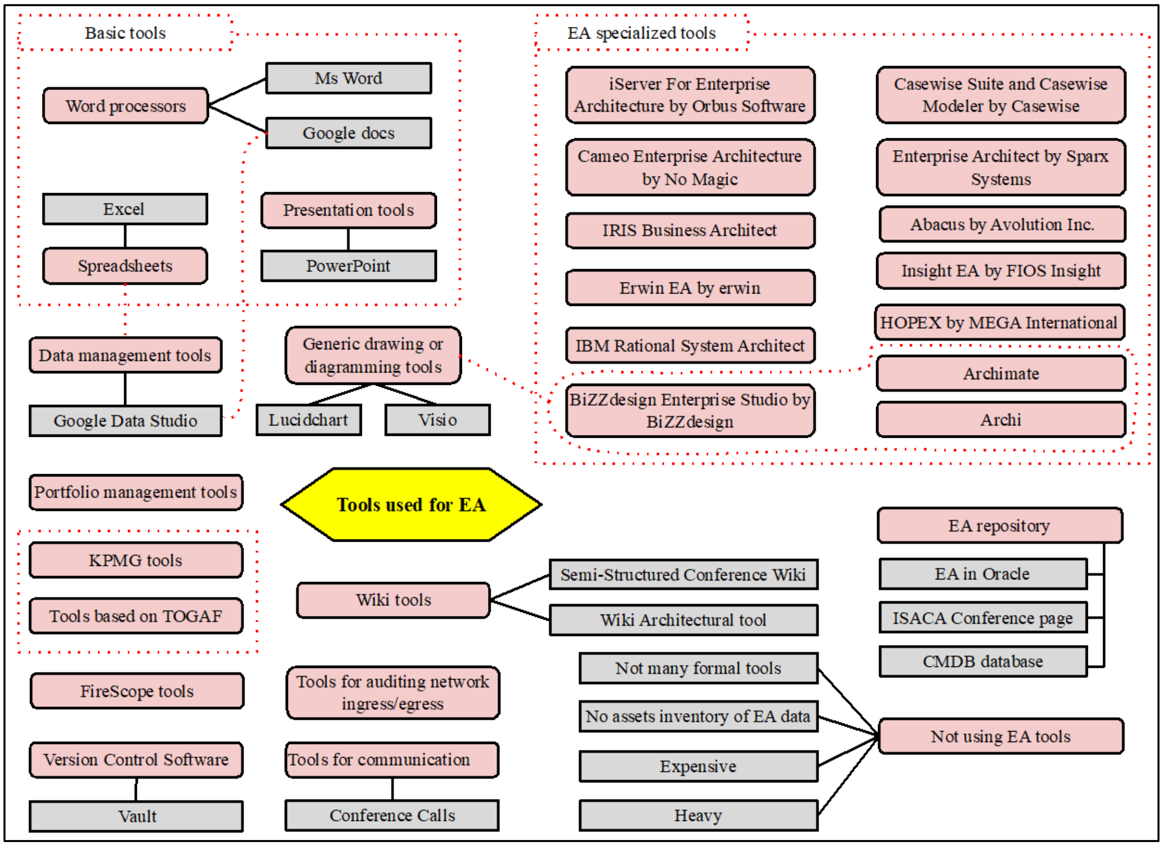

Figure 29 Tools used to develop and support EA in HE institutions (GT results)

> *"...we do use Archi as ArchiMate modeling tool and Visio ... to a large extent at this point, we have not been enabled to make a significant investment in EA software tools..."*

Another category is the generic drawing or diagramming tools that were used to create detailed diagrams such as Lucidchart and Visio.

A further category includes the data management tools that were used for storing, synchronizing, analyzing and distributing data such as Oracle Data Management Suite and Google Data Studio.

Moreover, some interviewees said that they used the EA repository, which was used to store, manage and provide access to the EA artifacts such as Abacus from Avolution Software and CMDB database.

Also, they said they used version control software, which was used to manage and track changes to files, code and assets over time and allow for team collaboration. An example cited was Vault by SourceGear LLC.

Another class of tools used by our interviewees are wiki tools that enable creating and collaboratively editing web pages through a web browser. Examples cited include the semi-Structured Conference Wiki and Wiki Architectural tool.

Also, some interviewees mentioned that they used specific tools to enable internal and external communication such as conference calls. One of our interviewees said that they used the FireScope Secure Discovery & Dependency Mapping (SDDM) tool to populate and maintain CMDBs using an automated approach to discovery and dependency mapping of all the assets in the enterprise. Finally, some interviewees used tools that were based on TOGAF or from KPMG; others used tools for auditing network ingress/egress.

We used a list of these tools to build a question in our survey, asking our participants to what extent they used them. We then analyzed and coded the answers regarding the advantages of the tools used by the interviewees in Table 20. The table has main categories of the advantages and the description of some of them.

Table 20 Advantages of tools used by HE institutions to support EA from GT results

Main Category	Concept	Description
Tool type	Specialized tool	Example: Enterprise Architect.
	Interim tool	Tool that is not heavy nor expensive.
	Web-based tool	Cloud-based tool.
	Open-source architecture modeling tool	
Quality	Ease of use	Simplicity and sufficient. Lightweight tool.
	Cost-effective (not expensive)	Availability and accessibility in terms of finances and training. Have different kinds of licenses.
	Support of cross-platforms	Work on Mac and Windows. Have different user privileges.
	Integration with other tools	Integrate artifacts of a university's business, and with additional tools and frameworks.
Capability	Integration with a central repository of EA information	Integrate a repository with EA services closely and enable sharing all services.
	Production of good and understandable models	Flexibility to create the models. Use of describing or drawing tool.
	Maintaining information consistency	Capture and store all assets in the system and architectural information and keep that database and models up to date.
	Management of specific EA representations, data, and relationships	
	Validation of models and diagrams	
	The ability for service access and delivery	
	Support for EA standards	
	Support of EA frameworks	

Use case	Collaboration, communication and sharing	The ability of architects to share the diagrams and architecture. The ability of top management and executives to review the architectural artifacts. Capture notes for meetings, drafts for proposals and statements for work.
	Populating EA data and getting the value back	Have an object-oriented database.
	Creating data-driven roadmapping and capability mapping	
	Ability to be implemented within the central IT unit or at a small scope	

We used Table 20 to build our survey question about the likable aspects of the tools used for EA. We shorten the list because we were limited by the time that participants had to fill out the survey.

We also analyzed and coded the answers regarding the disadvantages or dislikable aspects of the tools, as shown in Table 21.

Table 21 Disadvantages of tools used by HE institutions to support EA from GT results

Main Category	Description
Hard to maintain models and data and keep them up to date.	A repeated process of manually and periodically update EA.
Not easy to use.	Heavy and have many features related to EA practice.
Inflexible.	Not evolving without an external effort.
No central repository.	A waste of resources and duplications because of an ad-hoc manner of storing and maintain models and data.
Not allowing for validation.	Not confirming artifacts by the EA team and stakeholders.
Not suited for EA tasks.	Having limited features.
Too general for a domain.	Not an architecture tool.
Expensive.	
Requiring a lot of learning time.	
Not having well-organized information.	
No integration with other tools due to cost prohibitive.	
No automatic sort and population of data and models.	
Excessive time to set up and configure.	
No tracking of changes.	
Not allowing foe easy collaboration or sharing.	
No time to manage assets.	
Not containing much semantic information.	
Hard to identify security zones for a solution because of lots of details in network models.	

We also summarize this list of disadvantages and then built a survey question about the dislikable aspects of the tools by using this table.

In the following sections, we provide and discuss the results of the survey and the lessons learned and recommendations.

6.3 Survey

The following is an overview of the questions we posed about frameworks and tools in our survey. Those marked * are the mandatory questions. We discussed the method of the survey in Chapter 4, and the demographic questions of the survey in Chapter 5.

Q28*. "For each of the following frameworks or reference models, please indicate the extent to which it has influenced your EA process:" with answers ranging from 'Never heard of it' to 'Follow it closely.' We listed all the frameworks encountered during our grounded theory study.

Q29*. Motivations for choosing the framework selected in Q28. We will summarize the key results of this.

Q30. "To what extent do you manage each of the following kinds of models in your EA process?" on a scale from 'Not at all' rated 1 to 'Extensively' rated 5. We listed all the models encountered during our grounded theory study.

Q31*. "To what extent do you use each of the following tools to manage your EA?" on a scale from 'Do not use' rated 1, to 'Use extensively' rated 4.

Q32. "What do you like about the tool(s) that you selected in the last question?" Participants could select any of the 12 key things they liked about tools (each type of benefit was among those that had been identified during the grounded theory work).

Q33. "What do you dislike about the tool(s) that you use?" Participants could choose from 14 reasons for disliking a tool (that had been identified during the grounded theory).

6.3.1 Survey Results

6.3.1.1 Frameworks (Q28 and Q29)

For Question 28, we received a total of 82 complete responses from HE institutions in 22 countries, which is considered good. Figure 30 shows the extent to which various EA frameworks are used by the participants (as asked in Q28). It is notable that almost 87% of institutions at least knew about TOGAF, and 61% used it or were at least aligned with it, but only 5% followed it closely. 21% said they had adapted it.

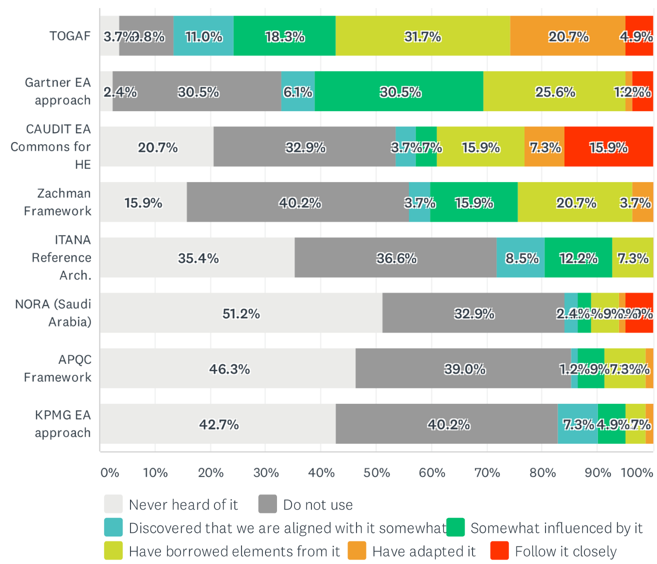

Figure 30 EA frameworks (Q28)

The CAUDIT Higher Education Commons was followed closely by 16%, primarily in Australia and New Zealand; respondents in three other primarily English-speaking countries said they had at least borrowed elements from CAUDIT. The Gartner approach was also widely known and followed.

The figure for this question probably should not be considered globally representative, since the local differences are particularly notable for this question. We received 59 responses from the top six countries. Australian institutions followed CAUDIT closely (72.7%) or had adapted it (the remaining 27.3%). Saudi Arabia similarly followed or had adapted NORA, and also had the highest percentage that said they had adapted TOGAF.

We also received 17 additional comments from the participants on this question, as follows:

1. Using the IT Infrastructure Library (ITIL) as an EA framework:
   - Dovetail with and compliment the TOGAF framework and other frameworks.
   - Drive EA from the context of ITIL focus.
   - Borrow or influenced by ITIL ITSM (IT Service Management) and ITSM 4.
   - Align with ITIL.
2. HORA (Hoger Onderwijs Referentie Architectuur in Dutch - Higher Education Reference Architecture in English): used as a reference model by many Dutch HE institutions. English version on https://hora.surf.nl/index.php/Hoofdpagina

3. UCISA EA Capability Framework (Jisc Capability Framework for HE sector) and UCISA higher education reference model: The Universities and Colleges Information Systems Association EA Capability Framework in the UK.
4. Borrowing elements from the Pragmatic Enterprise Architecture Framework (PEAF) and integrated them into the primary methodology TOGAF.
5. Integrated Architecture Framework (IAF): it is linear and easier to explain
6. GEMMA (eGovernment Reference Model Architecture)
7. Finnish public sector recommendation JHS-179 (based on TOGAF v. 9.1): English version on http://www.jhs-suositukset.fi/suomi/jhs179
8. Visual Architecting Process (VAP): for local roots
9. Using elements of the BCS (the Chartered Institute for IT) Reference Model for Enterprise and Solutions Architecture
10. Aligning with other IT frameworks, including ITIL and PRINCE2 (PRojects IN Controlled Environments).
11. IT4IT (vendor-neutral Reference Architecture).
12. ArchiMate (ArchiMate modelling language):
    - Somewhat influenced/using concepts from ArchiMate
    - Used for modelling support.
    - Incorporate another framework in it.

We did not use statistical analysis to determine any significant differences in the data presented in Figure 30 because the responses (shown in the figure legend) do not form a semantic difference scale. Table 22 shows the reasons (Q29) why the institutions chose the frameworks. We received 66 responses to this question.

Table 22 Reasons (rows) for choosing frameworks (columns), expressed as percentages of those who used each framework (Q29) *

Reasons	TOGAF	CAUDIT	Gartner	Zachmann	NORA	APQC	ITANA	KPMG
Helps guide the choice of IT and business solutions	38.0% (n=19)	12.0% (n=6)	26.0% (n=13)	12.0% (n=6)	4.0% (n=2)	4.0% (n=2)	2.0% (n=`1)	2.0% (n=1)
Aligns well with the university's functions and challenges	19.1% (n=9)	59.6% (n=28)	4.3% (n=2)	4.3% (n=2)	2.1% (n=1)	2.1% (n=1)	6.4% (n=3)	2.1% (n=1)
Gives guidance for organizing an EA team	46.7% (n=21)	13.3% (n=6)	24.4% (n=11)	6.7% (n=3)	6.7% (n=3)	0.0%	2.2% (n=1)	0.0%
Complements other frameworks	33.3% (n=14)	19.0% (n=8)	11.9% (n=5)	23.8% (n=10)	4.8% (n=2)	4.8% (n=2)	2.4% (n=1)	0.0%
Very general	44.7%	10.5%	15.8%	10.5%	7.9%	5.3%	2.6%	2.6%

Reasons	TOGAF	CAUDIT	Gartner	Zachmann	NORA	APQC	ITANA	KPMG
	(n=17)	(n=4)	(n=6)	(n=4)	(n=3)	(n=2)	(n=1)	(n=1)
Very complete	55.2% (n=16)	13.8% (n=4)	3.4% (n=1)	10.3% (n=3)	6.9% (n=2)	6.9% (n=2)	3.4% (n=1)	0.0%
Helps manage risks	60.0% (n=12)	5.0% (n=1)	5.0% (n=1)	5.0% (n=1)	10.0% (n=2)	0.0%	10.0% (n=2)	5.0% (n=1)
We were required to use it	14.3% (n=1)	0.0%	0.0%	0.0%	85.7% (n=6)	0.0%	0.0%	0.0%
Unknown (it was chosen by my predecessors)	80.0% (n=4)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.0% (n=1)

* The light-grey shaded cells indicate the important/interesting data

The values in each cell represent the percentages of respondents (among those who have either adapted the framework or followed it closely) who indicated the particular reasons (rows) for using the framework.

CAUDIT stands out for aligning well with university functions and challenges: 59.6% gave this reason, and this was consistent from all five countries that at least have borrowed elements from it. This makes sense given that CAUDIT is a specialized higher-education framework.

TOGAF scores well for giving guidance on organizing a team, being general, being complete, helping manage risks, and guiding the choice of IT and business solutions. Although 80% still indicated that it was chosen by predecessors and so the reasons for

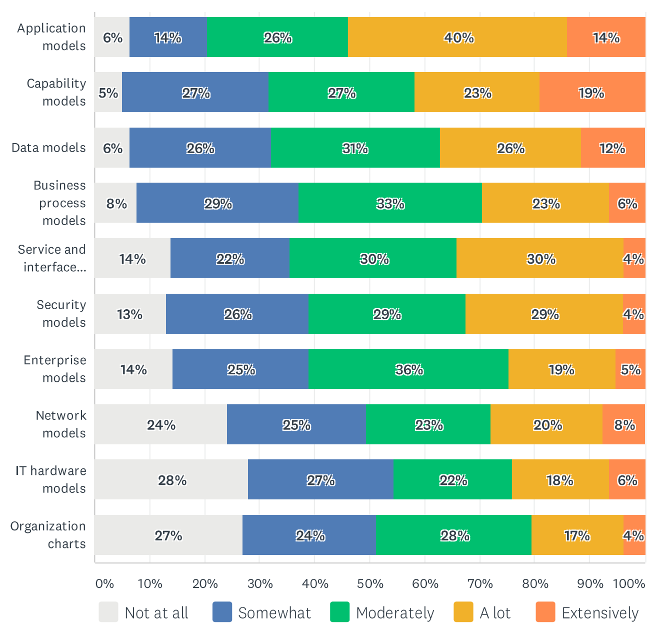

Figure 31 Kinds of models used (Q30)

using it are somewhat lost to history. 85.7% of NORA (all in Saudi Arabia) users said they used it because they were required to.

6.3.1.2 Kinds of Models (Q30)

Figure 31 shows the kinds of models that are managed by the participants' EA teams. We received about 79 responses to this question. It is clear that most teams managed a wide variety of model types, with application, capability and data models standing somewhat above the rest in terms of importance. Model use was relatively consistent among the top six countries. One exception was that Saudi Arabia reported higher use of models of all types. Also, Australia and New Zealand made much more use of capability models than other countries, due to their presence in CAUDIT.

We also received 7 additional comments on this question suggesting other types of models that were not included in our list. These include information exchange models, application integration models, operating models, and delivery models. One participant said that they created models in certain instances and managed them for a project, but they did not do any of the "enterprise source of truth management." Another participant indicated that they had "a custom-developed model-driven visualization engine capable of taking structured data and applying them to alter the visual appearance of a predefined model exported from draw.io."

We converted the responses regarding the models as follows: 0= 'Not at all,' 1= 'Somewhat,' 2= 'Moderately,' 3= 'A lot,' and 4= 'Extensively.' Table 23 gives basic statistics. In particular, it shows that most model types are used close to 'Moderately,' with hardware models and organization charts being used significantly less than the top 7.

Table 23 Basic statistics regarding models used in HE institutions; n=79 (Q30)

Models	Mean	Std. Dev	95% Confidence Interval of mean	
Application models	3.41	1.09	2.16	2.66
Capability models	3.24	1.18	1.97	2.51
Data models	3.10	1.10	1.85	2.35
Business Process Models	2.91	1.04	1.67	2.15
Service and interface models	2.89	1.10	1.64	2.13
Security models	2.84	1.09	1.59	2.09
Enterprise models	2.77	1.08	1.52	2.01
Network models	2.62	1.26	1.34	1.90
IT hardware models	2.48	1.24	1.20	1.76
Organization charts	2.46	1.16	1.20	1.73

6.3.1.3 Tool Use (Q31-33)

Figure 32 shows the use of tools among the participants to manage their EA models from Question 31. We received 81 responses to this question. It is very notable that the top four tools used were those found in a typical office suite (i.e., spreadsheets such as Excel, word processors, drawing tools and presentation tools), in other words very generic tools that can only describe data, not model it at a deep semantic level.

ArchiMate was used at least a little by about 38.3% of participants, but all other specialized EA tools were used very little. ArchiMate was not reported to be used in New Zealand.

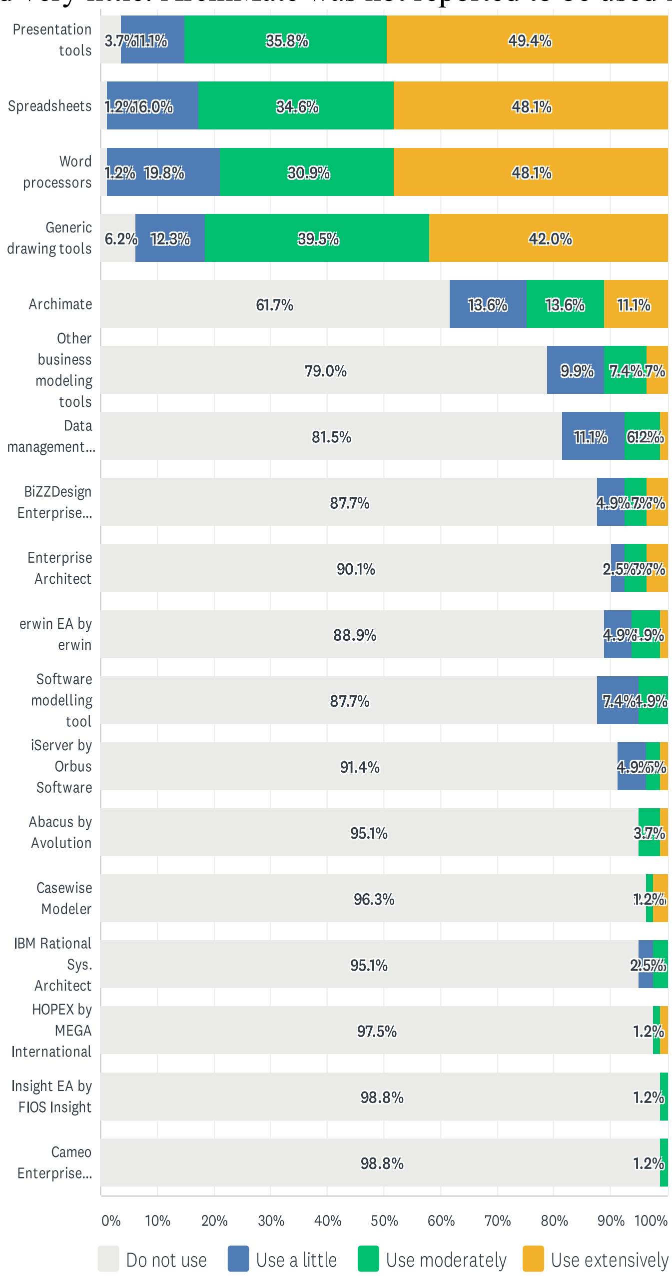

Figure 32 Use of tools (Q31)

The other tools that were used by less than 10% of participants are iServer (8.6%), Abacus (4.9%), Casewise (3.7%), IBM Rational System Architect (4.9%), HOPEX by MEGA International (2.5%), Insight EA (1.2%), and Cameo Enterprise Architecture (1.2%).

Participants reported that they used the following tools that were not listed in the survey: Essential by the Essential Project, LeanIX, BarometerIT by Changepoint, Configuration Management Database (CMDB), Software AG ARIS (2 users), Visual Paradigm, QPR EA, ProVision by OpenText, Mind Maps, Essential Cloud, SharePoint Repository and ITSM Tools.

Table 24 shows the basic statistics regarding the tools. The data were converted to numbers where 0= 'Do not use,' 1= 'Use a little,' 2= 'Use moderately,' and 3= 'Use extensively.' The office tools were all used moderately, and ArchiMate was used a little. On average, the other tools were not used.

Table 24 Basic statistics regarding tools used by HE institutions; n=81 (Q31)

Tools	Mean	Std. Dev	95% Confidence Interval of mean	
Presentation tools (e.g., PowerPoint)	2.31	0.82	2.13	2.49
Spreadsheet tools (e.g., Excel, Google sheets)	2.30	0.78	2.12	2.47
Text editors or word processors (e.g., Word, Google docs, Wikis)	2.26	0.82	2.08	2.44
Generic drawing or diagramming tools (e.g., Visio, Lucidchart)	2.17	0.88	1.98	2.37
ArchiMate	0.74	1.07	0.50	0.98
Other specially designed business modeling tools	0.36	0.78	0.19	0.53
Data management tools (e.g., Google Data Studio)	0.27	0.63	0.13	0.41
BiZZDesign Enterprise Studio by BiZZDesign	0.23	0.69	0.08	0.39
Enterprise Architect by Sparx Systems	0.21	0.68	0.06	0.36
erwin EA by erwin	0.19	0.57	0.06	0.31
Other software or system modeling tools (e.g., Papyrus)	0.17	0.49	0.06	0.28
iServer by Orbus Software	0.14	0.49	0.03	0.24
Abacus by Avolution	0.11	0.50	0.00	0.22
Casewise Modeler by Casewise	0.10	0.51	-0.02	0.21
IBM Rational System Architect	0.07	0.35	0.00	0.15
HOPEX by MEGA International	0.06	0.40	-0.03	0.15
Insight EA by FIOS Insight	0.02	0.22	-0.02	0.21
Cameo Enterprise Architecture by No Magic	0.02	0.22	-0.02	0.07

A total of 30.7% of participants used some specialized tool, other than office tools, extensively. Considering specialized tools other than ArchiMate, these proportions dropped to 19.6%, respectively. Although the literature review showed more interest in specialized EA tools (Alamri, Abdullah & Albar, 2018a) and ArchiMate (Clark, Barn & Oussena, 2011, 2012a. 2012b), the survey results indicated that most participants prefer to use Office tools.

In Question 32, participants were asked to select the aspects they liked about the tools they used. As Figure 33 shows, the most common reasons for liking tools were ease of use, cost-effectiveness, and collaboration. All four of the office suite tools were liked roughly equally for these three reasons. The second tier of likability aspects was being cross-platform (e.g., Windows + Mac) and producing good models. The least liked aspects were

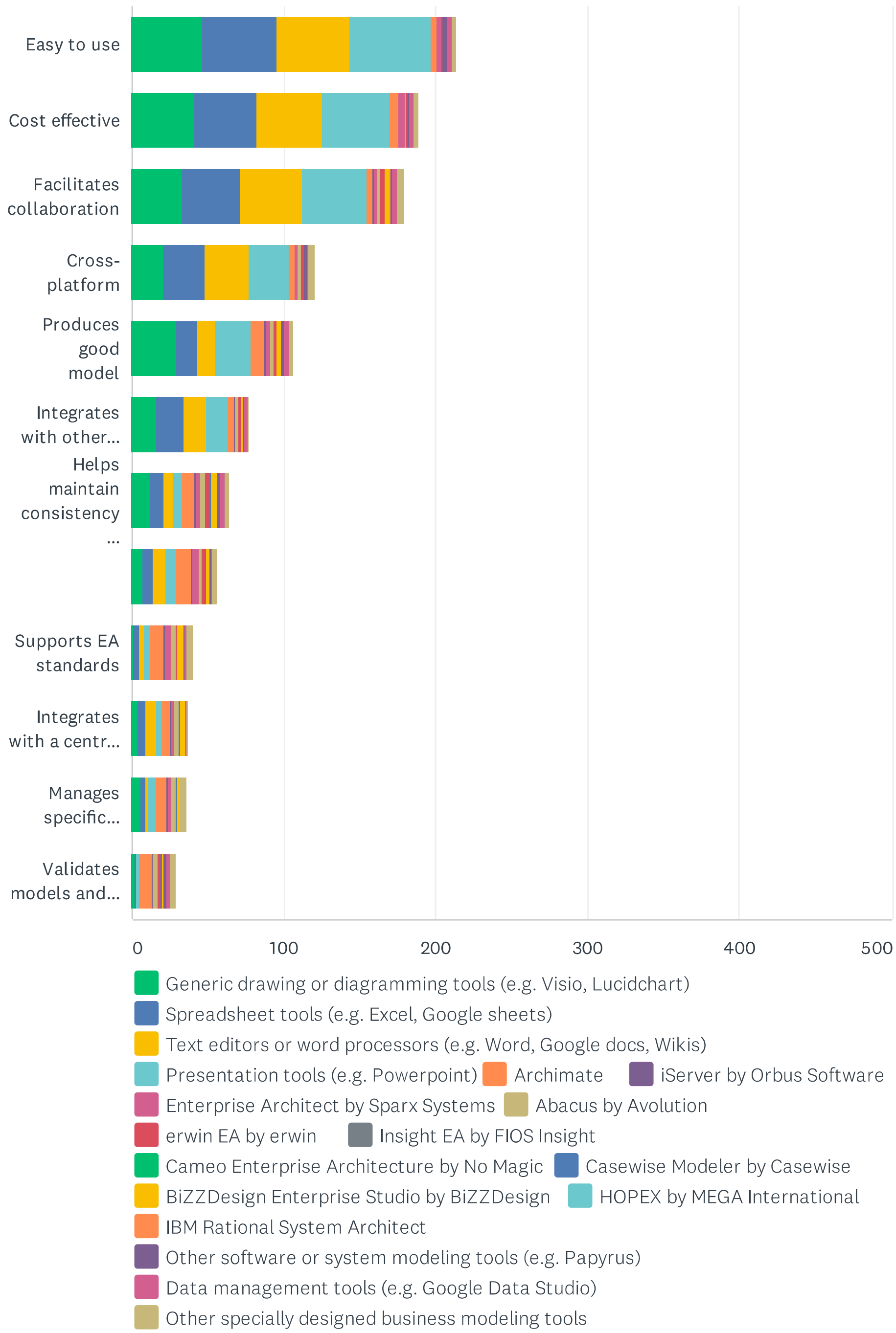

Figure 33 Aspects of tools that are liked (Q32)

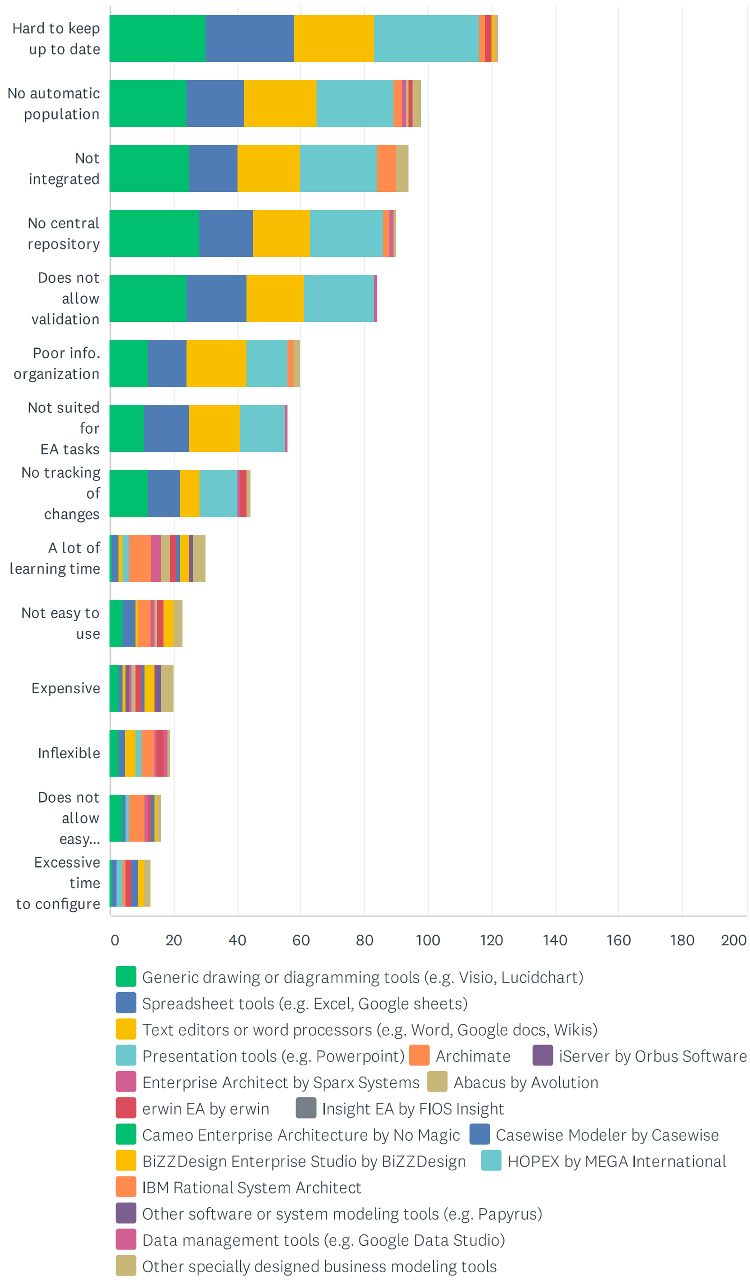

Figure 34 Aspects disliked (Q33)

validation of models and diagrams, management of specific representations, integration with a central repository, and the support of EA standards.

Figure 34 shows the aspects the participants disliked about the tools used for EA (from Q33). The most important of these was keeping models up to date.

Two related reasons came next: lack of automatic population of data and lack of integration among tools. Behind this came a lack of central repository and a lack of validation of data. There were no notable country-specific differences in this data.

The four reasons that came at the bottom of the rankings were the need for a lot of learning time, the lack of ease of use, expensiveness, inflexibleness, the lack of collaboration or sharing, and the excessive time to configure.

6.3.1.4 Participants Who Have a Plan for EA Implementation (Q11)

We asked the participants who had a plan to adopt EA at their institutions to what extent they managed the set of models that were not yet under the EA umbrella. We received a very small number of responses (12). The result is shown in Figure 35.

Data models, network models, security models, service interface models, and business process models stood out above the rest in terms of use by all respondents. This result differs from the result of the participants who adopted EA at their institutions. The enterprise model was the least used among other types of models by 33.3% participants.

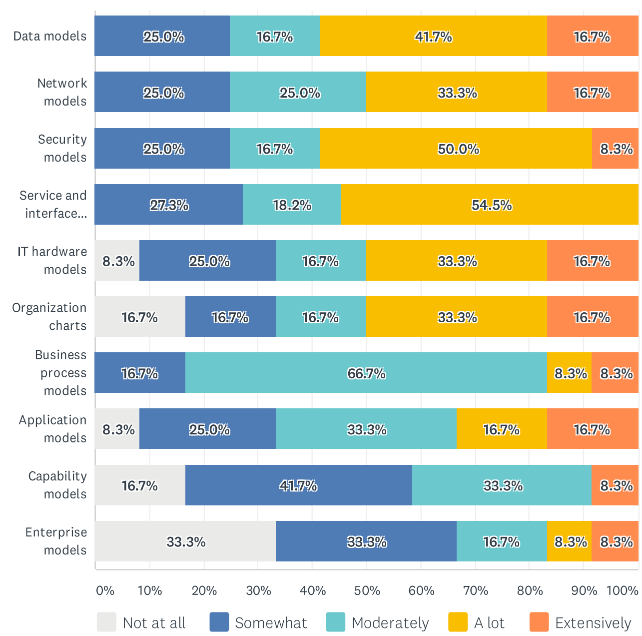

Figure 35 Models used by participants plan to adopt EA at HE institutions (Q11)

6.4 Lessons Learned and Recommendations

The ultimate purposes of this chapter are to better understand the frameworks, tools, models used currently in higher education, and to suggest potential improvements. The most important lessons reported here are:

- Enterprise Architecture is widely used in higher education, especially where there is a good, tailored framework (CAUDIT for Australia and New Zealand and NORA for Saudi Arabia).
- HE enterprise architects are looking for frameworks that align with higher-education needs. They are motivated by a desire to facilitate the alignment of business and IT and associated projects. They also want to enable digital transformation, reduce duplication and leverage assets.
- 86.5% of participants used the TOGAF framework to some extent, although the Gartner and CAUDIT approaches also have significant influence. The results should help guide enterprise architects in improving their processes and should guide tool developers in improving their products.
- CAUDIT is a specialized higher-education framework, and it was therefore distinguished by its better aligning with university functions and challenges, based on the opinions of 59.6% of our participants.
- Higher education enterprise architects also used customizable frameworks adapted from various existing frameworks. On the other hand, some participants did not follow specific frameworks for EA.
- Some participants used specific frameworks because they were required to do so, such as the NORA framework, where 85.7% said this was the reason for using it.
- Some of the reasons for choosing EA frameworks in HE institutions were to create an architecture overview and processing models, guide the development of detailed architecture, create models and artifacts for the solutions, map all real applications and infrastructure, and complement other existing frameworks, according to our participants.
- When developing or using EA frameworks, enterprise architects and developers should use these required qualities: creating architecture overview, process models,

and solution models, guiding the development of detailed architecture, and mapping applications and infrastructure.

- They work with a wide variety of models, particularly application, capability, and data models. Enterprise architects also tend to make moderate use of the business process, service, security and enterprise models.
- Model use was relatively consistent among the top six countries. However, Saudi Arabia reported higher use of models of all types.
- Enterprise architects should use or create reference models for application, capability and data shared within HEIs.
- Following specific EA frameworks may lead to increased use of their models; for example, Australia and New Zealand used Capability models more than other countries, due to their presence in CAUDIT.
- Data models, network models, security models, service interface models, and business process models were some of the most used models according to the respondents who had a plan for implementing EA in HE institutions, and the enterprise model was the least used.
- In HE institutions, models are built based on architecture, stakeholders, business cases, project-by-project basis, solutions, or data availability.
- Some of the reasons for creating and using models in HE institutions based on our interviewees' answers were to illustrate the current situation and maturity of a university and using different viewpoints to say how to invest in current capability or new capability and understand roadmaps on describing what the EA team does and how they need to think and act. Other reasons were to get everyone on board by adopting enterprise models, diagram business processes from the student perspective, and when the requirements conflict with each other, identifying the security zones and the main components that help avoid redundancy, and identify ROIs and any risks involved.
- Business Process Model and Notation (BPMN), Unified Modeling Language (UML), the CAUDIT Higher Education EA Reference Architecture, simple standards for conceptual data modelling, and ArchiMate standards were examples

of modelling notations or standards used by some of our interviewees in HE institutions.

- Enterprise architects do the vast majority of their modelling using presentation tools, spreadsheets, word processors and generic drawing tools. The only special-purpose modelling tool to be used significantly was ArchiMate, with about 38.3% using it at least a little. No other special-purpose modelling tool or tool category was used by more than 21% of the participants.
- EAs are looking for tools that are as easy to use and as cost-effective as office suite tools. Also, they want tools that facilitate collaboration, permit validation based on model semantics, integrate with other tools, and allow an automatic population of data so models can be kept up to date in a central repository.
- The tools currently used for most EA in higher education lack many of the qualities listed in the last bullet. There is, therefore, a significant opportunity to develop such tools, or perhaps enhance existing tools (such as Archi or Enterprise Architect), so they have the required qualities.
- Tool vendors need to allow flexibility of office-style tools while enabling collaboration, decision making, and digital transformation.
- Although aligning projects with institution goals, mission, and vision is a top motivation for EA (Figure 27) and a top benefit of EA, there seems to be a disconnect between what is claimed is done and the technologies involved in terms of frameworks, tools, and models.

Chapter 7 Enterprise Architecture Principles

In this chapter we discuss the enterprise architecture principles that the participants in our research employ in their institutions. We present the grounded theory results, survey results (including analysis of which principles appear most important) and compare our results to existing sets of principles.

7.1 Introduction and Background

Principles are pivotal elements of the EA. However, research in this area is limited (Stelzer 2009).

Stelzer (2009) proposed to define EA principles as, "fundamental propositions that guide the description, construction, and evaluation of enterprise architectures." This definition was derived from multiple resources. One of them is the definition of 'architecture' by TOGAF, which is "The structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time" (The Open Group, 2018). The other definition was inspired by the TOGAF's definition of 'architecture principles,' which is "a set of principles that relate to architecture work" (The Open Group, 2018). The principles hence may refer either to the architecture itself or the processes involved in creating and maintaining it. According to these definitions, the EA principles are categorized into two classes: design principles and representation principles (Stelzer, 2009). In fact, the principles are means to achieve business, IT, or architecture objectives by governing the architecture process, which, as a result, affects the use, development, and maintenance of the EA (The Open Group, 2018).

There are some architectural principles available in the literature. The most widely-referenced ones are the TOGAF 9.2 architecture principles which fall into four groups, as shown in Table 25: business principles, data principles, application principles, and technology principles. Some HE institutions follow this exact set of principles, and others use them as a reference when they build their own EA principles. We use the TOGAF principles later in the discussion of the grounded theory and survey findings by referring to their numbers.

In the context of the use of EA principles in the HE institutions, we found that the number of publications that discussed this side of research is even smaller. A few universities made their EA principles publicly available, but we will not review them here.

Table 25 TOGAF 9.2 architecture principles (The Open Group, 2018)

Principles	Examples
20.6.1 Business Principles	20.6.1.1 Primacy of Principles
	20.6.1.2 Maximize Benefit to the Enterprise
	20.6.1.3 Information Management is Everybody's Business
	20.6.1.4 Business Continuity
	20.6.1.5 Common Use Applications
	20.6.1.6 Service Orientation
	20.6.1.7 Compliance with Law
	20.6.1.8 IT Responsibility
	20.6.1.9 Protection of Intellectual Property
20.6.2 Data Principles	20.6.2.1 Data is an Asset
	20.6.2.2 Data is Shared
	20.6.2.3 Data is Accessible
	20.6.2.4 Data Trustee
	20.6.2.5 Common Vocabulary and Data Definitions
	20.6.2.6 Data Security
20.6.3 Application Principles	20.6.3.1 Technology Independence
	20.6.3.2 Ease-of-Use
20.6.4 Technology Principles	20.6.4.1 Requirements-Based Change
	20.6.4.2 Responsive Change Management
	20.6.4.3 Control Technical Diversity
	20.6.4.4 Interoperability

We found four sources that referred to these principles without providing much detail. The first source is the work done by Bergh-Hoff et al. (2015) which is a report approved by the Agency for Public Management and eGovernment (Difi) in Norway. It explained the seven IT architecture principles that are used by ICT (represented by enterprise and ICT architects as well as people working on ICT systems design) in the HE sector. Those principles are service orientation, interoperability, accessibility, security, transparency, flexibility, and scalability. The purpose of these principles is to ensure that ICT solutions support the HE activities such as education, research, and dissemination and also to facilitate the alignment between business processes and ICT solutions. As a result, the aim of these principles is to enable better digital services and prevent the development of information systems that do not communicate with each other. These principles focus more on the IT side of the HE institutions and show how to align with the business side. In most cases, it is not very easy to know how the organizations distinguish EA principles from IT principles or business principles, according to Stelzer (2009). However, Bergh-Hoff et al. (2015) clarified that these architecture principles should be embedded in the common EA for the public sector and incorporated by the HE institutions in their own architecture to help ensure that the ICT solutions support their business processes, and they are realized in a broader context.

Oderinde (2010) claimed that the use of specific EA principles, such as the Open Group's principles, is not necessarily applicable to the HE institutions due to the decentralization of their decision-making process. Therefore, the HE institutions should create EA principles that help them make fully informed and rapid decisions and to be innovative in order to achieve the desired benefits. Oderinde (2012) suggested that the EA principles should be business-driven and be applied in a top-down approach, which will encourage a unified way of working throughout the institution and will facilitate making a rapid business decision by encouraging conversations between administrative staff and IT. However, Oderinde (2010, 2012) did not provide examples of how these principles should look like and what the layer or domain of the institution these principles will be applied.

The Reform Support Network, sponsored by the U.S. Department of Education, developed a framework called Education enterprise architecture (EEA) to ensure aligning an education agency's business and programs with its IT and hence accomplishing its vision and goals (The Reform Support Network, 2014). To achieve that, they developed a set of architecture principles (see Table 26) to guide and govern the deployment of all agency's information and technology resources. These principles were developed for all architecture domains: business, information, application, as well as technology architecture (The Reform Support Network, 2014). We use these principles later for the discussion of our findings by referring to their numbers.

Table 26 EEA architecture principles (The reform support network, 2014)

Principles	Examples
1. Business Principles	1.1 Agency Benefits are Maximized
	1.2 Information Management is Everybody's Business
	1.3 Service Orientation
2. Information Principles	2.1 Data are Assets
	2.2 Data Stewardship
	2.3 Common Vocabulary and Data Definitions
3. Application Principles	3.1 Common Use Applications
	3.2 Technology Independence
	3.3 Ease-of-Use
4. Technology Principles	4.1 Requirements-Based Change
	4.2 Interoperability
	4.3 Limit Technical Diversity

We explored the use of EA principles in the HE institutions because we found that there was an interest in this topic through our initial interviews. Hence, we added a separate question about it in the subsequent interviews. Then we added multiple questions about these principles in the survey based on the results obtained from the interviews. The findings of the interviews and surveys help bridge the literature gap on EA principles in the context of HE.

7.2 Grounded Theory Results on the EA Principles in the HE Context

In this section, we discuss the findings of the grounded theory research regarding the use of EA principles in the HE institutions. We interviewed 21 persons who have a role in applying EA at their institutions. Some of our initial interviewees mentioned that it is important to have a set of EA principles for guiding the EA process at their institutions and explained how important it is to apply them appropriately. This motivated us to add a question to the subsequent interviews to ask specifically if the interviewees followed any EA principles and what they were.

The main question was:

> *Do you have a set of principles? If yes, what are they?*

I6 out of 21 interviewees said they had EA principles. Five of these respondents said they applied these principles informally because they were not approved by the management yet. Eleven of the respondents (including three from one university) said they had a formal set of principles. Five of the respondents said they did not have EA principles, and that was because either they did not have an official EA program, or they did not think about the principles yet.

Here are some examples of responses that indicated that the EA principles were applied and used formally in the universities:

> *"...Yah, we have a set of principles that again they fall in line, so what we have done...We have done principles that can be then directly related back to the university goals... they feature within our architectural structure..."*

> *"...There is a set of it out there that they were developed before I arrived by a group that put them in place, and we are thinking about re-visiting them this year that*

cover our roadmap and just come back and look at them again and change... update them at least...”

“... As per our board forming decision, and the board missions, the EA principles in our organization are...”

Here are the examples of responses that showed that the universities applied the EA principles informally:

“... Not yet, we had many discussions. We had many suggestions for what principles to adopt. There are a few that we are practicing anyway, but we do not have a formal document that lists all of our principles...”

“...Yes, but pending for approval from the top management...”

“... Not really... for this organization we are actually fairly lightly resourced...”

One of the interviewees mentioned that they used the TOGAF architecture principles as a reference, saying that they were somewhat influenced by them. Another interviewee said they were influenced by the five COBIT principles, which are: (1) meeting stakeholder needs, (2) covering the enterprise end-to-end, (3) applying a single integrated framework, (4) enabling a holistic approach, and (5) separating governance from management (ISACA, 2012). Also, some interviewees talked about the benefits of applying EA principles in an appropriate way to organize their EA work and help to collaborate with other departments. One of the interviewees believed that having EA principles was not necessary for their work, and that was why they did not focus on them.

7.2.1 Data Analysis

The use of EA principles covers only one aspect of our study. In this section, we follow the grounded process steps illustrated in Chapter 4 to analyze the data obtained from the interviews regarding the EA principle in HE institutions. We illustrate how we coded transcribed data using the coding procedures (open coding, axial coding, and selective coding) adapted from Birks and Mills (2011) work. The researcher and her supervisor engaged in the process of coding and interpreting the collected data for this study. We frequently met to review the extracted concepts and categories, and we built the final list of the EA principles used by the participants engaged in the interviews. We used this list later to construct the survey questions regarding the EA principles. We did not use a particular format for writing the codes, such as gerunds, because it may change the meaning in some cases. We used the format that helps deliver the right meaning.

In Table 27, we provide two examples for coding two quotes from the interviews related to the EA principles. We use these examples to illustrate the analysis process: the open, axial, and selective coding phases.

The goal of the grounded theory is to conduct concurrent data collection and analysis. In other words, we coded the data, and at the same time, we continued collecting the data by conducting more interviews. This helped us uncover new ideas about the use of EA principles at the HE institutions.

The first step in the coding process was the open coding in which we went through the interview transcripts line-by-line to generate as many concepts (initial codes/ideas) as possible. We ended up with a list of more than 166 concepts expressing the participants' ideas. We had a considerable amount of data from the participants who answered our open-ended question on the EA principles. These concepts covered several matters related to this topic including what these principles were, whether they were officially applied or not, how they were applied, what the benefits of their use were, and/or how they related to the university's principles.

To illustrate, we provide an example of these concepts gleaned from the first quote in Table 27.

The examples of concepts extracted from the first quote are 'No duplication of data should be allowed,' 'Maintain coherent identity for all users,' and 'Prefer open source s/w over commercial s/w whenever it is feasible.' Examples of concepts extracted from the second quote in the same table are 'Maximize the benefits to the university, and then from it, we got statement of rationale and alignment and engagement,' 'Data is shared as university asset,' 'Single system of record,' 'Information security is everyone's business,' 'Optimize management of information security risk,' 'Platform-independent,' 'Reuse first then buy then develop,' 'Configuration before customization,' 'Separation of concerns,' 'Fit-for-purpose,' 'Control technical diversity,' 'Interoperability,' 'Information is available,' and 'Design first.'

Table 27 Examples of interview quotes and coding

Raw data	Concepts (Initial coding)	Categories (Focused coding)	Main Category (Theoretical coding)	
"...one of the principles that we try to enforce very hard is no duplication of data should be allowed at all...there should be no multiple accounts for the same person and so on... we always prefer open-source s/w over commercial s/w whenever it is feasible to use one..."	No duplication of data should be allowed	Data is reused	Data principles	Data Management Principles
	Maintain coherent identity for all users	Data is kept secure, and security risks are managed		
	Prefer open-source s/w over commercial s/w whenever it is feasible	Prefer open solutions to commercial solutions	Application principles	Technology Management Principles
"...So what we have is principle #1 maximize the benefits to the university, and then from it we got statement of rationale and alignment and engagement. Principle #2 is data is shared as university asset. Then we got principle #3 is single system of record. Principle #4 is information security is everyone's business. #5 is optimize management of information security risk. #6 is platform independent. #7 is reuse first then buy then develop. #8 is configuration before customization. #9 is separation of concerns. #10 is fit- for-purpose. #11 is control technical diversity. #12 is interoperability. #13 is information is available. #14 is design first..."	Maximize the benefits to the university, and then from it we got statement of rationale and alignment and engagement	Maximize the benefits to the university	General principles	General EA Principles
		Align decisions and architecture with the strategic mission, vision and values of the university.		
	Data is shared as university asset	Data is shared	Data principles	Data Management Principles
	Single system of record	Data is integral, consistent, and maintainable		
	Information security is everyone's business	Data is kept secure, and security risks are managed		
	Optimize management of info. security risks	Data is kept secure, and security risks are managed		
	Platform independent	Ensure applications are independent of specific technology choices.	Application principles	Technology Management Principles
		Avoid vendor lock-in		
	Reuse first then buy then develop	Use or try out applications and technologies before buying		
		Buy instead of building		
	Configuration before customization	Configure instead of customizing		
	Separation of concerns	Orient the architecture to provision of services	Business principles	General EA Principles
	Fit- for-purpose	Design solutions such that they are 'good enough' in order to minimize costs and maximize value	Application principles	Technology Management Principles
	Control technical diversity	Controlled technical diversity	Technology principles	
	Interoperability	Ensure interoperability of technological components		
	Information is available	Data is accessible, available and discoverable	Data principles	Data Management Principles
	Design first	Design solutions such that they are 'good enough' in order to minimize costs and maximize value	Application principles	Technology Management Principles

The second step was to perform the axial coding by grouping the similar concepts into categories after identifying the links between them. We generated a list of 58 categories representing the EA principles by consistently and repeatedly comparing concepts for the similarities and differences and eliminating the concepts that were not expressing the principles themselves. We cleaned up the codes by eliminating any concepts that did not reflect the principle itself, and we kept the concepts that contributed most to the analysis. Then we grouped similar concepts into the same category, which expresses the idea of the principle. Notes were taken to explain each category and examine its properties.

An example of these categories is the 'Data is kept secure, and security risks are managed' category that includes three concepts extracted from the two quotes mentioned in Table 27, which are 'Maintain coherent identity for all users' (from the first quote), 'Information security is everyone's business,' and 'Optimize management of information security risks' (from the second quote). We found these three concepts explain the idea of keeping the data and information secured by not allowing for multiple accounts for the same user and avoiding any practices that will ruin the identity as well as having a single system of record. We repetitively and continually used the axial coding technique to identify the links between concepts, categories, and properties together after each open coding session.

The final step of the coding process is selective coding. In this step, we refined the final list of the categories to identify how they related to each other, and to identify the core (main) categories that explained the main groups/constructs of the EA principles. Table 27 shows an example of these main categories. For example, 'Data is kept secure, and security risks are managed' category was grouped into a main category labelled 'Data management principles' that include all the principles that guide how to deal with data and information in the HE institutions such the data should be shared, data must be secured and protected, data should be available and accessible, common vocabulary and data definitions should exist, data should be considered as university's assist, a trustee should control data, data must be reused, and data should be governed according to the university's policies and data management guidelines.

Following the selective coding step and continuing the iterative constant comparisons among categories resulted in the emergence of five main categories or overarching theoretical categories. Table 56 in the Appendix F shows the main categories with their subcategories. We refined these main categories and created the final list of principles with three main categories in Table 28.

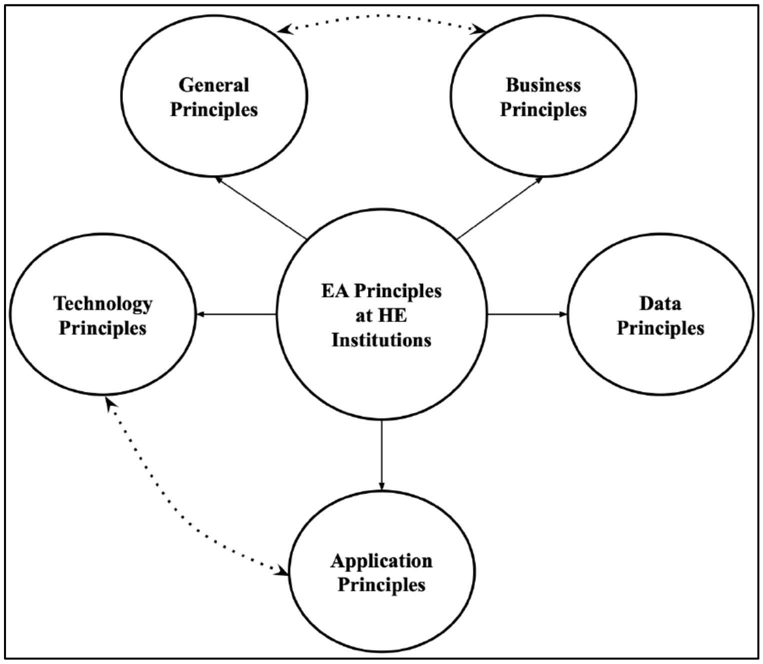

Figure 36 EA principles main categories applied by HE institutions (GT results)

7.2.2 Results and Discussion

Figure 36 shows these main categories: general principles, business principles, data principles, application principles, and technology principles.

In Appendix F, we list all the principles under the main categories in Table 57. It is recommended that organizations do not use a large number of EA principles to guide their EA process because these principles may reduce the flexibility of architecture (The Open Group, 2018). It is preferred to use 10 to 20 high-level principles. Also, Prajapati (2017) said that "Less is more," so he suggests defining and using not more than six principles in each category of EA principle.

For the above reason, we decided to merge the similar principles and remove others to come up with a reasonable list to be used in our survey. Therefore, we decided to merge the general principles and the business principles into one main category called 'General EA Principles.' We found that the general and business principles were used interchangeably by our participants because some examples of general principles and the business principles were inter-related.

The same applies to the principles of technology and the principles of applications, as they were used interchangeably by our participants, which made us merge them into one main category called ‘Technology Management Principles.’ For example, ‘Buy instead of building’ applies equally to applications as to infrastructure technology (such as the corporate database); also, as more applications reside in the cloud, the distinction between applications and other types of technology is diminishing.

We used imperative sentences to express the principles and make them understandable. We also merged or left out the principles that have similar interpretations. For example, the ‘Control technical diversity’ principle overrides the ‘Common use application’ principle (Table 56 in the Appendix F) so, we removed the later one from our final list. The aim was to make the survey questions short so that we could cover other topics because we wanted to limit the time completing the survey to about a half-hour, to prevent people dropping out before completing it.

The final list of the main categories of the EA principles and their sub-categories used in the HE context are shown in Table 28 which we used later to construct our survey questions.

7.2.2.1 General Enterprise Architecture Principles

General and business principles are interrelated and are applied collectively. Hence, we merged them under the first main category, ‘General EA Principles.’ The general principles are a set of general rules and guidelines that are applied across all the domains of the HE institutions: business, data, application, and technology domain. These principles guide and support how the university fulfills its mission and achieves its short- and long-term objectives. The business principles are a set of rules that informs and guides the decision-making process as well as the business processes at the university.

This main category consists of 18 principles, as shown in Table 28 that span the different domains of the university. Some examples of these principles are:

Maximize the benefits to the university.

This principle implies that any decision made should provide the maximum benefits to the university as a whole, and not just to a particular organizational unit (The Open Group, 2018). In other words, making any information management decision must take under primary consideration the motives and priorities at the enterprise level to provide the maximum return on investment to the university as a whole.

Table 28 EA principles in the HE institutions from GT results

Main Categories	Categories
General enterprise architecture principles	Align decisions and architecture with the strategic mission, vision and values of the university.
	Maximize the benefits to the university
	Ensure compliance with laws, standards and policies
	Be digitally integrated
	Enhance simplicity
	Be responsive to stakeholders as their needs change
	Ensure the continuity and recoverability of critical university operations
	Enable partnership between business units and IT units
	Be agile
	Enable a holistic approach
	Ensure the architecture is maintainable
	Focus on efficiency of using resources
	Orient the architecture to provision of services
	Enable quick, accurate decision-making support
	Base change on careful requirements analysis
	Focus on the performance of the organization
	Enable a single federated enterprise-wide architecture
	Ensure elements of the architecture are measurable
Data management principles	Data is kept secure, and security risks are managed
	Data is an asset
	Data is accessible, available and discoverable
	Data is shared
	Data is reused: duplication of data should be avoided
	There are policies and data management guidelines for data
	Data is under the control of a trustee
	There is a common vocabulary and definitions for data
Technology management principles	Ensure the interoperability of technological components
	Comply with technological standards and policies
	Applications must be easy to use
	Ensure end users can perform their work as efficiently as possible
	Control technical diversity
	Buy instead of building
	Configure instead of customizing
	Design solutions such that they are 'good enough' in order to minimize costs and maximize value
	Ensure applications are independent of specific technology choices
	Use or try out applications and technologies before buying
	Avoid vendor lock-in
	Align with multiple products from a single vendor to best leverage that vendor's ecosystem
	Prefer open solutions to commercial solutions
	Using cloud-based technology first

Ensure the continuity and recoverability of critical university operations.

This principle implies that the university operations should be maintained regardless of external events that could lead to interruptions of the system (The Open Group, 2018). That is, the university departments and units should be provided with the capability to continue their business functions through alternative mechanisms for information delivery.

Be agile.

This principle implies that the university should be agile in terms of technology, business processes, and IT solutions. The modularized and flexible business processes and associated IT solutions will allow for more agility and rapid implementation of changes to business processes.

Enable a single federated enterprise-wide architecture.

This principle indicates that the university should apply a single integrated framework that comprises the various established frameworks (such as TOGAF, Zachman, etc.) and standards and guidelines to govern and manage the university IT (ISACA, 2012).

Enable a holistic approach.

Generally speaking, what is meant by a holistic approach is to think about the big picture totally from all aspects. This principle implies that the holistic approach should be taken when it comes to the design and decision of IT solutions. In other words, the IT solutions should be validated based on the institution-level without preventing addressing and considering other faculties and departments' requirements. This will allow for sharing the IT solutions within the departments and faculties. This principle also states that the holistic approach should be taken to IT management and governance (ISACA, 2012). The decisions should be made with an institutional perspective, which, as a result, will have a higher value in the long-term. In other words, all the architecture solutions and decisions should be confirmed to the university's strategy, priorities and motivations. This will lead to enhancing the achievement of common goals (ISACA, 2012). Using a generalized EA framework, which considers different views (such as strategy, policy, organization, and process), will help to enable the holistic approach.

7.2.2.2 Data Management Principles

The second main category is 'Data Management Principles.' It consists of 8 principles (as shown in Table 28) that guide and govern the data used within the university. It informs how the data is processed, managed, stored, and accessed within the university.

Here are some examples of these principles:

Data is secure.

The principle implies that the university should ensure the confidentiality, integrity and security of its data. It should control access to the data using authentication and authorization. Also, the university should have a single system of record. It should maintain a coherent identity for all of its users. The information should be protected according to university policies using cost-effective access controls.

Data is accessible, available and discoverable.

This principle indicates that the information should be timely and accurately available and discoverable to authorized users within the university. The data should be managed as a single source of truth.

Data reuse.

This principle pushes for enabling the reuse of data. In other words, the duplication or duplicated collection of data should be avoided.

7.2.2.3 Technology Management Principles

The third main category is the 'Technology Management Principles,' which defines the standards for managing, developing, designing, and configuring the technology and applications for the university. It consists of 14 principles (as shown in Table 28) that provide guidelines for the use and deployment of all IT technology and application in the university.

The examples of some of these principles are:

Ensure the interoperability of technological components.

The university should ensure that its systems comply with specific standards that foster interoperability for the different technological components (The Open Group, 2018). Interoperability standards help to ensure consistency and thus improve the ability to manage the systems, enhance user satisfaction and protect IT investments (The Open Group, 2018).

Control technical diversity.

Controlling and limiting the number of alternative technologies supported for multiple processing environments should simplify maintainability and reduce the infrastructure costs needed to support and keep them interconnected (The Open Group, 2018). Using limited resources to share a set of technology is the best way to control management and technical support costs (The Open Group, 2018).

Avoid vendor lock-in.

The university should minimize or avoid the dependence on one vendor for obtaining products or services. For this reason, the university will be able to reduce the risks and costs of replacing or using other vendors.

7.3 Survey Results

This section discusses the statistical analysis of the survey results regarding EA principles in higher education. It presents each type of data and discusses the implications of its interesting aspects.

7.3.1 Survey Questions about EA Principles in HE Institutions

We used the findings from the grounded process shown in Table 28 to construct the survey questions about EA principles. The aim of survey questions was first to find out the extent to which these principles have been applied (an indicator of their importance), whether any other principles are missing, and the extent to which the participants believe there is resistance to principles, or that these principles affect the flexibility of the institutions' architecture.

The following is an overview of the questions. Those marked * are the ones that respondents must answer.

*Q34-36: Three matrix/rating scale question indicating the extent to which general, data management, and technology management principles respectively are applied in participant's organization. The scale used was: 'Not applied at all' rated 0, 'Considered sometimes' rated 1, 'Important but informally applied' rated 2, and 'This is similar to one of our organization's formal EA principles' rated 3,

Q37 An open question inquiring if there are any other very important principles that are not mentioned in the previous questions

Q38 An open-ended question inquiring about whether there is resistance to following the EA principles and what it is.

Q39 A multiple choice question indicating to what extent EA principles affect the flexibility of the architecture, on a scale 'Reduce flexibility a lot' rated -2, 'Reduce flexibility a little' rated -1, 'Has no effect' rated 0, 'Increase flexibility a little' rated 1, and 'Increase flexibility a lot' rated 2.

7.3.2 Characterization of the Sample

We received a total of 73 complete responses for questions 34, 35, and 36. We hence received a 31.9% response rate to our direct contacts for these questions. For question 39, we had 72 complete responses. Those were mandatory questions.

For questions 37 and 38, we received 15 and 29 answers, respectively. Those were optional questions, so they were skipped by most respondents.

Figure 37 presents the coverage of the countries from which we received responses to the mandatory questions on the EA principles.

We received complete responses from 19 different countries. This is considered good because the responses to these questions covered the continents of North America, Australasia, Europe, Asia as well as Africa. The countries with the highest number aof

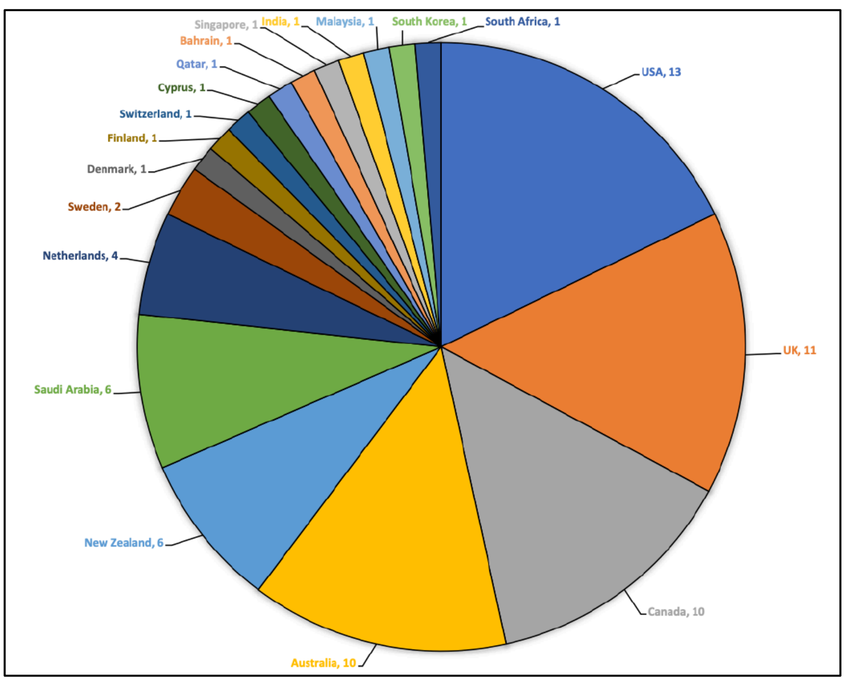

Figure 37 Countries of participants in the survey from EA principles questions

responses are the USA (13), the UK (11), Canada (10), Australia (10), New Zealand (6), and Saudi Arabia (6). Later, we compare the 56 results from those top six countries which have 6 or more responses.

7.3.3 General Enterprise Architecture Principles (Q34)

In Question 34, we asked our participants to rate 18 general EA principles. We obtained 73 answers to this question. The result is presented in Table 29 (light-grey shaded cells indicate the important/interesting data) and Figure 38 (the row labels have been shortened). Table 29 provides the basic statistics in which the responses converted to numbers where 0= 'Not applied at all,' 1= 'Considered sometimes,' 2= 'Important but informally applied,' and 3= 'This is similar to one of our organization's formal EA principles.'

As Table 29 shows, most participants applied these principles formally (they were similar to their institutions' EA principles) or informally (they thought these principles were important).

In this table we have also applied the tags we developed from the definitions of EA in Table 16 and the motivations for EA in Table 17. Most of the motivational tags reappear, but many from the definitions do not (e.g., formalizing and automation).

Table 29 Basic statistics regarding General EA principles; n=73 (Q34)

Principle	Mean	Std. Dev	95% Confidence Interval of mean		Tags
Align decisions and architecture with the strategic mission, vision and values of the university.	2.40	0.88	2.19	2.60	[Alignment] **[Institution-Wide]**
Maximize the benefits to the university	2.38	0.74	2.21	2.56	**[Institution-Wide]** **[Effectiveness]**
Ensure compliance with laws, standards and policies	2.18	0.96	1.95	2.40	[Alignment]
Be digitally integrated	2.01	0.94	1.80	2.23	[Digital Transformation]
Enhance simplicity	2.01	0.91	1.80	2.22	[Simplification] **[Ease of use]**
Be responsive to stakeholders as their needs change	2.01	0.86	1.81	2.21	**[Stakeholder-Collaboration]**
Ensure the continuity and recoverability of critical university operations	2.00	0.99	1.77	2.23	**[Continuity and Sustainability]**
Enable partnership between business units and IT units	1.99	0.89	1.78	2.19	**[Stakeholder-Collaboration]**
Be agile	1.96	0.84	1.76	2.16	**[Adapting and agility]**
Enable a holistic approach	1.88	0.97	1.65	2.10	**[Institution-Wide]**
Ensure the architecture is maintainable	1.84	0.99	1.61	2.07	**[Continuity and Sustainability]**
Focus on efficiency of using resources	1.81	0.84	1.61	2.01	[Rationalization] [Cost-Reduction]

Principle	Mean	Std. Dev	95% Confidence Interval of mean		Tags
Orient the architecture to provision of services	1.77	0.98	1.54	2.00	[Value-Delivery]
Enable quick, accurate decision-making support	1.71	0.94	1.49	1.93	[Better-Decision-Making]
Base change on careful requirements analysis	1.68	0.90	1.48	1.89	[Change-Management]
Focus on the performance of the organization	1.62	1.02	1.38	1.85	**[Institution-Wide]** [Value-Delivery] **[Effectiveness]**
Enable a single federated enterprise-wide architecture	1.48	1.09	1.22	1.73	**[Adapting and agility]** **[Recognizing-Interdependence]**
Ensure elements of the architecture are measurable.	1.25	0.97	1.02	1.47	

Most importantly, the majority of participants tended to apply 'Align decisions and architecture with the strategic mission, vision and values of the university' and 'Maximize the benefits to the university' informally (close to 2.0), with 60.3% and 50.7% who had similar principles in their universities and 24.7% and 39.7% who applied them informally.

On the other hand, 'Ensure elements of the architecture are measurable' was almost at the bottom of the ranking (close to 1.0), with only 9.6% had it in their institutions, and 32.9% considered it important but applied it informally. It also got the highest percentage of respondents who indicated they did not apply it at all, with 27.4%.

Moreover, 'Focus on the performance of the organization' and 'Enable a single federated enterprise-wide architecture' had small means (1.62 and 1.48) and large standard deviations (1.02 and 1.09), respectively, which means that the unofficial application of these principles was quite spread out among the institutions.

It is also interesting to see that 'Be agile' was not applied at all by only 1.4% (only one participant), and 65.8% said they applied it either formally or informally. That gives us a hint of how important it is to ensure that EA is agile, which we address in Chapter 9.

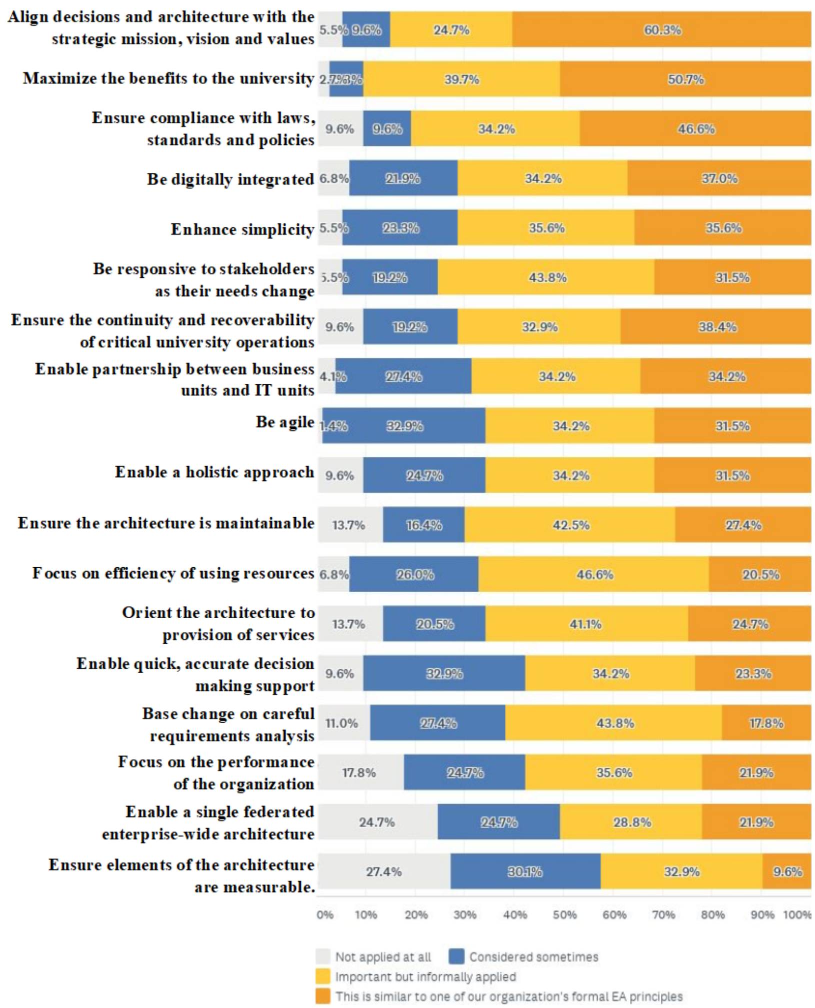

Figure 38 General EA principles applied at HE institutions (Q34)

Among the top six countries, 'Align decisions and architecture with the strategic mission, vision and values of the university' was applied formally with at least 50.0% of participants (the lowest percentage is from American participants). New Zealand stood out, with 83.3% who had a similar principle in their institutions. Saudi Arabia, Australia, and Canada did not report 'Not apply it at all.'

Australia had the highest percentage of participants (80.0%), who had a similar principle as 'Maximize the benefits to the university.' However, all Saudi Arabia participants applied this principle either formally (33.3%) or informally (66.7%). Also, Saudi stood out with 100.0% of institutions that applied 'Be digitally integrated' and 'Focus on efficiency of using resources' formally (66.7%) or informally (33.3%).

Moreover, 100.0% of Australia participants applied 'Ensure compliance with laws, standards and policies' either formally (40.0%) or informally (60.0%).

The principles that received the highest percentage of respondents who did not apply them at all at their institutions were ‘Focus on the performance of the organization’ with 50.0% in New Zeeland and ‘Enable a single federated enterprise-wide architecture’ with 40.0% in Australia.

7.3.4 Data Management Principles (Q35)

In Question 35, we asked our participants to rate 8 data management principles on a scale: ‘Not applied at all’ rated 0, ‘Considered sometimes’ rated 1, ‘Important but informally used’ rated 2, and ‘This is similar to one of our organization’s formal EA principles’ rated 3.

We also received 73 responses. Table 30 (light-grey shaded cells indicate the important data) and Figure 39 (the row labels have been abbreviated here) present the statical and graphical results.

We applied the same tags to this table as appeared in the last and some earlier tables relating to definitions and motivation of EA. Only a few of the tags apply to this set of principles.

As Table 30 and Figure 39 demonstrate, the result shows an increased interest in the data management principles because a large percentage of respondents said they applied these principles, either formally or informally. In other words, the participants cared more about these principles, perhaps because of the sensitivity of data.

Table 30 Basic statistics Data Management principles; n=73 (Q35) *

Principle	Mean	Std. Dev.	95% Confidence Interval of mean		Tags
Data is kept secure, and security risks are managed	2.64	0.63	2.50	2.79	[Security]
Data is an asset	2.45	0.71	2.29	2.62	
Data is accessible, available and discoverable	2.36	0.82	2.16	2.55	[Leverage]
Data is shared	2.30	0.76	2.12	2.48	
Data is reused: duplication of data should be avoided	2.25	0.92	2.03	2.46	[Rationalization]
There are policies and data management guidelines for data	2.22	0.87	2.02	2.42	[Management] [Systematic] **[Continuity and Sustainability]**
Data is under the control of a trustee	2.08	1.00	1.85	2.31	**[Careful-Focus]** **[Security]** **[Continuity and Sustainability]**
There is a common vocabulary and definitions for data	2.05	0.86	1.85	2.26	[Rationalization]

* The light-grey shaded cells indicate the important/interesting data

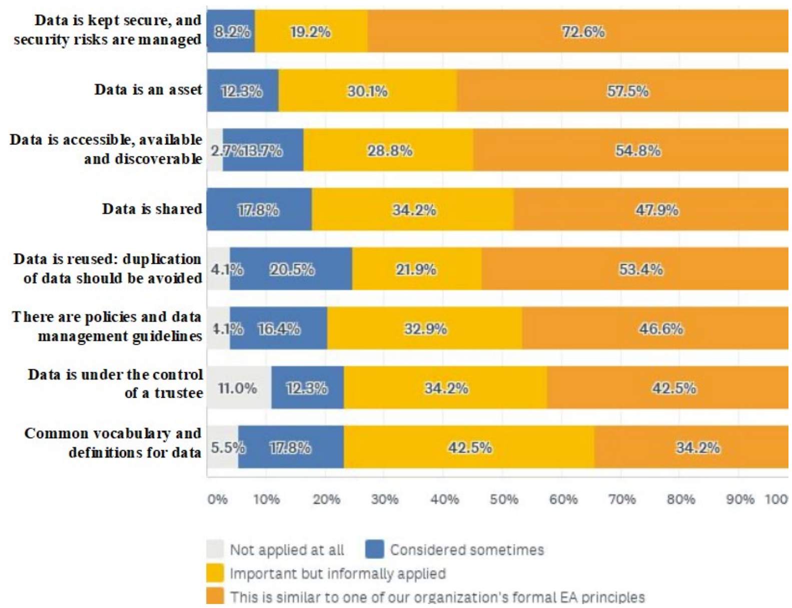

Figure 39 Data Management Principles Applied at HE Institutions (Q34)

On average, most participants had ‘Data is kept secure, and security risks are managed’ in their formal EA principles list (close to 3.0), with 72.6%. ‘Data is an asset’ was also applied formally by 57.5% of participants. None of the participants rated it at ‘Not applied at all.’

In contrast, ‘Data is under the control of a trustee’ was not applied by the highest percentage of participants, with 11.0%. Besides, ‘There is a common vocabulary and definitions for data’ came at the bottom of the ranking.

The participants from all the top six countries considered ‘Data is kept secure, and security risks are managed’ as the most critical principles because they all applied it formally or informally, or they sometimes considered it. However, Saudi Arabia emerged in this regard, with 100.0% of participants saying that they had this principle in their formal list. None of the participants from these countries said that they did not apply this principle at all.

Likewise, ‘Data is an asset’ and ‘Data is shared’ were applied by the participants from all the six countries. Australia and Saudi Arabia stood out, with 100.0% of participants applied these principles officially.

Furthermore, 100.0% of Australian participants said they formally had a similar principle as ‘Data is accessible, available and discoverable’ in their list.

On the other hand, Australia reported the highest percentage of participants (20.0%) that did not apply 'Data is under the control of a trustee' at all. In particular, the participants from four of these countries had never applied this principle in their institutions with varying percentages.

7.3.5 Technology Management Principles (Q36)

In Question 36, we asked our participants to 8 technology management principles on a scale: 'Not applied at all' rated 0, 'Considered sometimes' rated 1, 'Important but informally used' rated 2, and 'This is similar to one of our organization's formal EA principles' rated 3.

We received 73 responses to this question. We show the result in Table 31 (light-grey shaded cells indicate the important/interesting data), and Figure 40 (the row labels have again been abbreviated here). Once again, we have applied tags relating back to the definitions and motivations for EA.

As shown in Table 31, 'Ensure the interoperability of technological components' emerged with the highest percentage of participants (53.4%) who had this principle formally in their institutions. 31.5% of participants think it is important and apply it informally (close to 2.0).

On the contrary, 'Prefer open solutions to commercial solutions' ranked at the bottom with only 17.8% who had a similar principle in their institutions and 27.4% who did not apply it all (which considers the highest percentage here).

'Using cloud-based technology first' is an important principle mentioned by numebrs of our interviwees but we did not include it in the survey.

Table 31 Basic statistics regarding Technology Management principles; n=73 (Q36)

Principle	**Mean**	**Std. Dev.**	**95% Confidence Interval of mean**		**Tags**
Ensure the interoperability of technological components	2.34	0.84	2.15	2.54	[Alignment] **[Recognizing-Interdependence]** **[Effectiveness]**
Comply with technological standards and policies	2.25	0.88	2.04	2.45	[Alignment]
Applications must be easy to use	2.19	0.81	2.00	2.38	**[Ease of use]**
Ensure end users can perform their work as efficiently as possible	2.19	0.68	2.03	2.35	[Cost-Reduction] **[Ease of use]**
Control technical diversity	2.18	0.89	1.97	2.39	[Simplification]

Principle	Mean	Std. Dev.	95% Confidence Interval of mean		Tags
Buy instead of building	2.15	0.95	1.93	2.37	
Configure instead of customizing	2.12	0.90	1.91	2.33	
Design solutions such that they are 'good enough' in order to minimize costs and maximize value	1.85	0.79	1.66	2.03	[Cost-Reduction] [Simplification] [Value-Delivery]
Ensure applications are independent of specific technology choices	1.81	1.00	1.58	2.04	**[Continuity and Sustainability]**
Use or try out applications and technologies before buying	1.63	0.86	1.43	1.83	
Avoid vendor lock-in	1.58	0.88	1.37	1.78	**[Continuity and Sustainability]**
Align with multiple products from a single vendor to best leverage that vendor's ecosystem	1.44	0.88	1.23	1.64	[Technology-Infrastructure] [Alignment]
Prefer open solutions to commercial solutions	1.38	1.08	1.13	1.63	**[Continuity and Sustainability]**
Using cloud-based technology first *					

* This principle was not included in the survey question.

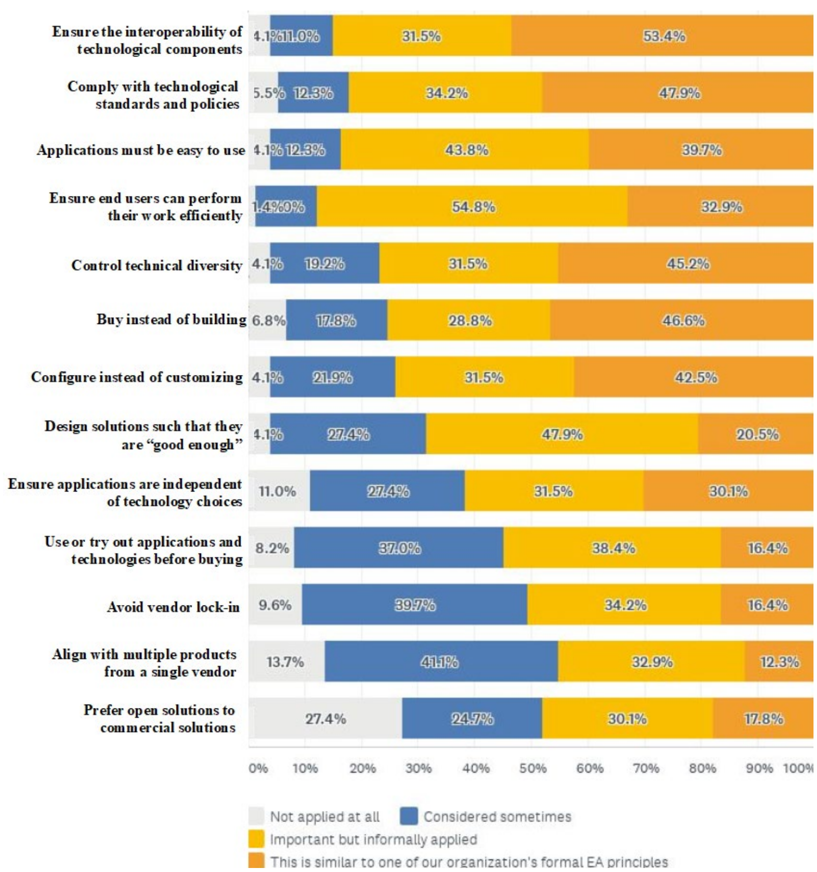

Figure 40 Technology Management principles applied at HE institutions (Q34)

The result shows that our participants from the top six countries said that they had 'Ensure the interoperability of technological components' in their formal list of principles, with at least 38.5%. In addition, all of the participants from these six countries applied 'Ensure end users can perform their work as efficiently as possible’ either formally or informally or considered it sometimes. However, Saudi Arabia stood out, with 100.0% of participants that had a formally similar principle. Also, Saudi Arabia was prominent, with 100.0% of respondents who applied ‘Applications must be easy to use’ either formally (83.3%) or informally (16.7%).

Also, 90.0% of Australian participants said that they had ‘Buy instead of building’ officially, and 10.0% applied it informally. On the other hand, Saudi Arabia stood out with the highest percentage of respondents (33.3%) who did not apply it at all.

Australia had the highest percentage of participants who had never applied ‘Prefer open solutions to commercial solutions’ with 40.0%, followed by the U.S. participants with 33.8% and New Zealand participants with 33.3%.

7.3.6 Other Important Principles Not Mentioned in the Previous Questions (Q37)

In Question 37, 14 participants provided additional principles that were used by their institutions to guide the EA process. We analyzed all the answers and classified them into our three main categories of the EA principles. We hence have two tables of principles.

Table 32 shows a set of principles that matched some of the principles we presented in our previous questions.

To illustrate, from the first category ‘General EA Principle,’ we have the ‘Maximizing benefit to the enterprise,’ ‘Service above Self,’ and ‘Focus on the university's needs not individual points of pain’ principles, which matched the ‘Maximize the benefits to the university’ principle from our list. Another example is the ‘Business continuity,’ which matched the ‘Ensure the continuity and recoverability of critical university operations’ principle from our list.

Table 32 Principles match up with our results for EA principles

Main Category	Principles that respondents suggested should be added	Tags	Related principles listed in our survey, or obtained in grounded theory
General EA Principles	Maximizing benefit to the enterprise *	[Institution-Wide]	Maximize the benefits to the university
	Service above Self		
	Focus on the university's needs not individual points of pain	[Institution-Wide]	

Main Category	**Principles that respondents suggested should be added**	**Tags**	**Related principles listed in our survey, or obtained in grounded theory**
	Business continuity *	**[Continuity and Sustainability]**	Ensure the continuity and recoverability of critical university operations
	Compliance with statutory obligations	[Alignment]	Ensure compliance with laws, standards and policies
	Reducing duplication and expending effort on solutions that are re-usable in a decentralized environment	[Rationalization], [Simplification], [Cost-Reduction]	Enhance simplicity Ensure applications are independent of specific technology choices Align with multiple products from a single vendor to best leverage that vendor's ecosystem
	Simplicity of processes and focus on user efficiency (from Q38)	[Simplification]	Enhance simplicity Ensure end users can perform their work as efficiently as possible
	Primacy of principles		Primacy of principles (Table 57 in Appendix F)
	Information management is everybody's business		Information management is everybody's business (Table 57 in Appendix F)
	IT responsibility		IT responsibility (Table 57 in Appendix F)
Technology Management Principles	Minimizing the amount of custom-made functionality	[Simplification], [Cost-Reduction]	Configure instead of customizing
	Common use applications		Control technical diversity
	Control technical diversity *	[Simplification]	
	Ensure the ability to use all solutions with staff from within and outside the institution		Ensure end users can perform their work as efficiently as possible
	Avoiding multi/hybrid cloud lock-in		Avoid vendor lock-in
	Cloud-first *		Using cloud-based technology first
	Buy before building *		Buy instead of building
	Purchase rather than developing *		
	Prefer off-the-shelf solutions		
	Being pragmatic and following 'just enough' architecture	[Pragmatism]	Design solutions such that they are 'good enough' in order to minimize costs and maximize value
	Technology independence *		Ensure applications are independent of specific technology choice
	Ease of use *	**[Ease of use]**	Applications must be easy to use
	Solutions must be capable of being deployed, operated and supported remotely by own system partners		Align with multiple products from a single vendor to best leverage that vendor's ecosystem
	Requirements-based change *	[Change-Management]	Base change on careful requirements analysis
Data Management Principles	Data security *	**[Security]**	Data is kept secure, and security risks are managed
	Data is an asset *		Data is an asset

Main Category	Principles that respondents suggested should be added	Tags	Related principles listed in our survey, or obtained in grounded theory
	Data is shared *	**[Recognizing-Interdependence]**	Data is shared
	Data is accessible *		Data is accessible, available and discoverable
	Data trustee *	**[Continuity and Sustainability]** [Management]	Data is under the control of a trustee

* The principles that participants provided as an answer to this question though they were provided in our survey's questions

Table 33 outlines new principles that were not included in our previous lists of EA principles. In other words, these principles were not mentioned by the people we previously interviewed.

Table 33 Additional new EA principles

Main Category Principle	New Principles
General EA Principle	EA team operates as an advisory board, and business owners make the decision.
	Follow a risk-based process when making decisions
	User experience-driven whole ecosystem system approach (a broader community within and outside the campus)
Technology Management Principles	Consider process change before technology
	Take into account the life cycle perspective in information technology
	Get COTS (Commercial-Off-The-Shelf) and SaaS landscape (Software as a Service) to interoperate
Data Management Principles	Data will be analyzable

7.3.7 Resistance to the EA Principles (Q38)

It is not only important to have principles to guide the EA process in universities, but also it is important to know the reasons why some stakeholders resist these principles; the latter allows EA team members to either work towards overcoming the resistance, or perhaps to determine that the principle might not be always applicable. We had an optional question in the survey (Q38) to ask our participants if they faced any resistance to their EA principles, and we received 29 comprehensive answers to this question. We classified these answers into two main groups: the resistance to the EA principles in general, and the resistance to some technical and application principles, as shown in Table 34 and Table 35.

The first group in Table 34 includes seven main general reasons why people at universities resist following the EA principles from participants' points of view.

The first reason is the lack of understanding the value of EA and the EA principles themselves. Some people see the principles as guidelines rather than rules, which reduces the overall effectiveness of the EA process. Others do not understand the business value of EA and instead believe that it may require much overhead. Another source of resistance is lack of management support. The management either does not have an interest in EA or there are general management and authority problems. One of our participants said:

> *"Middle managers refuse to be governed by somebody outside their hierarchical line authority"*

That leads to the second reason for the resistance, which is the isolated departments or faculties and the autonomy in doing the work and making decisions. Some departments or faculties see these principles as irrelevant or obstructive. It is challenging to get agreement on these principles from all the groups at the university, specifically in the decentralized institutions. Another challenge is process harmonization over different departments and faculties, which may lead to the resistance of some EA principles if there is no harmonious acceptance of them by different stakeholders. Also, creating silos within a large, decentralized university may preclude the interaction among staff, which leads to the ignorance of how other departments work. This results in duplication of data or applications rather than re-using them by other departments, and this conflicts with EA principles. One of our participants explained this issue as:

> *"The silos created within a large, decentralized environment preclude the interactions required between staff to avoid duplication and enable re-use. This isn't "resistance", it is ignorance ("I didn't know that other department was building the same solution"). There is no motivation to collaborate to reduce someone else's costs. Establishing a "Technical Advisory Board" that meets quarterly to discuss upcoming solutions to academic or administrative needs is being established to hopefully mitigate this situation to some extent."*

The other form of resistance relates to how to interpret how the EA principles are applied. For example, some people misunderstand how to the trade-off between complexity and future agility when interpreting some of the EA principles, as clarified by one of our participants:

> *"When our EA practice suggests a requirement that adds complexity (and with it, cost and/or elongated project timelines) it is sometimes hard to persuade business*

leaders that adding complexity now will make the long term cost of the solution less (both in terms of maintenance costs and the cost of adapting to future, yet unknown, business process or legislative requirement). i.e. people's interpretation of a how a principle is applied can be an issue."

Also, change of CIOs and leadership teams may reduce or eliminate the support for EA, and therefore, any adherence to these principles may be on a personal basis rather than an agreed official basis.

Moreover, some EA principles are not followed because sometimes designs are misaligned with business goals, constraints, and risk mitigation. Also, the business part of the university can be misaligned with the IT part, which makes getting agreement on the principles difficult and sometimes not possible.

Another form of resistance is the academic community's resistance to complying with the university's standards, procedures and policies. Also, the lack of resources is another reason for not having or applying the EA principles, according to our participant.

Table 34 Resistance to EA principles in general

Reasons for resisting the principles	**Justifications**	**Important Factors for Successful Application of EA Principles (Section 8.2)**
Lack of understanding of EA and the principles, and lack of management support.	Lack of executive (non-IT) interest in EA. Prioritization (rather than resistance) and an understanding of the business value of EA in the long term. Unwillingness to follow the discipline and tradeoffs that are inevitable as part of the institute-wide EA process. EA is perceived to be too much overhead. Reduction of the overall effectiveness of EA principles by seeing them as guidelines rather than as rules.	Improving communication and awareness of EA among all leaders and stakeholders (3.02). The usefulness, transparency and openness of EA itself to understanding the value and benefits of EA (3.02). Obtaining top management support, commitment and sponsorship (3.38). Adding value to the institutions by implementing EA (3.33).
Independence of work and decision-making in departments and faculties	Siloed command and control organization. Resistance to following EA principles as a result of the faculty or department's autonomy in making decisions in which these principles may be considered irrelevant or obstructive. Process harmonization over different faculties. Difficult to get all groups across the organization to agree, particularly in a very decentralized organizationally university. Ignorance as a result of creating silos within a large decentralized environment, which precludes the interactions between staff that will help avoid duplication and enable re-use to reduce someone else's costs. It can be mitigated to some extent by establishing a 'Technical Advisory Board.'	Increasing collaboration with different departments and units (3.09). Understanding EA stakeholders from various departments and from within and outside the university (3.06). Buy-in of the EA from stakeholders (3.06).

Reasons for resisting the principles	Justifications	Important Factors for Successful Application of EA Principles (Section 8.2)
Application and interpretation of principles	Lack of understanding of the trade-off between complexity and future agility when interpreting some of the EA principles.	Having a good set of EA principles (2.80) and following the defined EA principles (2.56).
	Adoption of EA Principles can be fairly ad-hoc across the university because of its very complex ecosystem.	
	Any adherence to any of the established principles is purely on a personal basis as a change in CIO.	
	The tension between principles, such as being secure and being simple.	
	Resistance to principles depends on situation and people because projects and teams have their priorities, and application of the principles is voluntary.	
Misalignment of designs with business goals, constraints, and risk mitigation	Misalignment between design and business goal.	Supporting the university's mission and goals (3.50). Clarity of EA vision, goals, and objectives (3.20).
	Misalignment between design and project constraints.	
	Misalignment between design and risk in operation.	
Misalignment between Business and IT	Business units do not think IT knows the business and it is operational, not purely strategic	Collaboration with different departments and units (3.09). Supporting the university's mission and goals (3.50). Clarity of EA vision, goals, and objectives (3.20).
Resistance to comply with standards and policies	Resistance to standardization, policy and procedures from the academic community.	Conformance of the architecture to standards (2.30). Following a disciplined EA process (2.15).
Lack of resources	Lack of resources and bandwidth.	Obtaining top management support, commitment and sponsorship (3.38) are important to provide the necessary resources to apply the principles and having a good EA team (3.02) is also important to do what is required.

The second group in Table 35 provides examples of resisting some of the technology and application principles.

Table 35 Resistance to some technical and application principles

Reasons for resisting the principles	Justifications
Resistance to the 'buy before build' principle.	University likes open source, has long operated as an app development shop, and/or prefer to build custom in-house solutions.
	University assumes in house effort costs nothing.
	The management team at the university prefers vendor-supported products while staff prefer open-source, so this does create disagreement, especially in a financially constrained situation.
	Minimizing the number of custom-made solutions may not be supported if they threaten the ability of a specific stakeholder to realize all their requirements.
Resistance to the 'comply with technical standards' principle.	Compliance with standards may not be supported if they threaten the ability of a specific stakeholder to realize all their requirements.
	Ignorance of technical standards.
	The idea of 'standard' is perceived as an effort to exert control.
Unwilling to get committee or board's approval.	Resistance from employees to take their designs to the Technical Design Authority (TDA) due to complicated process to accept the designs.
	Staff attachment to some vendors and commercial support.

Reasons for resisting the principles	Justifications
Use of the vendor-supported products	Leveraging a vendor's ecosystem also creates tension because sometimes the CIO (not architecture team) mandates using specific solutions that would not enable the institution to get the best solution.
	Unable to have local EA if the SaaS vendor's EA team decides what the institution does.
Resistance to the 'Common use applications' principle.	Resistance to the 'common use applications' principle because academics tend to want very specific solutions (bespoke).
Use of the quick win solutions	Introducing a temporary quick win solution that meets short term budget constraints to help EA to meet own timeframes.
Resistance to the 'good enough solutions' principle	Resistance to adopting the Minimum Viable Product (MVP) approach because it is against university culture to accept good enough solutions. Designing 'good enough' solutions leads to minimize costs and maximize value

For example, some people at the university resist following the 'buy before build' principle because they prefer open-source solutions or prefer to build custom in-house solutions because they believe they cost nothing. Also, some people do not support buying solutions instead of developing ones because they may not meet the stakeholders' requirements.

Besides, some staff and managers prefer to use vendor-supported products, which may not enable the university to use the best solutions. Other people prefer to use quick-win solutions that fit within the university's short-term budget to assist in meeting the EA short goals.

Also, some academics in different departments prefer to use particular solutions, which may result in having multiple similar applications and services. That is contrary to the 'Common use applications' principle.

Another example is that people at the university may not follow the 'compliance with the technical standards' principle because they think that the standards are an effort to exert control and may not meet the requirements of stakeholders.

Other examples of resisting the technical principles are that some people refuse to get a committee or board's approval for their designs, and some are against university's culture to design the 'good enough solutions' by resisting adopting the Minimum Viable Product (MVP) approach. Designing 'good enough' solutions contributes to maximizing values and reducing costs.

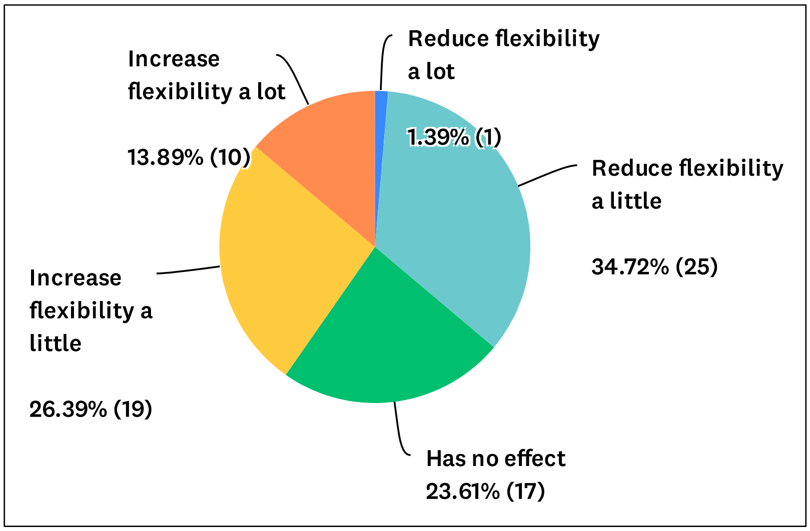

Figure 41 Impact of EA principles on the architecture flexibility in the survey (Q39)

7.3.8 Impact of EA Principles on the Architecture Flexibility (Q39)

In Question 39, we asked our participants *"to what extent do your EA principles affect the flexibility of the architecture?"* As shown in Figure 41, a total of 27 participants answered this question.

The responses were very close. 29 respondents (40.3%) believed that the EA principles might increase the flexibility of architecture, answering either 'Increase flexibility a lot' (10 responses) or 'Increase flexibility a little' (19 responses). On the other hand, 26 respondents said that these principles might reduce the flexibility of architecture, answering either 'Reduce flexibility a lot' (just one response) or 'Reduce flexibility a little' (25 responses). 23.6% (about the quarter of the responses), said that the principles have no impact on the flexibility of the architecture (17 responses). Indeed, the use of many EA principles may reduce the flexibility of architecture, according to (The Open Group, 2018). The diversity of responses may be due to the fact that the understanding of these principles differed among the participants as well as the number of principles that they applied in their institutions was also different.

Regarding the top six countries, we received 55 answers to this question, and there were some interesting differences between them. The UK has the lowest number of participants who believed that the EA principles reduced the flexibility of architecture with just only one response. In contrast, more than a half of participants (6) believed the principles increased the architecture's flexibility, and 4 respondents believed these principles did not affect the flexibility.

On the other hand, there was only one participant from Saudi Arabia who believed that the EA principles increased the flexibility of architecture, which was interesting, as it contradicts the main result we obtained from all participants. On the contrary, 4 of the Saudi participants said that these principles reduced the architecture's flexibility, and two thought that they had no impact on the flexibility of the architecture.

Moreover, we obtained some balanced results from Canadian and American participants. 4 participants from Canada believed that these principles reduced the flexibility of architecture, whereas the other 4 thought that they increased the architecture's flexibility. There was also only one participant who said that these principles did not affect the flexibility of the architecture.

In the US, 5 responses were with reducing the flexibility of the architecture. Conversely, the other 5 were with increasing the flexibility of the architecture. Three participants did not believe that the EA principles had any effect on flexibility.

Finally, in Australia, 50.0% (5) of its participants believed that these principles had no impact on the flexibility of the architecture.

7.4 Results of Participants Planning to Adopt the EA Program

We also asked the participants who did not adopt EA yet but had a plan to do so about the importance of applying the EA principles. We added mandatory questions to the survey (Question 12, Question 13, and Question 14) to ask how important the general EA principles, data management principles, and technology management principles were to the participant's institutions, on a scale from 'Not important at all' rated 0 to 'Absolutely essential' rated 4. We also added an optional question (Question 15) to ask if there were any other very important principles that were not mentioned in the previous questions in the survey.

We received 12 responses to Q12, Q13, and Q14. We did not receive any response to Q15. This sample of answers is not considered good, but at least it shows that the participants were aware of the importance of applying EA principles in their institutions.

7.4.1 General Enterprise Architecture Principles (Q12)

For Question 12, most of the principles had high importance, but ‘Align decisions and architecture with the strategic mission, vision and values of the university’ was at the top of the ranking, as shown in Figure 42, with 41.7% thinking it was absolutely essential and 41.7% thinking it was very important.

On the other hand, ‘Ensure elements of the architecture are measurable’ was almost at the bottom of the ranking, with only 25.0% considering it very important.

Only two principles had a percentage of participants who believed they were not important at all, which are ‘Enable a holistic approach’ with 8.3% and ‘Focus on the performance of the organization’ with 8.3%.

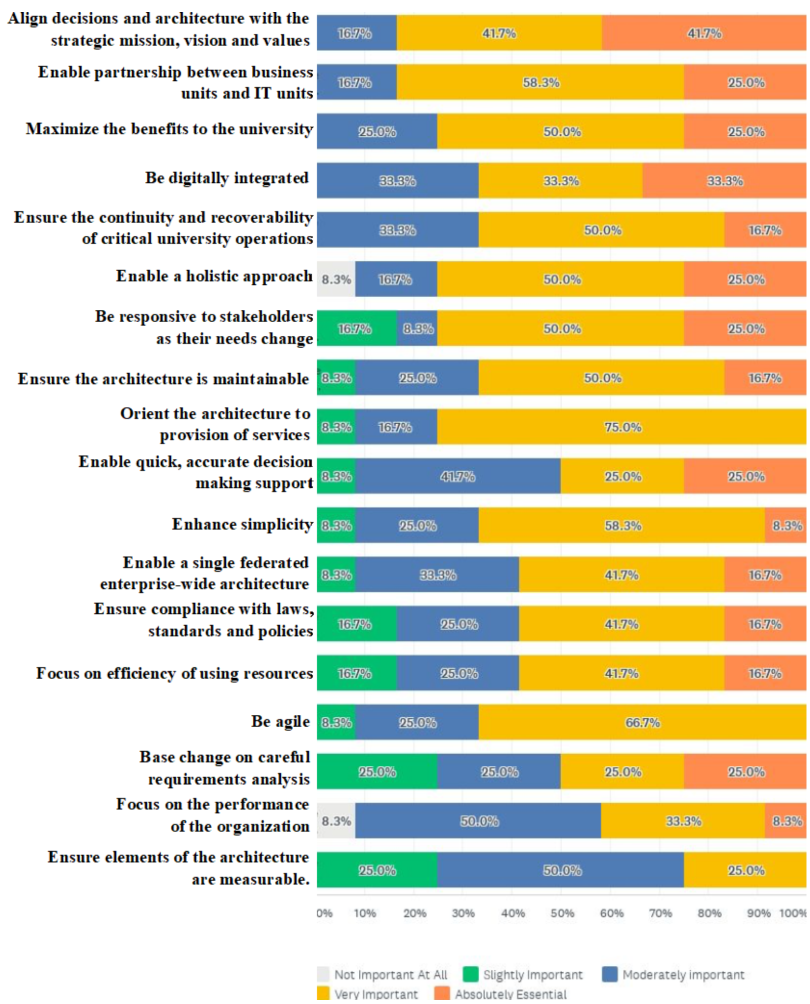

Figure 42 General EA principles (Q12)

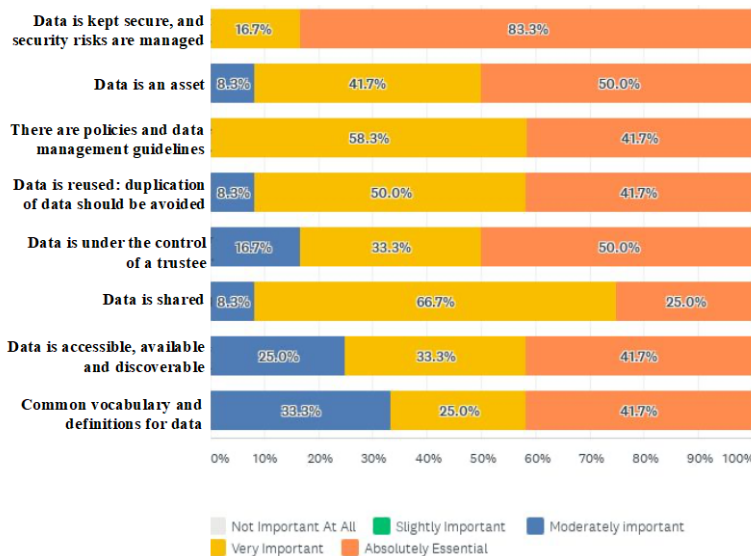

Figure 43 Data Management principles (Q13)

7.4.2 Data Management Principles (Q13)

Figure 43 shows that all the data principles had moderate, high and absolute importance, but 'Data is kept secure, and security risks are managed' had the highest percentage of participants who think it was absolutely essential with 83.3%, followed by 'Data is an asset' and 'Data is under the control of a trustee' with 50.0%.

7.4.3 Technology Management Principles (Q14)

In Question 14, two principles stood out as participants considered they were very or absolutely important, as shown in Figure 44. They are 'Ensure the interoperability of technological components' with 50.0% thinking it was absolutely essential and 50.0% thinking it was very important, and 'Ensure end users can perform their work as efficiently as possible' with 8.3% saying it was absolutely essential and 91.7% saying it was very important.

Only three principles had a percentage of participants who considered them not very important at all. They are 'Prefer open solutions to commercial solutions' with 8.3%, 'Buy instead of building' with 16.7%, and 'Align with multiple products from a single vendor to best leverage that vendor's ecosystem' with 16.7%.

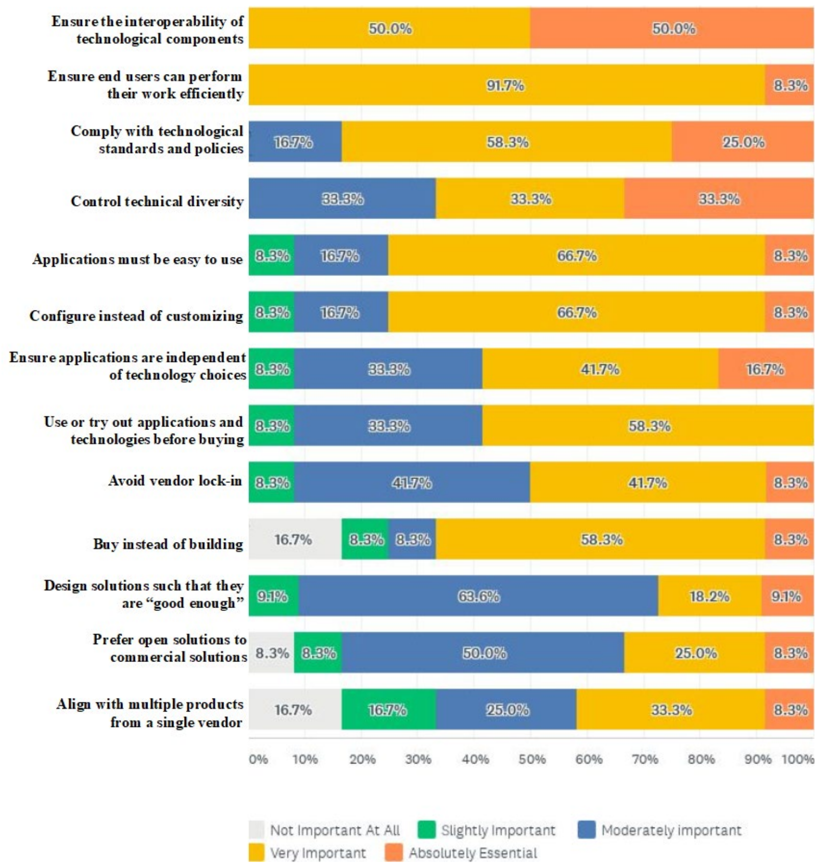

Figure 44 Technology Management principles (Q14)

7.5 Discussion

We compared our final list of the EA principles in the HE institutions (Table 28) with the TOGAF architecture principles, COBIT principles, and EEA principles. These sets of principles were either mentioned by our interviewees or existed in the literature.

In Table 36, we identify which principles in our list are in the other sets of principles. We also identify the number of times each of these principles was mentioned in the grounded theory results. Finally, we identify the percentage that each of these principles was formally applied in the institutions from the survey results. We then provide a recommendation that determines what principles have the highest priority to be applied in the HE institutions.

Based on the comparison in Table 36, we found that 'Align decisions and architecture with the strategic mission, vision and values of the university' is the most critical principle among the general EA principles, according to the opinion of 60.2% of our respondents. They stated that they had a similar principle in the list of their university formal EA principles. The alignment of IT and business with the university's goals and vision is one of the most critical issues facing HE institutions (Yunis, Surendro & Telaumbanua, 2010; Oderinde, 2010; Barn, Clark & Hearne, 2013; Amalia & Supriadi, 2017); applying this principle may help avoid this problem. This principle was not mentioned in the list of principles from the literature review provided in Table 36, but it was referred to by our interviewees three times.

Table 36 Comparison of our final list of EA principles with other principles in the literature review

Grounded Theory & Survey Results	Literature review	TOGAF 9.2 Principles	EEA Principles	COBIT Principles	No. OCC in GT	%formally applied in Survey	Mean
General EA Principles	Align decisions and architecture with the strategic mission, vision and values of the university.				3	60.2 %	2.40
	Maximize the benefits to the university	20.6.1.2	1.1		3	50.6 %	2.38
	Ensure compliance with laws, standards and policies	20.6.1.7			3	46.5 %	2.18
	Be digitally integrated				1	36.9 %	2.01
	Enhance simplicity				4	35.6 %	2.01
	Be responsive to stakeholders as their needs change	20.6.4.2		1	2	31.5 %	2.01
	Ensure the continuity and recoverability of critical university operations	20.6.1.4			3	38.3 %	2.00
	Enable partnership between business units and IT units			2	2	34.2 %	1.99
	Be agile				3	31.5 %	1.96
	Enable a holistic approach			4	1	31.5 %	1.88
	Ensure the architecture is maintainable				1	27.4 %	1.84
	Focus on efficiency of using resources				1	20.5 %	1.81
	Orient the architecture to provision of services	20.6.1.6	1.3		12	24.6 %	1.77
	Enable quick, accurate decision-making support				5	23.2 %	1.71
	Base change on careful requirements analysis	20.6.4.1			2	17.8 %	1.68
	Focus on the performance of the organization			2	3	21.9 %	1.62
	Enable a single federated enterprise-wide architecture			3	1	21.9 %	1.48
	Ensure elements of the architecture are measurable				1	9.5 %	1.25
Data Management Principles	Data is kept secure, and security risks are managed	20.6.2.6			8	72.6 %	2.64
	Data is an asset	20.6.2.1	2.1		4	57.5 %	2.45
	Data is accessible, available and discoverable	20.6.2.3			8	54.7 %	2.36
	Data is shared	20.6.2.2			5	47.9 %	2.30
	Data is reused: duplication of data should be avoided				2	53.4 %	2.25
	There are policies and data management guidelines for data				1	46.5 %	2.22
	Data is under the control of a trustee	20.6.2.4	2.2		1	42.4 %	2.08
	There is a common vocabulary and definitions for data	20.6.2.5	2.3		3	34.2 %	2.05
T	Ensure the interoperability of technological components	20.6.4.4	4.2		4	53.4 %	2.34

Literature review / Grounded Theory & Survey Results		TOGAF 9.2 Principles	EEA Principles	COBIT Principles	No. OCC in GT	%formally applied in Survey	Mean
	Comply with technological standards and policies	20.6.1.7			3	47.9 %	2.25
	Applications must be easy to use	20.6.3.2	3.3		9	39.7 %	2.19
	Ensure end users can perform their work as efficiently as possible				3	32.8 %	2.19
	Control technical diversity	20.6.4.3	4.3		4	45.2 %	2.18
	Buy instead of building				2	46.5 %	2.15
	Configure instead of customizing				2	42.4 %	2.12
	Design solutions such that they are 'good enough' in order to minimize costs and maximize value				1	20.5 %	1.85
	Ensure applications are independent of specific technology choices	20.6.3.1	3.2		3	30.1 %	1.81
	Use or try out applications and technologies before buying				1	16.4 %	1.63
	Avoid vendor lock-in				1	16.4 %	1.58
	Align with multiple products from a single vendor to best leverage that vendor's ecosystem	20.6.1.5 20.6.3.1	3.1 3.2		1	12.3 %	1.44
	Prefer open solutions to commercial solutions				1	17.8 %	1.38
	Using cloud-based technology first				2		

Another principle that received more than 50% of our participants who considered it very important is 'Maximize the benefits to the university.' They had a similar principle in their formal university list of EA principles. This principle is found in TOGAF 9.2 and EEA principles. Also, it was mentioned three times during the interviews. It implies that information systems' strategic decisions should always be taken from a university-wide perspective to provide maximum value to the university. In other words, information systems' decisions should adhere to enterprise-wide priorities and drivers to maximize the benefits to the university.

On the other hand, 'Orient the architecture to provision of services' was mentioned 12 times during interviews and is found in TOGAF 9.2 and EEA principles; yet only 24.6% of our survey participants said it was crucial.

As for the data management principles, they generally received the attention of most of our participants. The principles that got more than 50% of our participants believed they are critical and had similar principles in their formal university list of EA principles are as follows. 'Data is kept secure, and security risks are managed' was mentioned eight times by our interviewees and identified in TOGAF's list of principles. The sensitivity of university data and the importance of preserving it from risks are among the most critical topics that concern people in HE institutions. ‘Data is an asset’ and ‘Data is accessible, available and discoverable’ are also among the principles that our participants believed in its importance and were also found in TOGAF’s list of principles. ‘Data is reused: duplication of data should be avoided’ was also mentioned twice in the interviews but is not found in the list of principles from the literature review in Table 36 despite its importance.

As for the technology management principles, more than 50% of our participants believed that ‘Ensure the interoperability of technological components’ is very important as it was similar to what they had in their formal list of EA principles. Our interviewees mentioned it four times during the interviews and found in TOGAF 9.2 and EEA principles. It is important to ensure that the technological and software components adhere to standards that enhance the interoperability between data and business and technological applications. The importance of applying this principle is due to the fact that it helps make better decisions, facilitate system management, improve user satisfaction, protect information technology investments, and increase the speed of delivery of solutions.

‘Applications must be easy to use’ was mentioned nine times during the interviews and is found in TOGAF 9.2 and EEA principles. It is important to reuse the applications so that there is no repetition or duplications; however, only 39.7% of our respondents believed this principle is very important.

From the above, it is evident that there are interest and necessity to apply EA principles in higher education institutions. Table 36 above shows the different categories of these principles and their varying degrees of importance.

7.5.1 Lessons Learned and Recommendations

The most important lessons and recommendation are:

- It is always better to have a group of principles to guide the EA process at HE institutions. In this study, we suggest using three categories of EA principles: General (a combination of general and business principles), data management principles, and technology management principles (a combination of technology and application principles).

- Several EA principles were defined in the literature review, but the grounded analysis findings identified 18 most frequently applied general EA principles in HE institutions. These principles guide and support how the university achieves its mission and goals in all its different domains. They also inform and guide the decision-making process and business processes.
- Our survey results revealed that most of our participants applied all the general EA principles formally, as they were similar to the list of EA principles they had in their institutions or informally because they believed that these principles are very important.
- More than half of our participants applied ‘Align decisions and architecture with the strategic mission, vision and values of the university’ and ‘Maximize the benefits to the university’ formally. The finding shows the importance of applying these principles because they help the university align its decisions and architecture with its vision and goals and maximize its benefits. The finding is consistent with the top six countries’ results, but New Zealand and Australia stood out.
- ‘Align decisions and architecture with the strategic mission, vision and values of the university’ was not mentioned in the principles of EA in the literature review; whereas ‘Maximize the benefits to the university’ is found in TOGAF 9.2 and EEA principles.
- ‘Be agile’ was applied formally or informally by more than half of the participants, which indicates the importance of ensuring that EA is agile.
- ‘Ensure elements of the architecture are measurable’ received the highest percentage of participants who reported that they did not apply it at all.
- Saudi Arabia was distinguished by 100.0% of participants who applied ‘Be digitally integrated’ and ‘Focus on efficiency of using resources,’ formally or informally. The logical explanation for this finding is that the Saudi government has a vision for digital transformation in all public sectors, including the HE sector.
- 100.0% of Australian respondents applied ‘Ensure compliance with laws, standards and policies’ either formally or informally. Following the CAUDIT

framework could be one reason for following and complying with the standards and laws.

- ‘Focus on the performance of the organization’ and ‘Enable a single federated enterprise-wide architecture’ had the highest percentage of respondents who did not apply it at all.
- All the 8 data principles were applied either formally or informally in HE institutions on a different scale, which indicates that they are the most frequently applied principles among others because they guide and govern data used within the university and inform how to process, manage, store and access the data.
- More than half of our participants had ‘Data is kept secure, and security risks are managed’ and ‘Data is an asset’ in their official EA principles. There were identified in TOGAF’s list of principles. The participants from all the top six countries considered these two principles to be the most frequent principles. Saudi Arabia and Australia stood out in this regard with 100.0%.
- ‘Data is under the control of a trustee’ and ‘There is a common vocabulary and definitions for data’ were at the bottom of the ranking. The participants from four of the top six countries did not apply these principles in their institutions to varying degrees, with Australia emerged in this regard.
- ‘Data is reused: duplication of data should be avoided’ was mentioned twice in the interviews but is not found in the literature review despite its importance.
- The grounded theory results identified 14 technology management principles applied in HE institutions that provide guidelines for the use and deployment of all IT technology and application in the university and define the standards for their management, development, and design.
- ‘Ensure the interoperability of technological components’ was one of the most important principles applied formally or informally by most participants. It is also found in TOGAF 9.2 and EEA principles. This result was also consistent with the responses of our participants from the top six countries.
- ‘Prefer open solutions to commercial solutions’ ranked at the bottom with the highest percentage of respondents who had never applied it. Australia has the highest percentage of respondents who had never applied it.

- The results of the grounded theory showed that ‘Using cloud-based technology first’ is an important principle, but we did not include it in the survey.
- 100.0% of Saudi Arabia respondents applied ‘Ensure end users can perform their work as efficiently as possible’ and ‘Applications must be easy to use,’ either formally or informally.
- There is much consistency among the 6-top countries regarding applying the EA principles in the HE institutions.
- Our participants provided seven additional new EA principles that were not mentioned in the grounded theory and the survey results. They added three new principles to the group of general EA principles. Two of these principles focus on managing the decision-making process: ‘The EA team operates as an advisory board, and business owners make the decision’ and ‘Follow a risk-based process when making decisions.’ The third principle is ‘User experience-driven whole ecosystem system approach.’ In the set of data management principles, the participants emphasized the importance of having data being analyzable. In the set of technology management principles, three principles are identified: ‘Consider process change before technology,’ ‘Consider the life cycle perspective in information technology,’ and ‘Get COTS (Commercial-Off-The-Shelf) and SaaS landscape (Software as a Service) to interoperate.’
- We identified seven main general reasons that made people in universities resist following EA principles from the participants’ point of view. They are the lack of understanding of EA and the EA principles, and lack of management support, independence of work and decision-making in departments and faculties, failure to apply and interpret EA principles correctly, misalignment of designs with business goals, constraints, and risk mitigation, misalignment between Business and IT, resistance to comply with standards and policies, and lack of resources. We also identified some examples of resisting some of the technology and application principles by some of our participants which are: resistance to the ‘buy before build’ principle, resistance to the ‘comply to technical standards’ principle, resistance to the ‘common use applications’ principle, resistance to the ‘good enough solutions’ principle, unwilling to get committee or board’s approval, use

of the vendor-supported products, and use of the quick win solutions. We provided some justifications for these reasons and examples, and based on this, we suggested some factors to overcome the resistance of the EA principles.

- Having EA principles may not reduce the flexibility of architecture but having many principles can do so. The responses to the effect of EA principles on the architecture flexibility were very close, and the diversity of responses maybe because the understanding of these principles differs between the participants, and the number of principles they applied in their institutions was also different. However, the highest percentage of respondents believed that EA principles would increase the flexibility of the architecture.
- 57.1% of the Saudi participants believed that the EA principles reduced the architecture's flexibility, which is interesting because it contradicts the main result we obtained from all participants. In Australia, half of the respondents believed that the EA principles had no impact on the architecture's flexibility.
- The study shows awareness of the EA principles from the people who do not have an EA program in their institutions but plan to adopt it. Their responses were consistent with the main findings obtained from the participants who already adopted EA in their universities. The majority of participants believed that most of the general EA principles were very important and 'Align decisions and architecture with the strategic mission, vision and values of the university' was at the top of the ranking, whereas 'Ensure elements of the architecture are measurable' was almost at the bottom of the ranking. Likewise, all the data management principles had moderate, high and absolute importance according to the participants, with 'Data is kept secure, and security risks are managed' at the top of the ranking. As for the technology management principles, most participants believed that 'Ensure the interoperability of technological components' was a very important principle. The results of this chapter, whether from the grounded analysis or the survey, indicate that there are interest and necessity to apply EA principles in HE institutions.
- The tags we derived from the definitions and motivations for EA in an earlier chapter only appear sparsely among the principles in this chapter. This suggests

that definitions might need improving to encompass the principles more thoroughly. It also suggests that perhaps additional principles relating to agility, improving automation, and integration of IT with business planning perhaps ought to be added.

- EAs should use the list of EA principles we provided in this study to guide the work of EA in HEIs.

Chapter 8 Challenges, Critical Success Factors and Outcomes of EA in HE Institutions

In this chapter, we present and discuss the results of the grounded analysis and survey related to the challenges of implementing EA in HE institutions and the key factors that lead to successful adoption of EA in the institutions, as well as the impact of EA on various aspects of the institutions.

The structure of this chapter is as follows. Sections 8.1, 8.2, and 8.3 present the results of the grounded theory and the survey on the challenges of the EA adoption, critical success factors of EA, and critical success factors for the individual EA team members. Section 8.4 presents the results for the same set up topics from participants who plan to adopt EA in the future. Section 8.5 provides the results regarding EA impact on various aspects of HE institutions. Finally, Section 8.6 provides lessons learned and recommendations.

8.1 EA Adoption Challenges in HE Institutions

8.1.1 Grounded Theory Results

In this section, we provide the results that we gathered from the interviews regarding the issues and challenges that the HE institutions may face during the adoption of EA. We first provide a summary of the literature on EA adoption challenges in the HE sector. Then we provide and discuss the results of the grounded theory.

In Chapter 3, the result from the systematic literature review shows a clear gap in the research conducted to identify the issues and challenges of adopting EA in public sectors, including HE institutions. We reviewed few studies in this area, specifically in the UK, Finland and Norway. We then created a list of challenges that hinder the adoption of EA in the HE institutions based on these studies, as shown in Table 2 (Chapter 3).

In particular, Oderinde (2011), Syynimaa (2015a), and Olsen and Trelsgård (2016) investigated the EA adoption challenges facing the HE sector. Oderinde (2011) outlined these issues in certain HEIs in the UK. Syynimaa (2015a) proposed an EA Adoption Method (EAAM) based on a comprehensive understanding of the issues surrounding the EA adoption in the HE institutions in Finland. Additionally, Olsen and Trelsgård (2016) defined a set of problems that may hinder the adoption of EA in the Norwegian HE sector.

On the other hand, Seppänen (2014) explored the challenges and the CSFs of adopting EA in the public sectors in Finland.

We also found some studies that discussed the EA adoption challenges in public and private sectors. Although these studies could be applied to the HE sector, we decided to exclude them to focus more on the research that has mainly been conducted for the HE sector. Given that limited information, and as discussed earlier in this thesis, we decided to expand our research to include a broader range of HE institutions from other countries. In the first stage, we interviewed 21 participants from 19 HE institutions in 6 countries (see Section 4.1). We asked our interviewees the following question:

> *Let's talk about the challenges that EA might face. Do you encounter any critical challenges during the adoption of EA? ...Does EA receive a good support from higher-level management? Do you have any 'war stories' or 'things you wish you knew'?*

We followed the grounded theory process to analyze the collected data and identify the core categories and the relevant issues of the EA adoption challenges in HE institutions. We then used the findings to populate a survey question with issues that we believed to pose the most challenge to a successful EA adoption in HE institutions.

Figure 45, Figure 46 and Figure 47 illustrate the main categories of the challenges of adopting EA in the HE sector. In addition, Table 37, Table 38, and Table 39 present the 22 main categories of these challenges. Because a single figure covering these categories would not be clear, we divided them into three smaller figures to make them more readable.

Figure 45 and Table 37 show the first set of main categories and the relevant categories and concepts. In Figure 45, we illustrate the relationships between these main categories. For example, one of the problems that hinder the adoption of EA is the poor reputation of EA among the management and stakeholders in the institutions of higher education. The lack of resources (limited budget and time) that can be invested in the implementation of EA is considered one of the reasons leading to this problem. Another issue that may impede EA adoption is that there is more demand for EA than what the EA team can support or satisfy. Limited resources do not help teams in meeting this demand. Another example of these challenges is the lack of awareness of EA among leadership, teams and stakeholders.

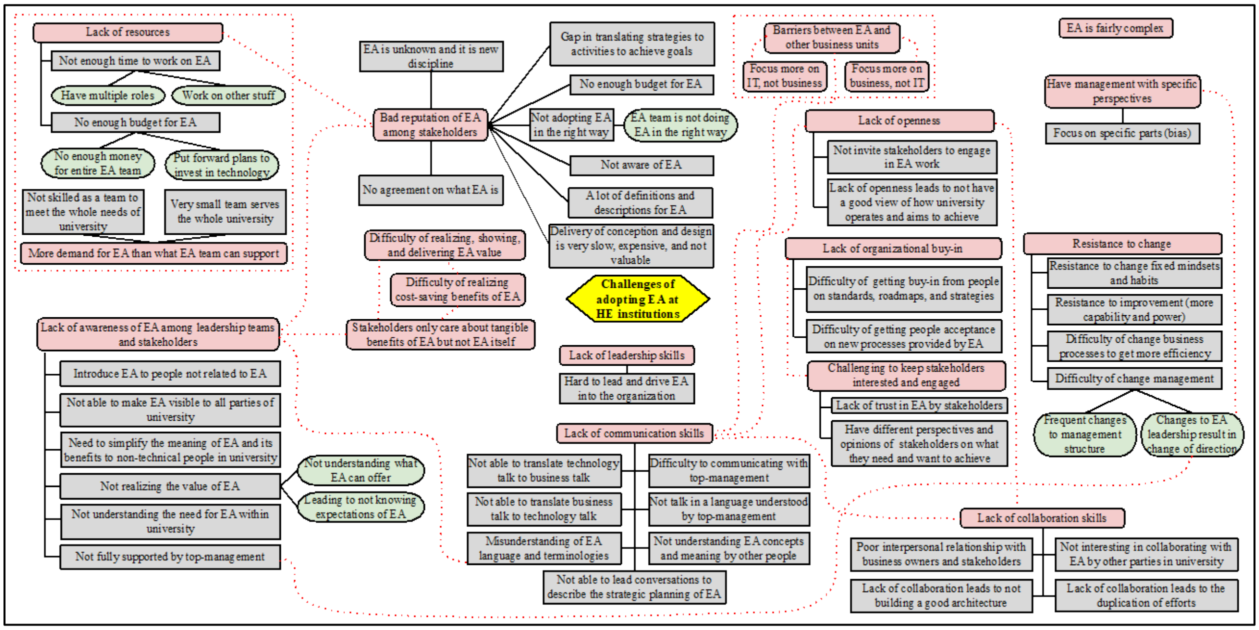

Figure 45 The EA adoption challenges in HE institutions (GT results) (Part 1)

The bad reputation of EA among some stakeholders also indicates that there is a lack of sufficient awareness of EA's importance, value and benefits. Also, one of the most essential reasons that hinder EA adoption, which was mentioned repeatedly during the interviews, is the lack of the required skills, whether from institutional leadership, EA teams, or other stakeholders. The skills included leadership skills, collaboration skills, and communication skills. The lack of these skills may also lead to a lack of openness to dialogue and participation among members of the university community, especially concerning EA adoption. Also, the lack of these skills is a reason for inadequate communication between the IT and business sides of the university, which is considered an EA adoption challenge. Also, the barriers between EA and other business and IT units may be due to an increased focus on IT, not on business or more focus on business, not on IT, which leads to the misalignment between IT and business.

In Table 37, we identify 11 main categories of EA adoption challenges. The challenges that were frequently mentioned by interviewees are misunderstanding and misconception of EA, lack of awareness and readiness, lack of skill sets, lack of support from management and stakeholders, and resistance to change.

Misunderstanding and misconception of EA are among the common challenges facing HE institutions. One of the interviewees indicated that his team has had difficulty introducing

EA to other parties in the university because EA is perceived as new and unknown discipline. EA has multiple definitions and descriptions, as we indicated in the literature review (Chapter 3), which makes it hard to communicate the importance and value of EA to other non-technical parties. The same interviewee said:

> *"The common challenges that we have been facing are the introduction of EA because it is still an unknown discipline ... a new discipline in the industry, and it has not matured yet, and looking at even the number of definitions and descriptions of what EA is in the industry... no... There is no common agreement on what EA is."*

A failure to adopt EA in the right way is a reason for the poor reputation of the EA among stakeholders and other parties in the university, which makes it difficult to convince them of its importance and value.

A lack of EA awareness indicates that other parties at the university may not realize the value of EA or understand the need for it. Hence, there is a need to simplify the meaning of EA and its benefits for people who are non-technical or unrelated to EA at the university. One of the interviewees stated:

> *"When people do not understand or recognize the value that EA can bring, they do not know what to expect from EA work. That makes it challenging for us to get involved in the first place, so when you introduce EA to people, and they do not understand and do not realize or recognize what is the value of EA, that is one of the biggest challenges we have been... we have faced, and we are still facing..."*

A lack of required skills is another big challenge for adopting EA in the right way. Examples of these skills are communication, collaboration, and leadership skills. One of our participants said:

> *"The enterprise architect should be able to.... their job is to translate the business talk to technology talk and be able to talk to technical people but also take this technical stuff and be able to talk to the business people in business language, and that is certainly one of biggest challenges we faced here and also but also people understanding concepts around what EA really means…"*

In other words, communication skill is vital as the enterprise architects play the mediating role between the IT and business parties at the university, and they are also responsible for understanding the demands of these parties. Thus, enterprise architects should able to work and cooperate with different groups and properly manage their teams to carry out the necessary work and accomplish their goals.

The other issue is that EA may not be fully supported by top management or stakeholders or both. It is sometimes challenging to get organizational buy-in from people in management on new processes, standards, roadmaps, and strategies provided by EA, according to one of the interviewees. There is also a challenge to have stakeholders trust the EA process and keep them interested and engaged. They may have different perspectives and opinions on what they need or want to achieve other than what EA provides. They may also not be involved in the EA process and activities, which makes them not understand how EA can satisfy their needs.

Another common challenge for EA adoption in HE institutions is resistance to change. Often people at the university have fixed mindsets and habits. If they do something in a certain way or have specific business processes, it is difficult to get them to change or improve their way or processes or to apply new changes. EA is unknown and new to them; thus, they may resist accepting EA or the changes it brings. One of the participants said,

> *"One of the big problems, of course, is that EA is not just around putting in services and things, it is around trying to change … looking at business processes and then trying to make the business [change]…*
>
> *...So, one of the other biggest drawbacks the fact that faculties and schools have been doing what they are doing for decades, and they do not want to change. Someone is doing the same job for the last few years, and there is no way that they are going to change it..."*

Another issue is also to ensure that the changes made to the architecture or EA activities are managed coherently and that all parties are involved in the change management process.

Table 37 EA adoption challenges in HE institutions from GT results (Part)

Main Category	Category	Concepts
Lack of resources	Lack of resources	Not enough time to work on EA
		Not enough budget for EA
More demand for EA than what EA team can support	More demand for EA than what EA team can support	Very small team serves the whole university
		Not skilled as a team to meet the whole needs of the university
Misunderstanding and misconception of EA	Bad reputation of EA among stakeholders	Not adopting EA in the right way
		A gap in translating strategies to activities to achieve goals
		Not enough budget for EA
		Not aware of EA
		Delivery of conception and design is very slow, expensive, and not valuable
		No agreement on what EA is
		EA is unknown, and it is a new discipline
		A lot of definitions and descriptions for EA
Lack of awareness and readiness	Lack of awareness of EA among leadership teams and stakeholders	Not realizing the value of EA
		Introduce EA to people not related to EA
		Not able to make EA visible to all parties of university
		Not fully supported by top management
		Need to simplify the meaning of EA and its benefits to non-technical people in the university
		Not understanding the need for EA within the university
Lack of skill sets	Lack of collaboration skills	Poor interpersonal relationship with business owners and stakeholders
		Not interesting in collaborating with EA by other parties in the university
		Lack of collaboration leads to not building a good architecture
		Lack of collaboration leads to the duplication of effort
	Lack of openness	Not invite stakeholders to engage in EA work
		Lack of openness leads not to have a good view of how the university operates and aims to achieve
	Lack of leadership skills	Hard to lead and drive EA into the organization
	Lack of communication skills	Not able to translate technology talk to business talk
		Not able to translate business talk to technology talk
		Misunderstanding of EA language and terminologies
		Difficulty in communicating with top management
		Not talking in a language understood by top management
		Not understanding EA concepts and meaning by other people
		Not able to lead conversations to describe the strategic planning of EA
Lack of support from management and stakeholders	Lack of organizational buy-in	The difficulty of getting buy-in from people on standards, roadmaps, and strategies
		The difficulty of getting people acceptance on new processes provided by EA
		Lack of trust in EA by stakeholders

Main Category	Category	Concepts
	Challenging to keep stakeholders interested and engaged	Having different perspectives and opinions of stakeholders on what they need and want to achieve
Unclear leadership	Have management with specific perspectives	Focus on specific parts (bias)
Resistance to change	Resistance to change	The difficulty of change management
		Resistance to change fixed mindsets and habits
		Resistance to improvement (more capability and power)
		The difficulty of change business processes to get more efficiency
Lack of perceived value and benefits	Difficulty of realizing, showing, and delivering EA value	
	The difficulty of realizing cost-saving benefits of EA	
	Stakeholders only care about the tangible benefits of EA but not EA itself	
Lack of business-IT alignment	Barriers between EA and other business units	
	Focus more on IT, not business	
	Focus more on business, not IT	
The complexity of EA	EA is fairly complex	

Figure 46 and Table 38 show the second set of main categories and their relevant categories and concepts.

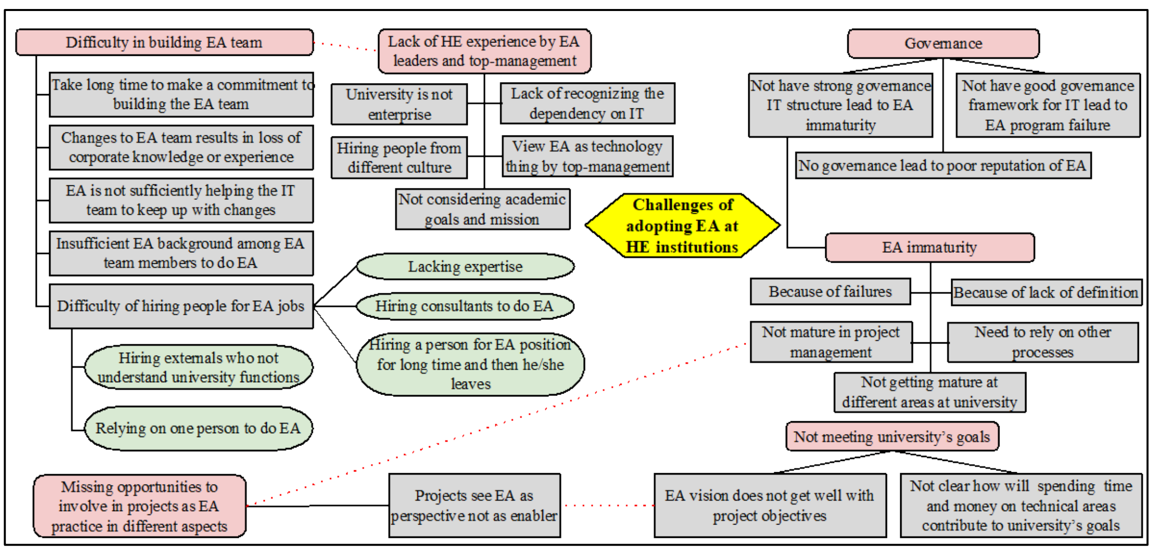

Figure 46 The EA adoption challenges in HE institutions (GT results) (Part 2)

Figure 46 illustrates that some of these challenges are related to other challenges. For example, if EA leaders or senior managers do not have sufficient experience in EA, this could lead to difficulty in building the EA team. Another example is that those concerned with EA may miss opportunities to involve EA in university projects as a practice from various aspects because they see EA as a perspective, not as an enabler or because EA vision does not align well with projects goals.

In Table 38, we identify 6 other main categories of the EA adoption challenges. The challenges that were frequently mentioned by interviewees are the challenge of building the EA team and the knowledge gap and lack of experience.

Table 38 EA adoption challenges in HE institutions from GT results (Part 2)

Main Category	Category	Concepts
Lack of integration with projects	Missing opportunities to involve in projects as EA practice is in different aspects	Projects see EA as perspective, not as an enabler
The challenge of building EA team	Challenging to building the EA team	Difficulty of hiring people for EA jobs
		Take a long time to commit to building the EA team
		Changes to EA team results in loss of corporate knowledge or experience
		EA is not sufficiently helping the IT team to keep up with changes
		Insufficient EA background among EA team members to do EA
Knowledge gap and lack of experience.	Lack of HE experiences by EA leaders and team members	University is not an enterprise
		Lack of recognizing the dependency on IT
		Hiring people from a different culture
		View EA as technology thing by top management
		Not considering academic goals and mission
EA immaturity	EA immaturity	Because of failures
		Because of a lack of definition
		Not having strong governance IT structure
		Need to rely on other processes
		Not getting mature in different areas at university
		Not mature in project management
Misalignment between EA and university goals	Not meeting university's goals	EA vision does not align with project objectives
		Not clear how spending time and money on technical areas contributes to the university's goals
Poor governance	Governance	Not having strong governance IT structure leads to EA immaturity
		Not having a useful governance framework for IT leads to EA program failure
		No governance leads to poor reputation of EA

Figure 47 shows the third set of codes and their relevant issues. In Table 39, we identify 5 other main categories of the EA adoption challenges and their relevant codes.

The challenge that was frequently mentioned by the interviewees is the rigidity of university policy. It is a challenge because EA may conflict with university policy, and the approval for a new policy by the relevant senate committee may be needed to align new projects, including EA, with this policy, which may take a long time to update or approve.

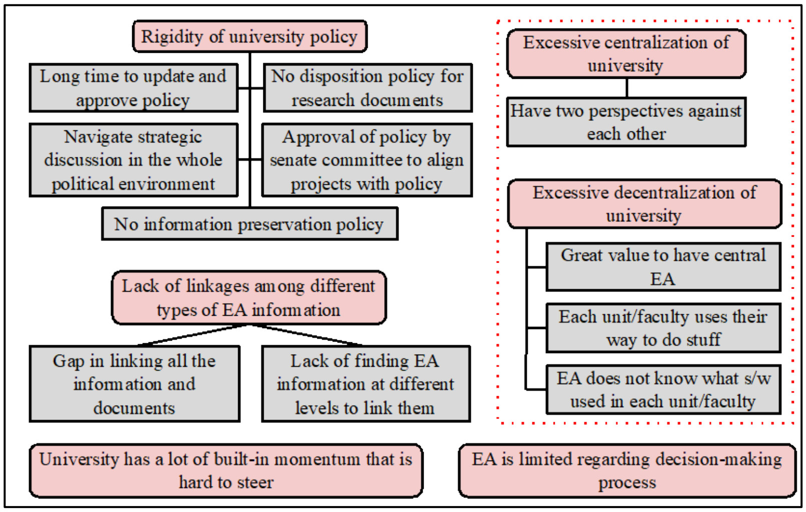

Figure 47 The EA adoption challenges in HE institutions (GT results) (Part 3)

Table 39 The EA adoption challenges in HE institutions from GT results (Part 3)

Main Category	Category	Concepts
The rigidity of university policy	Rigidity of university policy	Long time to update and approve a policy
		No disposition policy for research documents
		Navigate strategic discussion in the whole political environment
		Approval of policy by the senate committee to align projects with policy
		No information preservation policy
		EA Conflicts with university policy
Excessive centralized and decentralized structure	Excessive centralization of university	Have two perspectives against each other.
	Excessive decentralization of university	Great value to have central EA.
		Each unit/faculty uses their way of doing things.
		EA does not know what software is used in each unit/faculty.
Lack of linkages among different types of EA information	Lack of linkages among different types of EA information	Gap in linking all the information and documents
		Lack of finding EA information at different levels to link them
A large collection of disparate systems and business applications	University has much built-in momentum that is hard to steer	
EA is limited regarding the decision-making process	EA is limited regarding the decision-making process	

8.1.2 Survey Results

We used a shortlist of the grounded theory results (see Table 40) to build a survey question to determine what issues pose the greatest challenges to the adoption of EA in the HE institutions. In Question 42, we asked our participants to rate 25 EA adoption challenges (see Table 41) on a scale: ‘Not important’ rated 0, ‘A minor problem’ rated 1, ‘A moderate problem’ rated 2, ‘A major problem’ rated 3, and ‘A critical problem’ rated 4.

Table 40 EA adoption challenges added to a survey question (Q42)

Main Category	Survey Question
Lack of resources	• Not enough time to work on EA • Not enough budget for EA
More demand for EA than what EA team can support	• More demand for EA than what the EA team can support
Misunderstanding and misconception of EA	• Bad reputation of EA among stakeholders • Misunderstanding of EA language & terminology
Lack of awareness and readiness	• Lack of awareness of EA among university leadership and other stakeholders
Lack of skill sets	• Lack of leadership skills • Lack of communication skills • Lack of collaboration with other university units and stakeholders • Lack of openness (not inviting a broad spectrum of stakeholders to engage) • Poor inter-personal relationships with stakeholders
Lack of support from management and stakeholders	• Lack of organization buy-in • Different perspectives and opinions from stakeholders on what they need and what they want to achieve • Lack of trust in EA by stakeholders
Unclear leadership	• Frequent changes to management structure • Changes to EA leadership resulting in changes of direction
Resistance to change	• Resistance to change (fixed mindsets and habits) • Resistance to improvement
Lack of perceived value and benefits	• Difficulty in realizing, showing and delivering EA value • Difficulty in realizing cost-saving or other benefits of EA • Stakeholders only caring about tangible benefits of EA but not EA itself
Lack of business-IT alignment	• Focus too much on business aspects and not enough on IT • Focus too much on IT and not enough on business aspects • Barriers between EA and other business units
The challenge of building EA team	• Changes to EA team members resulting in loss of corporate knowledge or experience • Difficulty in hiring people for EA jobs • Insufficient background among EA team members to do required work • EA is not sufficiently helping the IT team to keep up with change
Knowledge gap and lack of experience	• Lack of higher education experience by EA leadership or the CIO
EA immaturity	• EA immaturity
Misalignment between EA and university goals	• Not meeting the university's goals
The rigidity of university policy	• Rigidity of university policies
Excessive centralized and decentralized structure	• Excessive decentralization of the university • Excessive centralization of the university
Lack of linkages among different types of EA information	• Lack of linkages among different types of EA information

We received 66 responses to this question. Table 41, Figure 48 and Figure 49 show the results regarding the EA adoption challenges that face HE institutions. The gray shaded rows in Table 41 show the most and the least critical EA adoption problems. It is clear that most institutions faced a variety of challenges to implement EA. As Table 41 shows, most of the challenges are considered major problems (close to 3.0), but the vast majority of respondents by 54.6% selected 'Resistance to change' as a critical problem (i.e., close to

4.0). In contrast, 'Excessive centralization of the university' is at the bottom of the ranking (rated as a moderate problem with an average close to 2.0), with 59.1% considering it not a problem at all. This is statistically significantly less than other EA adoption challenges in the list.

In Table 41 we have also tagged the various challenges with the keywords we originally associated with the definitions and motivations for EA in HE. It is notable that Stakeholder Collaboration is a major motivation, but it was not identified among some of the main challenges. Lack of change management and value delivery are also key to EA in general, but also pose key challenges. Some of the challenges have no tags: Lack of demand for EA and lack of time, budget or staff are challenges to EA that need independently addressing. Notably absent among the tagging in the table are automation and agility: These issues were not prominent challenges to EA adoption among the EAs who completed the survey.

Table 41 Basic statistics regarding the EA adoption challenges in HE institutions; n=66 (Q42)

Challenges of the EA adoption at HE institutions	Mean	St. Dev.	95% Confidence Interval of mean		Tags
Resistance to change (fixed mindsets and habits)	2.56	0.96	2.32	2.80	[Change-Management], **[Stakeholder-Collaboration]**
Lack of awareness of EA among university leadership and other stakeholders	2.35	1.12	2.07	2.62	**[Stakeholder-Collaboration]**
Different perspectives and opinions from stakeholders on what they need and what they want to achieve	2.30	1.19	2.01	2.60	**[Stakeholder-Collaboration]** **[Roadmap]**
Difficulty in realizing cost-saving or other benefits of EA	2.20	1.12	1.92	2.48	[Value-Delivery] [Cost-Reduction]
EA immaturity	2.17	1.11	1.89	2.44	
Difficulty in realizing, showing and delivering EA value	2.17	1.09	1.90	2.43	[Value-Delivery]
More demand for EA than what the EA team can support	2.17	1.10	1.90	2.44	
Not enough time to work on EA	2.14	1.05	1.88	2.39	
Focus too much on IT and not enough on business aspects	2.12	1.24	1.81	2.43	**[Roadmap]** [Alignment]
Difficulty in hiring people for EA jobs	2.06	1.07	1.80	2.33	
Not enough budget for EA	1.98	1.25	1.68	2.29	
Lack of organization buy-in	1.98	1.27	1.67	2.30	**[Stakeholder-Collaboration]** [Management]
Resistance to improvement	1.97	1.25	1.66	2.28	
Barriers between EA and other business units	1.94	1.12	1.66	2.22	**[Stakeholder-Collaboration]** [Management]
Lack of collaboration with other university units and stakeholders	1.91	1.22	1.61	2.21	**[Stakeholder-Collaboration]** **[Institution-Wide]**
Excessive decentralization of the university	1.86	1.38	1.52	2.20	**[Institution-Wide]**
Misunderstanding of EA language & terminology	1.80	1.03	1.55	2.06	

Challenges of the EA adoption at HE institutions	Mean	St. Dev.	95% Confidence Interval of mean		Tags
EA is not sufficiently helping the IT team to keep up with change	1.73	1.09	1.46	1.99	[Change-Management] **[Stakeholder-Collaboration]**
Lack of trust in EA by stakeholders	1.72	1.24	1.41	2.03	
Stakeholders only caring about tangible benefits of EA but not EA itself	1.71	1.26	1.40	2.02	**[Stakeholder-Collaboration]** [Value-Delivery]
Lack of leadership skills	1.69	1.22	1.39	2.00	
Lack of linkages among different types of EA information	1.67	1.11	1.39	1.94	**[Strategic-Information-Base]** **[Recognizing-Interdependence]**
Lack of communication skills	1.55	1.13	1.27	1.82	
Not meeting the university's goals	1.53	1.17	1.24	1.82	[Value-Delivery] **[Institution-Wide]** [Alignment]
Frequent changes to management structure	1.52	1.28	1.21	1.84	[Change-Management]
Insufficient background among EA team members to do required work	1.50	1.13	1.22	1.78	
Lack of openness (not inviting a broad spectrum of stakeholders to engage)	1.45	1.16	1.16	1.73	**[Stakeholder-Collaboration]**
Poor inter-personal relationships with stakeholders	1.41	1.24	1.10	1.71	**[Stakeholder-Collaboration]**
Rigidity of university policies	1.38	1.16	1.10	1.67	
Changes to EA team members resulting in loss of corporate knowledge or experience	1.29	1.26	0.89	1.60	[Change-Management] **[Continuity and Sustainability]**
Bad reputation of EA among stakeholders	1.24	1.25	0.93	1.55	**[Stakeholder-Collaboration]**
Changes to EA leadership resulting in changes of direction	1.15	1.23	0.85	1.45	[Change-Management] [Management]
Focus too much on business aspects and not enough on IT	0.91	1.08	0.64	1.17	**[Roadmap]** [Alignment]
Lack of higher education experience by EA leadership or the CIO	0.85	1.13	0.57	1.13	
Excessive centralization of the university	0.64	0.92	0.41	0.86	**[Institution-Wide]**

The responses to Question 42 from the top six countries were somewhat close. Most of the respondents rated 'Resistance to change' as either a moderate, major, or critical problem, with at least 66.7% doing so in in Saudi Arabia. Only 16.7% of Saudi participants said that it is not a problem at all.

Nobody believed that 'A lack of communication skills' is a critical problem.

More than 40% of respondents from the six countries said that 'Focusing more on business aspects and not enough on IT' is not a problem at all.

100% of respondents in New Zealand stated that 'The lack of a higher education experience by the EA leadership or CIOs' is not a problem. Respondents from other countries with at

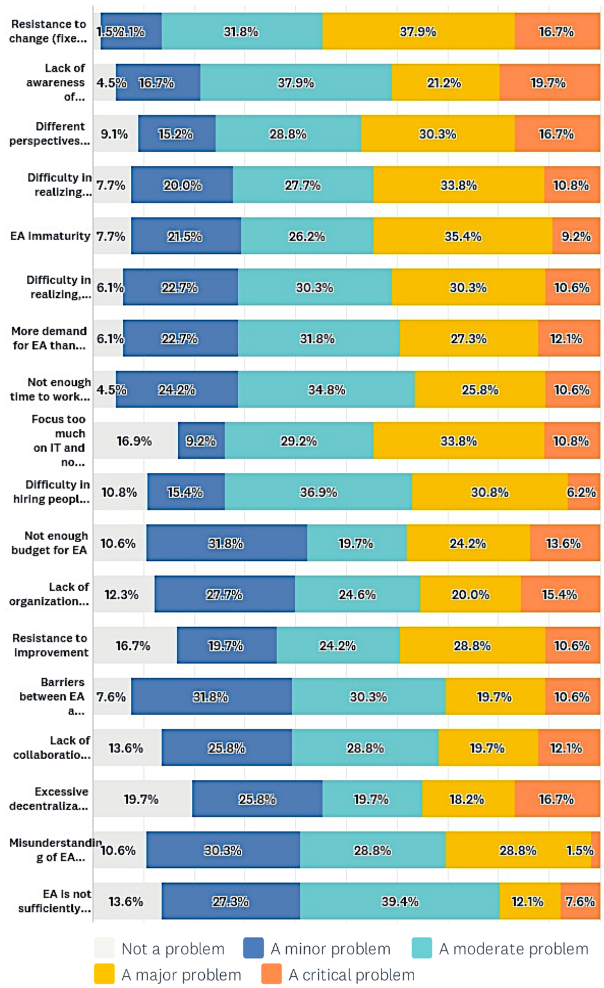

Figure 48 EA adoption challenges in HE institutions (Q42) (Part 1)

least 44% believed that it is not a problem too. Only 33.3% of Saudis stated that it is a critical problem.

At least 60.0% of the respondents from the six countries considered ‘Excessive centralization of the university’ not a problem at all, except for Saudi participants where 50% said it is a major problem and 33.3% of said it is not a problem at all.

Four participants wrote additional comments on this question and the responses were closely related to the same set of items that we asked participants to scale. In Table 42, we present the participants’ responses and the corresponding categories from the survey question.

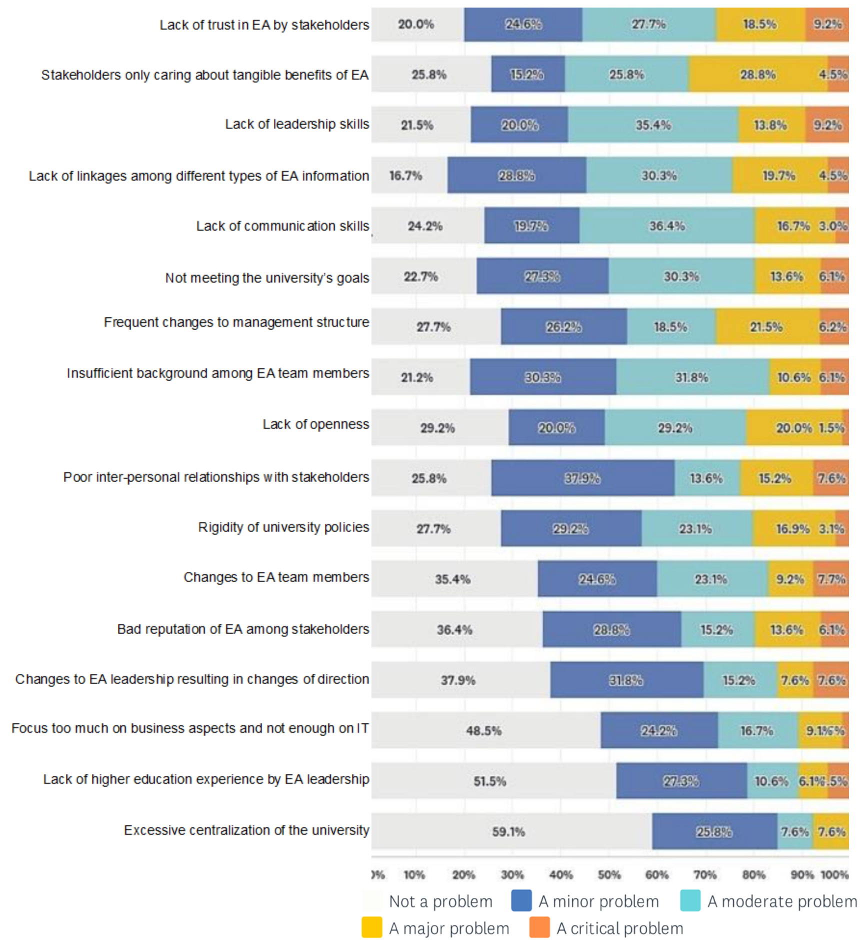

Figure 49 EA adoption challenges in HE institutions (Q42) (Part 2)

Table 42 Additional comments to Q42

Participants' Comment	Corresponding Survey Question
"Inability of institution to commit to a specific strategy and vision across different units and layers of the organisation"	• Not meeting the university's goals. • Lack of organization buy-in.
"There is a major change initiative that is doing EA without realising it; if we could collaborate more effectively both the change initiative and the EA team would benefit"	• Lack of collaboration with other university units and stakeholders.
"Senior executive reliance on the view of those from outside the institution - often with no HE experiences - in preference to those within"	• Insufficient background among EA team members to do required work. • Lack of higher education experience by EA leadership or the CIO.
"Shortage of professional managers in IT and the institution - lack of strategy, planning, and portfolio management perspectives"	• Insufficient background among EA team members to do required work. • Lack of higher education experience by EA leadership or the CIO. • More demand for EA than what the EA team can support.

8.1.3 Discussion Regarding Q42

In Figure 50, we compare the results obtained from the interviews regarding the challenges of adopting EA in HE institutions (Table 40) and the results of the systematic literature review (Table 2). There are some similarities and variations between the lists we created. We have added lines to indicate the relationships between similar categories, and we highlight distinct categories in gray.

An example of a similarity is that the ‘Lack of resources’ challenge corresponds to both ‘Resources’ and ‘Cost of adopting the EA work’ in the list from the literature review. Another example is that the difficulty in building an EA team corresponds to ‘Dedicated roles for EA teams’ and ‘Operational personnel development’ in the literature review list.

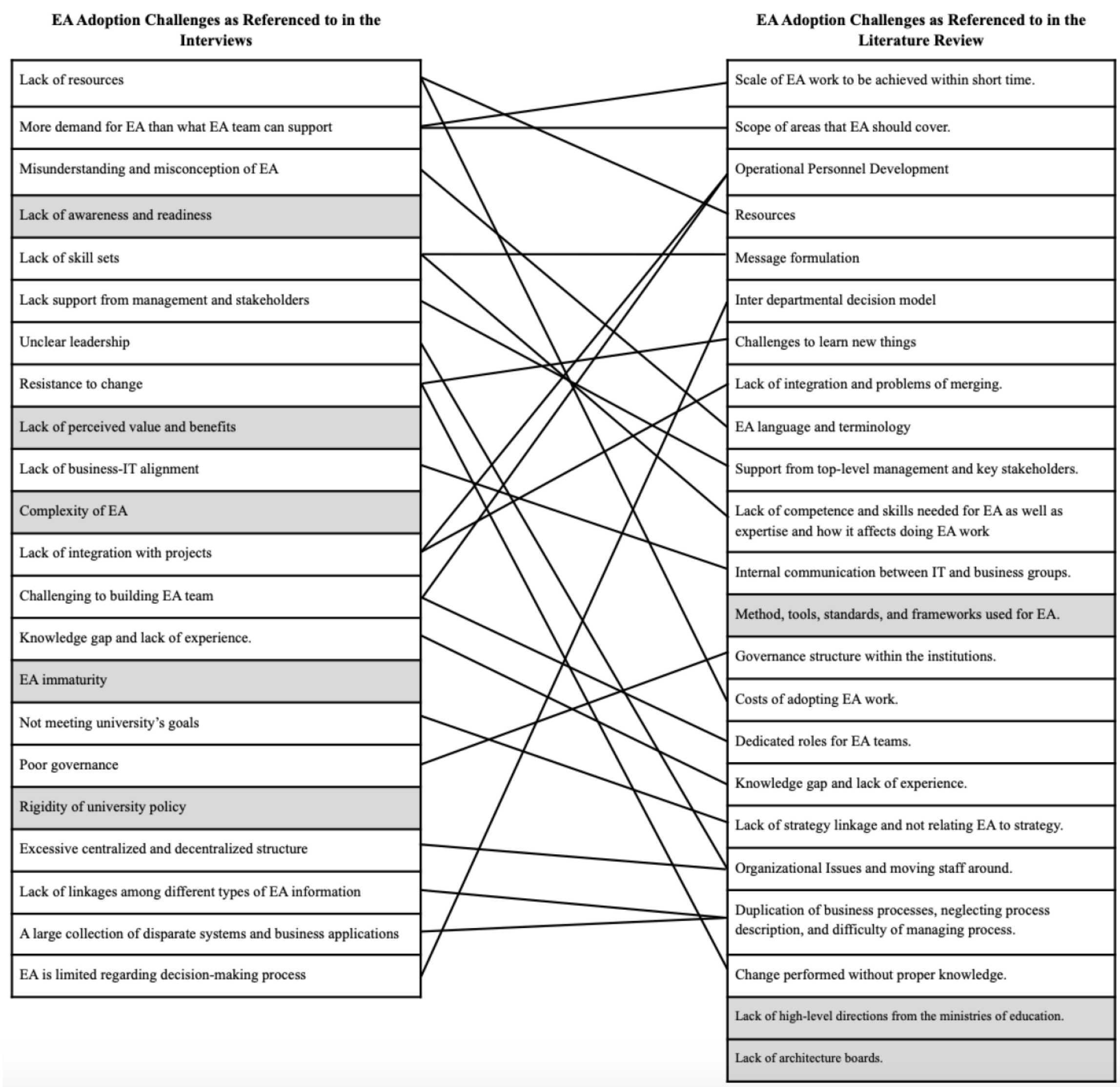

Figure 50 A comparison of results on the EA adoption challenges extracted from the interviews and the SLR

The operational personnel development challenge is identified by Syynimaa (2015a) as the inability to participate in the EA work due to the limited time or unwillingness to participate in developing EA.

Yet another example of a similarities between the results is that the demand for EA is more than what the EA team can offer and achieve. The corresponding item in the list of the literature review is that the scope of areas that EA should cover is higher than what the EA team can carry out and that the time for the scale of EA work to be achieved is short and limited.

As for the differences, we noticed that some challenges that participants talked about during the interviews were not mentioned in the literature review and vice versa. The EA adoption challenges we extracted from the interviews, but which are not addressed much in the literature, are:

- A lack of awareness and readiness.
- A lack of perceived value and benefits.
- The complexity of EA.
- The immaturity of EA.
- The rigidity of university policy.

The EA adoption challenges we defined that were only prominent in the literature review are:

- Method, tools, standards, and frameworks used for EA.
- A lack of high-level directions from the ministries of education.
- A lack of architecture boards.

However, it is interesting that the interviewees did not explicitly mention some of the challenges referred to in the literature review, but they implicitly mentioned them during their responses to other questions in the interviews.

For instance, the 'Method, tools, standards, and frameworks used for EA' challenge was mentioned by some of the interviewees during their talk about the challenges they faced while using tools and frameworks. Concerning the difficulties of using tools, some interviewees stated that they do not have sufficient resources to use specialized EA tools, or they are early on the adoption of EA tools. Some said that they never had the maturity of using the tools. Others told us that they spend more time maintaining tools rather than using them to produce valuable work to add value.

Regarding the problems of using frameworks, some participants told us that they use specific frameworks because their senior management suggested them or because they work with an external company that has developed a specific framework. Others said that they follow a specific framework because, with limited resources, this framework is better to understand the solution and reduce risk. One of the participants told us that they do not follow a specific framework because they tried to use the frameworks previously and noticed that these frameworks are too big for what they need compared to their limited resources, so they decided to work on roadmaps more than anything else at this stage.

Another example of the challenges mentioned in the literature review is ‘A lack of high-level directions from the ministries of education.’ Some interviewees told us that they were mandated by their government to adopt EA in their institutions. They also used a specific framework proposed by their Higher Education ministry accordingly.

The final example is the ‘Lack of architecture boards’ challenge. Some of our participants talked about the importance of having such boards where some decisions should pass by. However, they said that the architecture boards could have some challenges, for instance, the lack of openness with other members of the community.

We then used the survey to find out which of the 25 selected issues posed the greatest challenge to them and which of them were considered secondary challenges for them. The answers were varied, but it is clear that ‘Resistance to change’ was the most critical challenge among other EA adoption issues while ‘Excessive centralization of the university’ was the least challenging for institutions that adopted EA.

On the other hand, the survey results showed that the misunderstanding of EA language and terminology, the lack of organization buy-in, and the lack of required skills are not the major challenges according to our participants. However, they were among the most frequently mentioned challenges in the literature: EA language and terminology (Oderinde, 2011; Syynimaa, 2015a; Olsen & Trelsgård, 2016), support from top-level management and key stakeholders (Oderinde, 2011; Seppänen, 2014; Olsen & Trelsgård, 2016), and lack of competence and skills needed for EA (Oderinde, 2011; Seppänen, 2014; Olsen & Trelsgård, 2016).

8.2 Critical Success Factors for EA Adoption in the HE Sector

8.2.1 Grounded Theory Results

In this section, we first provide a summary of the current literature that highlights the key factors that influence the adoption of EA in the HE institutions. Then we present and discuss the results of the grounded theory and survey regarding this topic.

In Chapter 3, we reviewed the literature that revealed the various factors that influence the successful adoption of EA in the HE institutions. Realizing critical success factors helps to understand the status of institutions (Seppänen, 2014), avoiding challenges that hinder the successful adoption of EA and ultimately helping to achieve organizational and strategic goals and targeted benefits.

A few studies followed a qualitative approach to identify these factors in developed countries such as the UK and Finland. However, no studies in this area have been conducted in developing countries except for one study conducted in the Philippines. In the HE context, Oderinde (2011, 2012) identified a set of critical factors that influence the adoption of EA in the UK HE institutions. A list of these factors is shown in Table 3. Furthermore, Syynimaa (2015) classified the success factors of EA adoption in the Finnish HE sector into three distinct categories: organizational factors, EA related factors, and environmental factors. The list of these factors is presented in Table 3. We adopt this clarification in our study to make it easy to understand the type of these factors and which aspect they impact. Cruz (2020) defined the factors that influence EA adoption in HE institutions in the Philippines. She interviewed some individuals associated with EA projects in a Philippine university to understand how they think of EA. The results of the study revealed seven motivational factors for the EA adoption in the Philippine universities, as shown in Table 3.

On the other hand, in the public sector context, Seppänen (2014) proposed a 3D model of CSFs to adopt EA successfully in the Finnish public sector organizations. The three dynamic classes of these CSFs are Determination, Destination, and Dexterity. This proposed model of CSFs is general, which means it can be applied to any public organization, including HE institutions (Seppänen, 2014). The list of key factors provided by Seppänen (2014) is shown in Table 3.

Although these critical factors have a significant positive influence on the adoption of EA in the HE institutions, the literature in this field still lacks more studies. Therefore, we added the following question to our interview to explore this area further with our 21 participants from 6 different countries:

In your opinion, what are the critical success factors for EA?

Figure 51 shows the main categories of the factors affecting EA adoption in the HE sector extracted from the analysis and coding of the interview transcripts. The existing literature review inspired us to define four main categories of these factors: organizational factors, EA related factors, environmental factors, and technological factors. Technological factors refer to the technology and services operated by the universities.

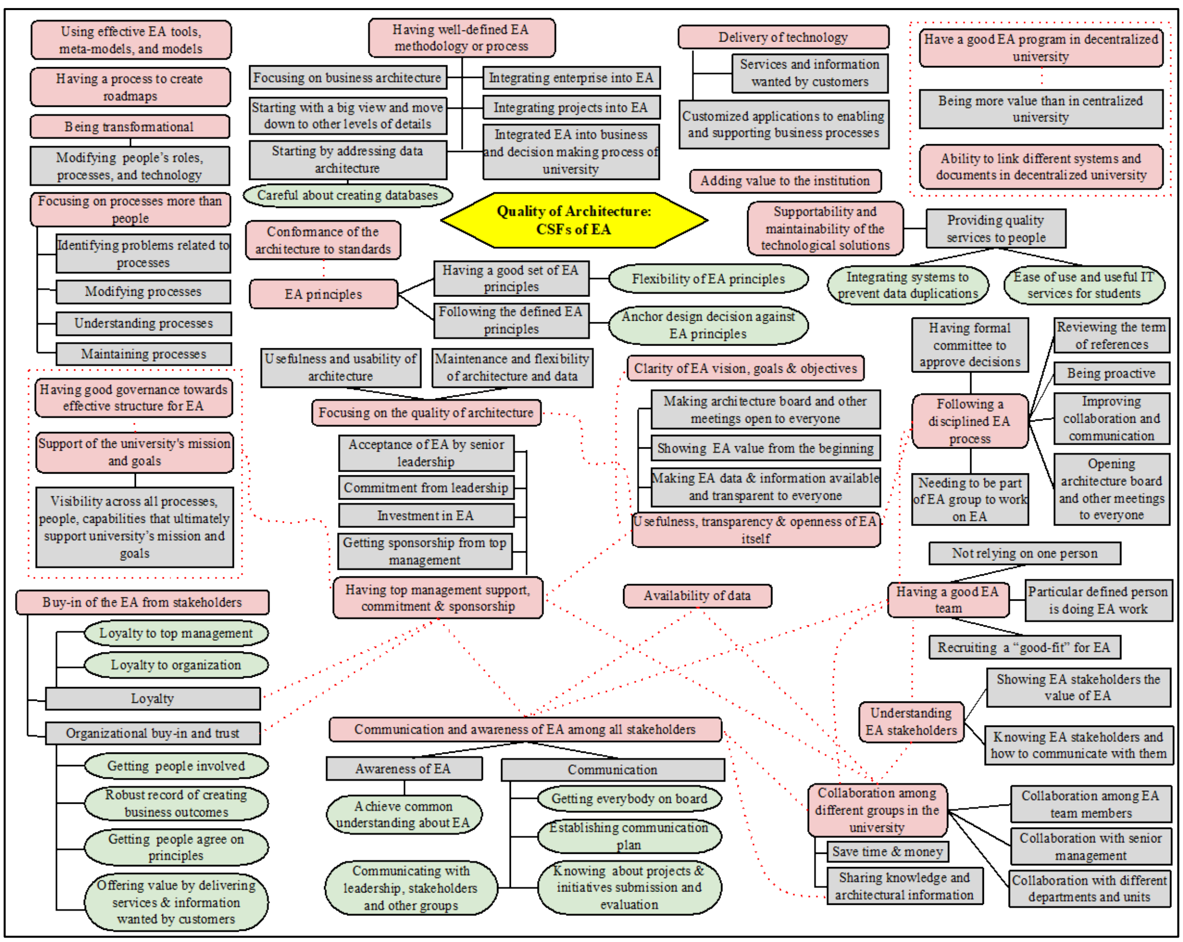

Figure 51 CSFs of the EA adoption in HE institutions extracted from GT results

Each main category has a set of categories and relevant concepts. For instance, one of the factors that may lay the ground for the successful adoption of EA in HE institutions is having top management support, commitment and sponsorship. This could be achieved by obtaining the acceptance and commitment from top management and stakeholders to adopt EA. Also, the main stakeholders and key decision-makers should be willing to invest in EA. Another example that may increase the successful implementation of EA is having and following a good set of defined EA principles.

The defined categories have a relationship with each other, as shown in Figure 51. For example, showing the benefit and value of EA to management and stakeholders in the university and increasing transparency and openness among them requires more collaboration and communication to increase EA awareness among them. This helps to obtain organizational buy-in and the trust of management and stakeholders and thereby obtaining their support, commitment and sponsorship. Another example is that the availability of data and clarity of EA vision and goals may increase the awareness of EA among different parties in the university. Moreover, having a good EA team who understand the EA key stakeholders and top management and have good communication and collaboration skills may contribute to adding more discipline to the EA program.

Table 43 illustrates the four main categories of the CSFs and their 25 relevant categories and concepts. First, the organizational factors category has 12 factors that describe the influence of the different aspects of the organization on the adoption of EA, such as getting top management support. In addition, the EA related factors category includes 9 factors that are related to the discipline and profession of EA, such as using the EA tools and models, having well-defined EA methodology or processes, or having well-defined EA principles. Moreover, the technological factors category consists of 3 factors that describe the impact of the university's technology and services on the EA adoption, such as the delivery of services and information required by customers. Finally, the environmental factors category has only one factor, which is having good governance towards effective EA structure.

Table 43 Critical success factors of the EA adoption in HE institutions extracted from GT results

Main Category	Category	Concept
Organizational Factors	Having top management support, commitment and sponsorship	Acceptance of EA by senior leadership
		Commitment from leadership
		Investment in EA
		Getting sponsorship from top management
	Usefulness, transparency and openness of EA itself	Making architecture board and other meetings open to everyone
		Showing EA value from the beginning
		Making EA data & information available and transparent to everyone
	Understanding EA stakeholders	Showing EA value to stakeholders
		Knowing EA stakeholders and how to communicate with them
	Collaboration among different groups in the university	Collaboration among EA team members
		Collaboration with senior management
		Collaboration with different departments and units
		Save time & money
		Sharing knowledge and architectural information
	Communication and awareness of EA among all stakeholders	Communication
		Awareness of EA
	Buy-in of the EA from stakeholders	Loyalty
		Organizational buy-in and trust
	Support of the university's mission and goals	Visibility across all processes, people, capabilities that ultimately support university's mission and goals [into high-levels or in deep levels]
	Clarity of EA vision, goals and objectives	
	Being transformational	Modifying people's roles, processes, and technology
	Adding value to the institution	
	Availability of data	
	Conformance of the architecture to standards	
EA Related Factors	Following a disciplined EA process	Having a formal committee to approve decisions
		Reviewing the term of references
		Being proactive
		Improving collaboration and communication
		Opening architecture board and other meetings to everyone
		Needing to be part of the EA group to work on EA
	Having a good EA team	Not relying on one person
		A particular defined person is doing EA work
		Recruiting a "good-fit" for EA
	EA principles	Having a good set of EA principles
		Following the defined EA principles
	Focusing on the quality of architecture	Usefulness and usability of architecture
		Maintenance and flexibility of architecture and data
	Focusing on processes more than people	Identifying problems related to processes
		Modifying processes
		Understanding processes
		Maintaining processes
	Having well-defined EA methodology or process	Integrating enterprise into EA
		Integrating projects into EA
		Integrating EA into business and decision-making process of university
		Focusing on business architecture
		Starting with a big view and move down to other levels of details

Main Category	Category	Concept
		Starting by addressing data architecture
	Having a good EA program in decentralized university	Being more valuable than in centralized university
	Using effective EA tools, meta-models, and models	
	Having a process to create roadmaps	
Technological Factors	Delivery of technology	Delivering services and information wanted by customers
		Customizing applications to enabling and supporting business processes
	Supportability and maintainability of the technological solutions	Providing quality services to people
	Linking different systems and documents in a decentralized university	
Environmental Factors	Having good governance towards effective EA structure	

8.2.2 Survey Results

We created a survey question from the grounded theory results (see Table 44) to find out how important the key factors for the successful adoption of EA in the HE institutions.

Table 44 Critical success factors of the EA adoption added to a survey question (Q40)

Main Category	Category	Survey's Question
Organizational factors	Having top management support, commitment and sponsorship	• Having top management support, commitment & sponsorship
	Understanding EA stakeholders	• Understanding EA stakeholders
	Buy-in of the EA from stakeholders	• Buy-in of the EA from stakeholders
	Collaboration among different groups in the university	• Collaboration among EA team members
		• Collaboration with senior management
		• Collaboration with different departments and units
	Usefulness, transparency and openness of EA itself	• Usefulness, transparency & openness of EA itself
	Availability of data	• Availability of data
	Clarity of EA vision, goals and objectives	• Clarity of EA vision, goals, and objectives
	Support of the university's mission and goals	• Support of the university's mission and goals
	Communication and awareness of EA among all stakeholders	• Communication and awareness of EA among all stakeholders
	Conformance of the architecture to standards	• Conformance of the architecture to standards
	Adding value to the institution	• Adding value to the institution
EA related factors	Having a good EA team	• Having a good EA Team
	EA principles	• Having a good set of EA principles
		• Following the defined EA principles
	Following a disciplined process	• Following a disciplined EA process
Technological factors	Supportability and maintainability of the technological solutions	• Supportability and maintainability of the technological solutions

We did not add all the factors to this survey question because the response time is limited as the survey included other questions, so we decided to add the most frequently cited factors from the grounded theory findings that affect the EA adoption in the HE sector.

In Question 40, we asked our participants to rate 18 critical success factors on a scale: 'Irrelevant' rated 0, 'Somewhat unimportant' rated 1, 'Moderately important' rated 2, 'Very important' rated 3, and 'Critical' rated 4.

We received 66 responses to this question. The results are presented in Table 45 and Figure 52 (we abbreviated row labels to reduce clutter). In Table 45, the gray shaded rows show the most interesting results.

Table 45 Basic statistics regarding CSFs in HE institutions; n=66 (Q40)

Critical success factors in EA process	**Mean**	**St. Dev.**	**95% Confidence Interval of mean**		**Tags**
Support of the university's mission and goals	3.50	0.61	3.35	3.65	[Alignment] **[Stakeholder-Collaboration] [Institution-Wide]**
Having top management support, commitment & sponsorship	3.38	0.80	3.18	3.58	**[Stakeholder-Collaboration] [Leadership]**
Adding value to the institution	3.33	0.79	3.14	3.53	[Value-Delivery] **[Institution-Wide] [Effectiveness]**
Collaboration with senior management	3.20	0.90	2.98	3.42	**[Stakeholder-Collaboration] [Leadership]**
Clarity of EA vision, goals, and objectives	3.20	0.83	2.99	3.40	**[Roadmap]**
Collaboration with different departments and units	3.09	0.94	2.86	3.32	**[Stakeholder-Collaboration] [Institution-Wide]**
Understanding EA stakeholders	3.06	0.78	2.87	3.25	**[Stakeholder-Collaboration]**
Buy-in of the EA from stakeholders	3.06	0.97	2.82	3.30	**[Stakeholder-Collaboration]**
Collaboration among EA team members	3.03	0.94	2.80	3.26	**[Stakeholder-Collaboration]**
Having a good EA Team	3.02	1.00	2.77	3.26	
Usefulness, transparency & openness of EA itself	3.02	0.75	2.83	3.20	**[Roadmap]**
Communication and awareness of EA among all stakeholders	3.02	0.95	2.78	3.25	**[Stakeholder-Collaboration]**
Availability of data	2.82	0.99	2.57	3.06	**[Automation] [Strategic-Information-Base]**
Having a good set of EA principles	2.80	0.90	2.58	3.02	**[Formalizing]**
Following the defined EA principles	2.56	0.84	2.35	2.77	**[Formalizing]**
Supportability and maintainability of the technological solutions	2.56	1.04	2.31	2.82	[Technology-Infrastructure]
Conformance of the architecture to standards	2.30	0.91	2.08	2.53	**[Formalizing]**
Following a disciplined EA process	2.15	0.92	1.93	2.38	[Process] **[Formalizing]**

We have applied the same tags to Table 45 that we have applied earlier in this thesis, relating to the definitions and motivations for conducting an EA program. The Stakeholder Collaboration tag is dominant in the table, indicating that doing this effectively is essentially a meta-success-factor. Most of the other tags also appear in Table 45, but the 'Change Management' and 'Adapting and Agility' tags are notably absent: It does not appear that in the initial thinking of our survey respondents that these factors are top-of-mind when thinking about success. That might be because they really are not success factors, or because they are not considered as such, but perhaps should be.

As Table 45 shows, most of the factors are very important on average (close to 3.0), but 'Support of the university's mission and goals' stood out as it is regarded, on average, as a critical factor (i.e., close to 4.0) by 56.1% of the respondents said it is a critical factor and 37.9% believed it is very important. Next in importance is 'Having top management support, commitment & sponsorship', which 53.0% of participants said it is a critical factor and 34.8% said that it is very important factor.

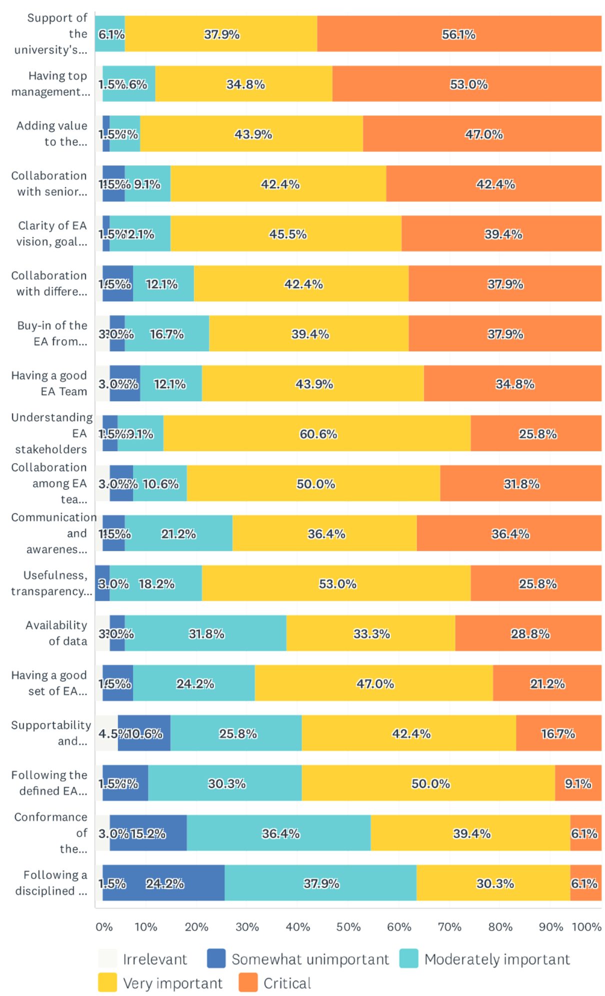

Figure 52 Critical success factors of the EA adoption in HE institutions (Q40)

‘Supportability and maintainability of the technological solutions’ and ‘Having a good EA team’ have high standard deviations (1.04 and 1.00 respectively) compared to other factors which indicate that the values are spread out over a wider range.

On the other hand, ‘Conformance of the architecture to standards’ and ‘Following a disciplined EA process’ are at the bottom of the ranking. They are regarded as moderately important factors on average (close to 2.0). Only 6.1% of participants considering both factors critical and 34.9% and 30.3% respectively said they are very important. Only 3.0% and 5.0% believed that these factors are irrelevant.

Regarding the results from the top six countries, the highest percentage of participants from these countries said that ‘Support of the university’s mission and goals’ is very important or higher. Saudi Arabia stood out with 83.3% of those who thought it is critical, and 16.7% said it is very important.

The second most crucial factor is ‘Adding value to the institution’ as the highest percentage of respondents from New Zealand (80.0%) and Australia (75.0%) considered it critical.

In third place was ‘Having top management support, commitment & sponsorship,’ with 100% of respondents from Saudi Arabia, New Zealand, and the USA saying it is very important or higher. 66.7% of Saudi participants, 40.0% of New Zealand participants, and 33.3% of the American participants said it is critical. 33.3% of Saudi participants, 60.0% of New Zealand participants, and 66.7% of the American participants said it is very important.

The factor that was the least important among the top six countries is ‘Following a disciplined EA process.’ Australia and New Zealand got the highest percentage of participants who thought it is somewhat unimportant, while 11.1% of respondents from the USA saying it is critical very important.

8.2.3 Discussion Regarding Q40

The result from the systematic literature review highlights 40 factors that impact the successful adoption of EA in the HE institutions, as shown in Table 3. The results of the grounded theory contributed to the identification of 25 additional influencing factors to the results of the literature review, as shown in Table 46.

In the systematic literature review, the two factors that were mentioned by all authors are 'Clear scope and goal set of EA work' and 'Experience and skills of EA staff' (Table 3) (Seppänen, 2014; Syynimaa, 2015; Oderinde, 2011, 2012 & Cruz, 2020). These two factors were very similar to the factors extracted from the results of the grounded theory (Table 46), as participants emphasized the importance of having a clear vision, goals, and objectives for EA in order to successfully adopt it in their institutions as well as having a good EA team. Those two factors are rated, on average, as very important by the respondents in the survey.

Another key point is that our interviewees mentioned a group of factors that were not discussed in the literature review. One of these factors, is having collaboration among different parties in the university, which indirectly falls under the factor of having an experienced and skilled EA team. Encouraging collaboration among groups addresses some of the time and money waste and duplication as one of our interviewees said. Also, this skill is important to bring different parties, specifically IT and business, together. Also, among the factors that were stated by our interviewees is the focus on the processes more than on people for adopting EA and this may also lead to focus more on the quality of architecture and following a disciplined EA process. The support of the university's goals and mission is also one of the factors that constitute a solid foundation for the successful adoption of EA. This includes having a background about how the university works, what objectives to accomplish, and what responsibilities needed to be fulfilled as one of our interviewees said:

> *"…The more rooted in the mission of the university they can be, the more rooted in the ongoing of the university like a deep understanding of the responsibilities involved…, the more successful they can be..."*

Other participants also emphasized the importance of making data available to all parties of the university. Making data available to all groups enhances the communication and cooperation between the various groups in the university. Additionally, technology-related factors are important when it comes to implementing EA in the HE institutions. An example of these factors is the rapid delivery of technology solutions at lower costs and greater effectiveness. The supportability and maintainability of the various technological solutions are important as well. Moreover, one interviewee specifically discussed the importance of having a good EA program in the decentralized universities, as well as the importance of having a good linkage between the systems and documents in the decentralized environment. Finally, to find out how successful the EA implementation has been in HE institutions, one of the interviewees said it depends on the value that EA adds to the institutions, whether it is tangible or intangible.

It should be noted that the survey results showed that the clarity of EA vision, goals, and objectives, and having a good EA team are not the most critical success factors for EA adoption according to our participants. However, they were among the most frequently mentioned factors in the literature: clear scope and goal set of EA work (Oderinde, 2011, 2012; Seppänen, 2014; Syynimaa, 2015; Cruz, 2020), and experience and skills of EA staff (Oderinde, 2011, 2012; Seppänen, 2014; Syynimaa, 2015; Cruz, 2020).

Table 46 A Comparison of results on CSFs referred to in the grounded theory and the SLR

Type	#	CSFs Referred to in Literature Review	CSFs Referred to in Grounded Theory
Organizational Factors	1	Appropriate organizational structures	
	2	Change management capability	
	3	Need for change in organizational culture	
	4	Organization's capability to adopt changes	
	5	IT portfolio management	
	6	Strategy driven change	
	7	Structured decision-making process	
	8	Conformance in change	Conformance of the architecture to standards
	9	EA frameworks' lack of focus on social perspective	
	10	EA adoption brings cultural clash to surface	
	11	Social perspective is important	
	12	EA is more about people than technology	
	13	Acceptance resistance to change	
	14	Importance of leadership	
	15	Top management support	Having top management support, commitment & sponsorship
	16	Organizational position of EA function	
	17	Communication (motivational skills, negotiation skills, and other soft skills)	Communication and awareness of EA among all stakeholders
	18	Clear scope and goal set of EA work	Clarity of EA vision, goals and objectives
	19	Viewpoint and qualities affecting the decision-making capabilities	Usefulness, transparency and openness of EA itself
	20	Key stakeholder buy-in and commitment	Buy-in of the EA from stakeholders
	21	Knowing the relevant stakeholders	Understanding EA stakeholders
	22	Evaluation metrics	
	23	Applying critical thinking and different problem-solving techniques.	
	24	Revolutionary innovation and activities meeting the needs of the future	Being transformational Having a process to create roadmaps
EA Related Factors	25	Selection of the EA framework	Having well-defined EA methodology or process

Type	#	CSFs Referred to in Literature Review	CSFs Referred to in Grounded Theory
	26	Vague definition of EA	Usefulness, transparency and openness of EA itself
	27	Use of principles	EA principles
	28	Experience and skills of EA staff (technical skills such as EA-related knowledge)	Having a good EA team
	29	Right people availability	Having a good EA team
	30	Techniques consisting of proposed structures to achieve the future state.	Using effective EA tools, meta-models, and models
Environmental Factors	31	Initiator and organization's internal drivers for EA adoption	
	32	Interoperability issues of related EAs	
	33	Steering power of external parties	
	34	Formalized governance structure	Having good governance towards effective EA structure
	35	Resources	
	36	A systematic and continuous approach to business process review	
	37	Simple and flexible IT infrastructure to enable requirements for integration, accessibility, and agility.	Being transformational
	38	Positive peer pressure and encouraging experiences of other organizations.	
	39	Combining the EA adoption with other organizational development projects or enterprise IT development activities.	
	40	Competence	
Extra CSFs referred to in the grounded theory	1		Collaboration among different groups in the university
	2		Support of the university's mission and goals
	3		Adding value to the institution
	4		Availability of data
	5		Following a disciplined EA process
	6		Focusing on the quality of architecture
	7		Focusing on processes more than people
	8		Having a good EA program in decentralized university
	9		Delivery of technology
	10		Supportability and maintainability of the technological solutions
	11		Linking different systems and documents in a decentralized university

8.3 Critical Success Factors of Individual EA Team Members

8.3.1 Grounded Theory Results

During the interviews, we found that some of our interviewees were differentiating between factors that influence the successful adoption of EA and factors to be considered when recruiting or promoting EA team members to help adopt EA successfully. Thus, we asked our participants the following a separate question regarding this:

What are the critical success factors for individual members of EA team?

We analyzed and coded the responses to identify the main categories of these factors and relevant concepts, as shown in Figure 53.

The factors most frequently mentioned by our interviewees were the skills and competencies that EA team members should possess. For example, they should have the ability to communicate, listen, collaborate and resolve conflicts. Another example of this type of skill is the ability to integrate well with other team members and people in the university and also understand their personalities, whether they are IT or business. It is also important to have a deep knowledge of higher education in general and to have a good background on the university the team works for. For this reason, some universities prefer to hire internal enterprise architects because they are more familiar with the university environment and more able to communicate and collaborate with different parties in the university.

The second most common factor was that the EA team members should have a high level of education and training in EA. They should have some background and understanding of EA-related stuff such as the different frameworks, models, tools and so on.

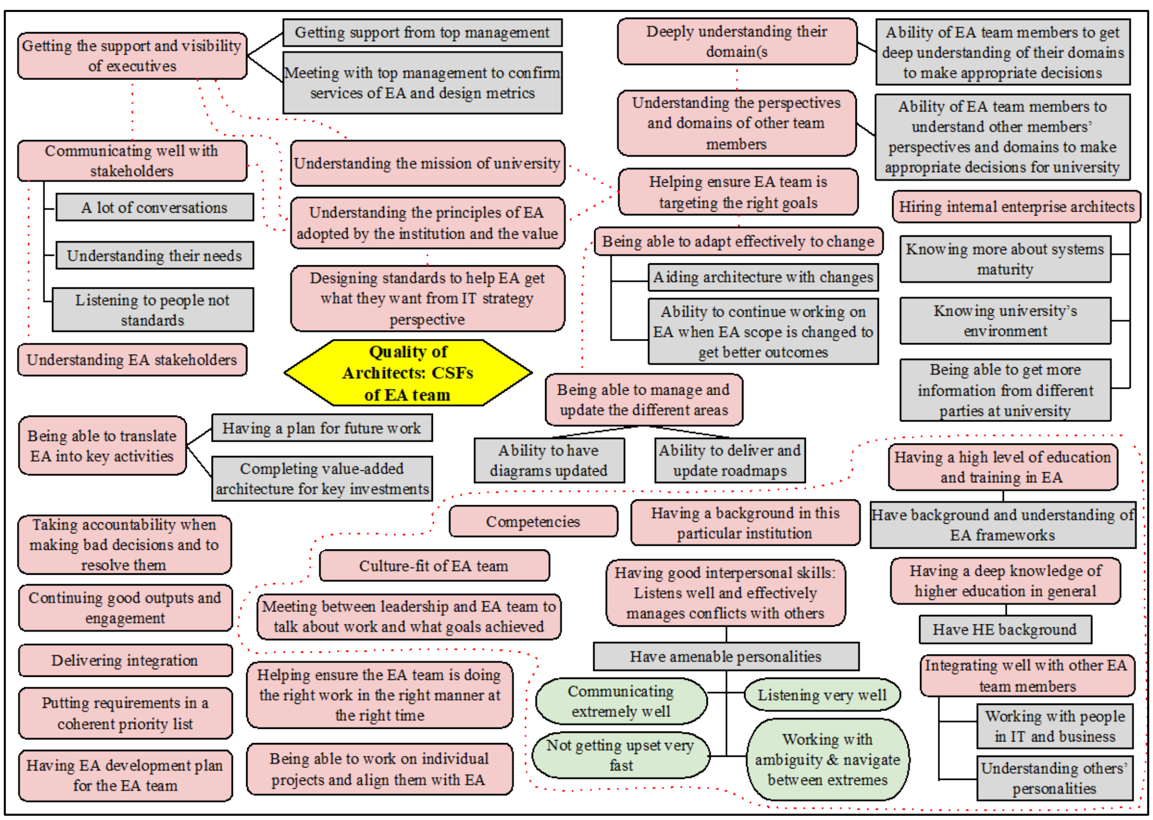

Figure 53 CSFs for individual members of EA team extracted from GT results

The other factor that was mentioned by our interviewees was that the EA team members should get the support and understanding of their senior managers and stakeholders. This includes having a regular meeting with them and understanding their needs. In that case, the team members should also understand the university's goals and mission as well as the EA principles and the value it adds to the university. This type of communication and understanding helps to make sure the team is working towards the right goal.

Another important factor to be considered when hiring the EA team members was the ability to adapt effectively to changes such as changing the EA scope or architecture to obtain better outcomes. Also, they should be able to manage and update different areas such as diagrams, roadmaps or documents.

One of the interviewees also highlighted an important factor which is the ability of a team member to deeply understand his/her scope and domain to make better decisions, and also to understand the perspectives and domains of other team members.

There are other examples of some important factors that were mentioned less often such as the ability of the team members to work on individual projects and align them with EA as well as the ability to translate EA into key activities and have a plan for future work. Another example is having an EA development plan for the EA team.

In Table 47, we defined a list of main categories of the key factors and relevant categories.

Table 47 Critical success factors of the EA team members extracted from GT results

Main Category	Category
Communicating well with stakeholders	A lot of conversations
	Understanding their needs
	Listening to people not standards
Understanding EA stakeholders	
Understanding the mission of the university	
Understanding the principles of EA adopted by the institution and the value	
Helping ensure EA team is targeting the right goals	
Deeply understanding their domain(s)	Ability of EA team members to get deep understanding of their domains to make appropriate decisions
Understanding the perspectives and domains of other team members	Ability of EA team members to understand other members' perspectives and domains to make appropriate decisions for university
Being able to adapt effectively to change	Ability to continue working on EA when EA scope is changed to get better outcomes
	Aid architecture with changes
Helping ensure the EA team is doing the right work in the right manner at the right time	
Having good interpersonal skills: Listens well and effectively manages conflicts with others	Have amenable personalities
	Listening very well

	Communicating extremely well
	Working with ambiguity & navigate between extremes
	Not getting upset very fast
Having a high level of education and training in EA	Have background and understanding of EA frameworks
Having a deep knowledge of higher education in general	Have HE background
Having a background in this particular institution	
Integrating well with other EA team members	Working with people in IT and business
	Understanding the personalities involved
Culture-fit of EA team	
Competency	
Getting the support and visibility of executives	Getting support from top management
	Meeting with top management to confirm services of EA and design metrics
Designing standards to help EA get what they want from IT strategy perspective	
Meeting between leadership and EA team to talk about work and what goals achieved	
Taking accountability when making bad decisions and resolve them	
Hiring internal enterprise architects	Knowing more about systems maturity
	Knowing university's environment
	Being able to get more information from different parties at university
Being able to translate EA into key activities	Having a plan for future work
	Completing value-added architecture for key investments
Putting requirements in a coherent priority list	
Continuing good outputs and engagement	
Delivering integration	
Being able to work on individual projects and align them with EA	
Having EA development plan for the EA team	
Being able to manage and update the different areas	Ability to have diagrams updated
	Ability to deliver and update roadmaps

8.3.2 Survey Results

In Question 41, we asked our participants to rate 14 critical success factors for individual EA team members on a scale: 'Irrelevant' rated 0, 'Somewhat unimportant' rated 1, 'Moderately important' rated 2, 'Very important' rated 3, and 'Critical' rated 4. The factors might be assessed when hiring or promoting such team members and might also be of use to enable team members to undertake self-improvement. We included only the most common key factors from the grounded theory results (see Table 48) due to time limitations.

Table 48 Critical success factors of the EA team members added to a survey question (Q41)

Grounded Theory Main Category	Grounded Theory Category	Survey Question
Having good interpersonal skills: Listens well and effectively manages conflicts with others	Have amenable personalities	Has good interpersonal skills: Listens well and effectively manages conflicts with others
	Listening very well	
	Communicating extremely well	
	Working with ambiguity & navigate between extremes	

Grounded Theory Main Category	Grounded Theory Category	Survey Question
	Not getting upset very fast	
Having a high level of education and training in EA	Have background and understanding of EA frameworks	Has a high level of education and training in EA
Having a deep knowledge of higher education in general	Have HE background	Has deep knowledge of higher education in general
Having a background in this particular institution		Has a background in this particular institution
Understanding the mission of the university		Understands the mission of the university
Understanding EA stakeholders		Understands EA stakeholders
Understanding the principles of EA adopted by the institution and the value		Understands the principles of EA adopted by the institution
Communicating well with stakeholders	A lot of conversations Understanding their needs Listening to people not standards	Communicates well with stakeholders
Integrating well with other EA team members	Working with people in IT and business Understanding the personalities involved	Integrates well with other EA team members
Helping ensure the EA team is doing the right work in the right manner at the right time		Helps ensure the EA team is doing the right work in the right manner at the right time
Helping ensure EA team is targeting the right goals		Helps ensure the EA team is targeting the right goals
Deeply understanding their domain(s)	Ability of EA team members to get deep understanding of their domains to make appropriate decisions	Deeply understands their domain(s)
Understanding the perspectives and domains of other team members	Ability of EA team members to understand other members' perspectives and domains to make appropriate decisions for university	Understands the perspectives and domains of other team members
Being able to adapt effectively to change	Ability to continue working on EA when EA scope is changed to get better outcomes Aid architecture with changes	Is able to adapt effectively to change

We received 66 answers to this question, and the result is presented in Table 49 and graphically in Figure 54. The gray shaded rows in Table 49 show the most interesting results.

Table 49 Basic statistics regarding critical success factors of the EA team members; n=66 (Q41)

Critical success factors for EA team members	Mean	St. Dev.	95% Confidence Interval of mean		Tags
Has good interpersonal skills: Listens well and effectively manages conflicts with others	3.50	0.66	3.34	3.66	**[Stakeholder-Collaboration]**
Communicates well with stakeholders	3.44	0.68	3.27	3.61	**[Stakeholder-Collaboration]**
Is able to adapt effectively to change	3.38	0.70	3.21	3.55	[Change-Management]
Understands the mission of the university	3.12	0.73	2.94	3.30	**[Institution-Wide]**
Understands EA stakeholders	3.09	0.74	2.91	3.27	**[Stakeholder-Collaboration]**
Integrates well with other EA team members	2.97	0.70	2.80	3.14	

Critical success factors for EA team members	Mean	St. Dev.	95% Confidence Interval of mean		Tags
Helps ensure the EA team is targeting the right goals	2.89	0.64	2.74	3.05	[Value-Delivery]
Understands the principles of EA adopted by the institution	2.86	0.74	2.68	3.05	
Deeply understands their domain(s)	2.85	0.86	2.64	3.06	
Understands the perspectives and domains of other team members	2.80	0.66	2.64	2.97	
Helps ensure the EA team is doing the right work in the right manner at the right time	2.77	0.86	2.56	2.98	
Has a deep knowledge of higher education in general	2.08	0.95	1.84	2.31	
Has a high level of education and training in EA	1.86	0.94	1.63	2.10	
Has a background in this particular institution	1.61	0.93	1.38	1.83	[Institution-Wide]

Table 49 shows that most of the factors are regarded as very important factors on average (close to 3.0). However, the two factors that had the highest percentage of participants who said that these factors are very important or critical are ‘Has good interpersonal skills: Listens well and effectively manages conflicts with others’ (57.6% said it is critical and 36.4% said it is very important) and ‘Communicates well with stakeholders’ (53.0% said it is critical and 39.4% said it is very important).

On the other hand, the three factors that located at the bottom of the ranking and considered as moderately important factors on average (close to 2.0) are: ‘Has a deep knowledge of higher education in general,’ ‘Has a high level of education and training in EA,’ and ‘Has a background in this particular institution,’ respectively. These factors also obtained the lowest percentage of participants who thought there are very important or higher.

As with in previous tables, we have applied the tags to Table 49 that we originally developed from the definitions and motivations of EA. Stakeholder Collaboration is once again critical. Notably absent is the ability of team members to be agile.

The responses of the participants from the top six countries were varied. The participants from Saudi Arabia considered all factors important in varying degrees, except the ‘Has a high level of education and training in EA’ factor, where only 16.7% believed it is somewhat unimportant.

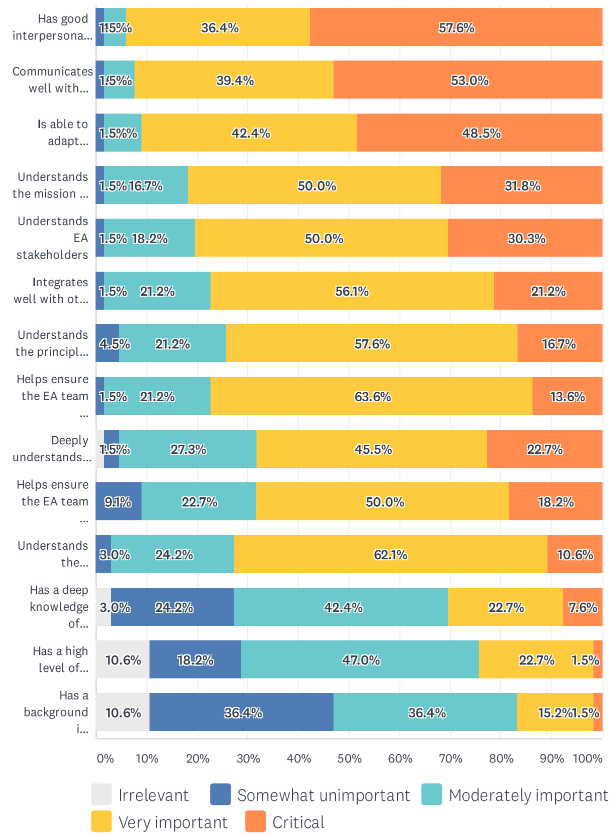

Figure 54 Critical success factors of the EA team members (Q41)

'Has good interpersonal skills: Listen well and effectively manage conflicts with others' has the highest percentage of participants from the six countries who thought it was very important or higher. Australia stood out, with 87.5% of its participants thought it is critical, and 12.5% thought it was very important.

Moreover, 'Is able to adapt effectively to change' came second, as most of the participants from the six countries said it is very important or higher. Canada had the highest percentage as 66.7% thought it was critical, and 33.3% said it was very important.

Five participants provided additional comments on this question. One of the participants explained that the factors would be very different between hiring and promoting, and therefore the answers would differ accordingly, where he said that *"You can hire people with potential, but you want to promote people who have developed."*

On the other hand, most of the other comments were similar to what was on the list that we asked participants to scale. For example, one participant mentioned, *"Humbleness, kindness, empathy, lack of arrogance, integrity. Very high EQ. Broad technical knowledge* *with deep skills in one or two areas is a given. A developer background is a distinct advantage,"* which corresponds to the following factors from the survey question:

- Having good interpersonal skills: Listens well and effectively manages conflicts with others.
- Having in-depth knowledge of higher education in general.
- Having a background in this particular institution.
- Having a high level of education and training in EA.
- Communicating well with stakeholders.
- Integrating well with other EA team members.

Another example is what another participant said that *"I have a degree of improved success in consultation because I DON'T know much about HE and have to ask!"* He indicated that having internal EAs is more efficient as they are more familiar with the university's internal environment. The similar factors in the survey question are:

- Having in-depth knowledge of higher education in general.
- Having a background in this particular institution.
- Understanding the mission of the university.

Finally, one participant commented that *"Able to stay committed to goals that take years to make progress on; able to partner with senior managers; able to work in an ambiguous, changing environment."* In the survey question, we had categories describing this quote, namely:

- Understanding the mission of the university.
- Understanding EA stakeholders.
- Being able to adapt effectively to change.

One of the participants provided a comment that added a new factor to what we mentioned earlier; that is, people who are candidates or responsible for implementing EA must have *"an architectural mindset."* In other words, these responsible people must have a background or training in this field.

8.3.3 Discussion Regarding Q41

The critical success factors for individual EA team members need to be correctly addressed and applied to have a successful implementation of EA in HE institutions. The current systematic literature review lacks any studies that examine these factors in the HE sector. Our study contributes to defining a list of the critical factors that need to be assessed when hiring or promoting team members to work on EA in the HE institutions. We extracted a set of these factors from the interviews that we conducted with 21 persons responsible for implementing EA in their universities. Then we evaluated them more broadly through the survey, which was filled out by a significant number of participants from different universities around the world. These factors consist of specific elements that need to be mainly assessed to get the best possible results from the EA implementation.

The most prominent factor covered during the interviews, and also the factor that received the highest percentage of participants who believed that it was crucial is that team members should have good interpersonal skills; that is, they should have amenable personalities. They should be able to effectively manage conflicts among other parties in the universities. The factor that came in the second place is the ability to communicate well with stakeholders, including senior management, and listen to them as well as understand their needs. The factor that was mentioned less during the interviews and got the lowest response rate in the survey is the need for team members to have a background on their institutions.

8.4 Results of Participants Planning to Adopt the EA Program

We received a few responses to these questions from participants who have not yet adopted EA in their institutions but are planning to establish an EA program at the most appropriate time. The number of responses was small, but it gives us a different view on what are the most critical factors leading to a successful EA implementation and what are the most problematic challenges that may hinder the EA implementation.

In Question 16, we asked, “in your opinion, to what extent is each of the following considered to be success factors in the EA process?” We received 11 answers to this question. The result is shown in Figure 55.

The result is similar to the results obtained in Section 8.2.2, where the most important factor, according to the opinions of the participants, was ‘Support of the university’s

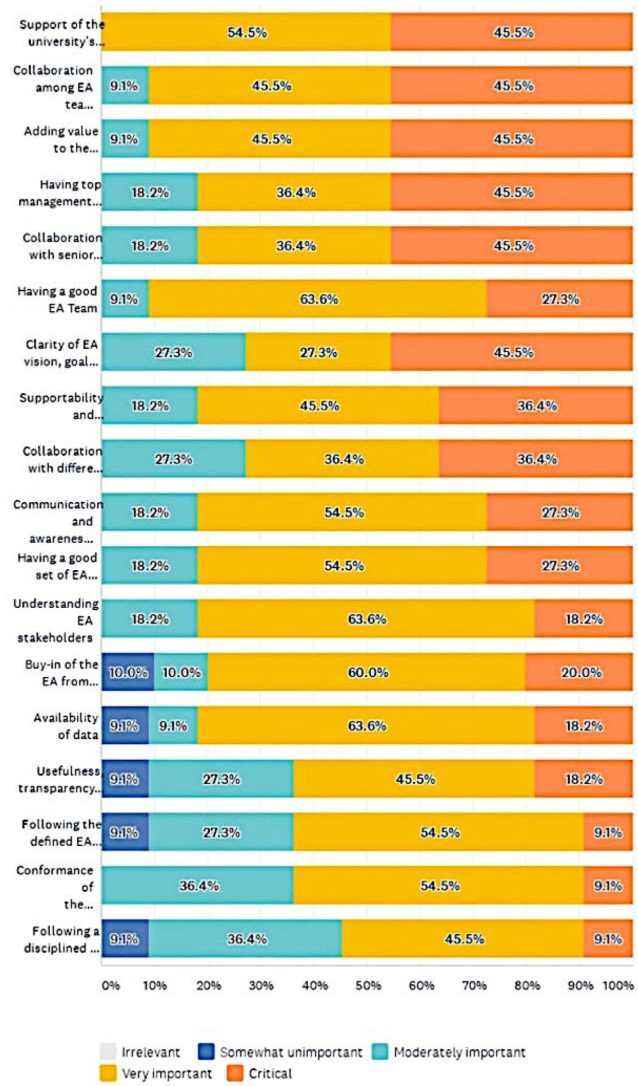

Figure 55 Critical success factors of the EA process in HE institutions (Q16)

mission and goal,' while the least important factor was 'Following a disciplined EA process.' The participants did not rate any factor to be irrelevant. In other words, the participants believed that all factors matter but to varying degrees.

In Question 17, we asked, "in your opinion, to what extent is each of the following considered to be success factors for individual EA team members?" We received 11 answers to this question, and the result is presented in Figure 56.

The result shows that participants believe that all factors are somewhat important as no factor was rated to be irrelevant. Contrary to the result of the same question that we got in Section 8.3.2, the most important factor was 'Communicates well with stakeholders,' and then 'Understands the mission of the university' came second. As for the least important

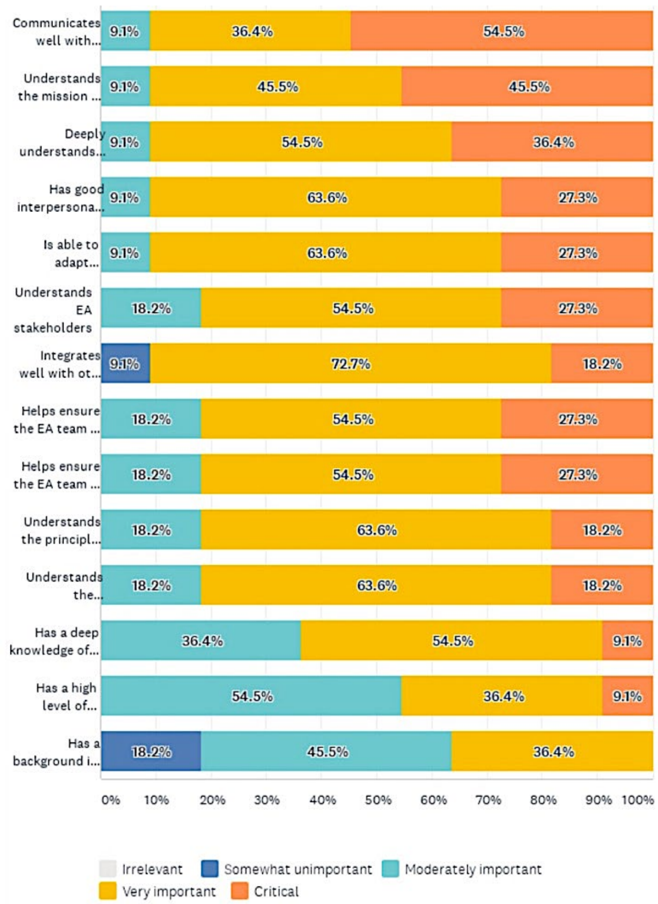

Figure 56 Critical success factors for individual EA team members (Q17)

factors, 'Has a background in this particular institution' came in the first place, and that was consistent with the result obtained in Section 8.3.2.

In Question 18, we asked "in your opinion, to what extent does each of the following pose a challenge to EA?" We received 12 answers to this question. The result is presented in Figure 57 and Figure 58.

The participants chose the 'Lack of awareness of EA among university leadership and other stakeholders' to be the first most important factor among other factors, while 'Resistance to change (fixed mindsets and habits)' became the third most important factor. That is contrary to the result we obtained in Section 8.1.2. The explanation for this result could be that for people who have already adopted EA, one of the most critical problems they may face is the resistance to change, and one of the reasons for this is the lack of EA awareness. Though for people who have not adopted EA yet, the lack of knowing EA and the lack of

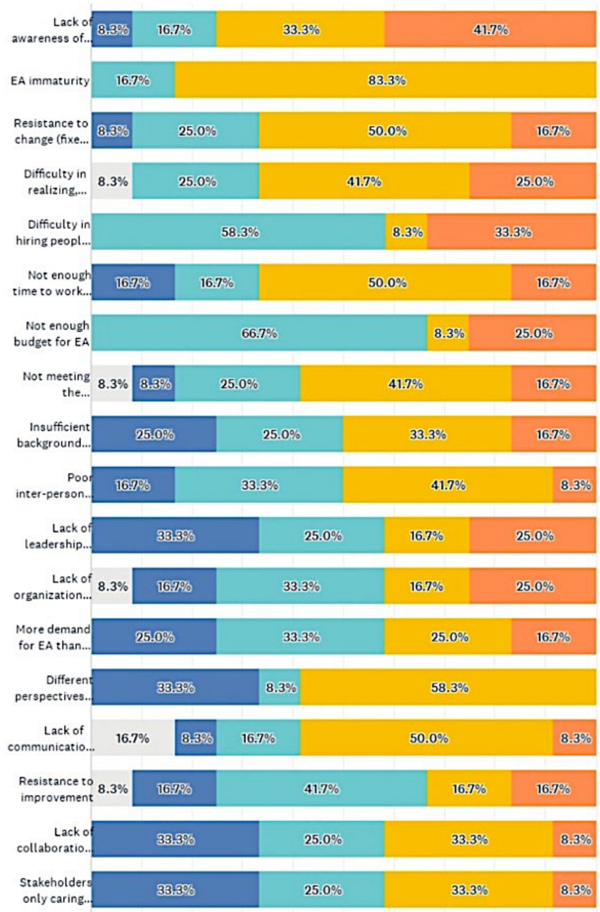

Figure 57 EA adoption challenge in HE institutions (Q18) (Part 1)

awareness of it between the different parties at the university is the most serious problem they face, and it may lead to resisting it when it is implemented.

The participants also considered that 'Excessive centralization of the university' is the least important factor, which corresponds to the results obtained in Section 8.1.2.

8.5 Impacts of the EA Adoption on the Different Aspects of HE Institutions

In Chapter 3, we reviewed three studies that discussed the benefits of adopting EA on public organizations, including HE organizations. We then presented the set of EA adoption's benefits in Table 4. We here outline the benefits of EA to the HE institutions mentioned in two or more studies. For example, Oderinde (2011, 2012) and Syynimaa (2015a) said that EA helps senior management make better-informed decisions. Also, EA enables different groups at the university to speak a common language (Oderinde, 2011, 2012; Syynimaa, 2015a), which means that it improves communication and cooperation

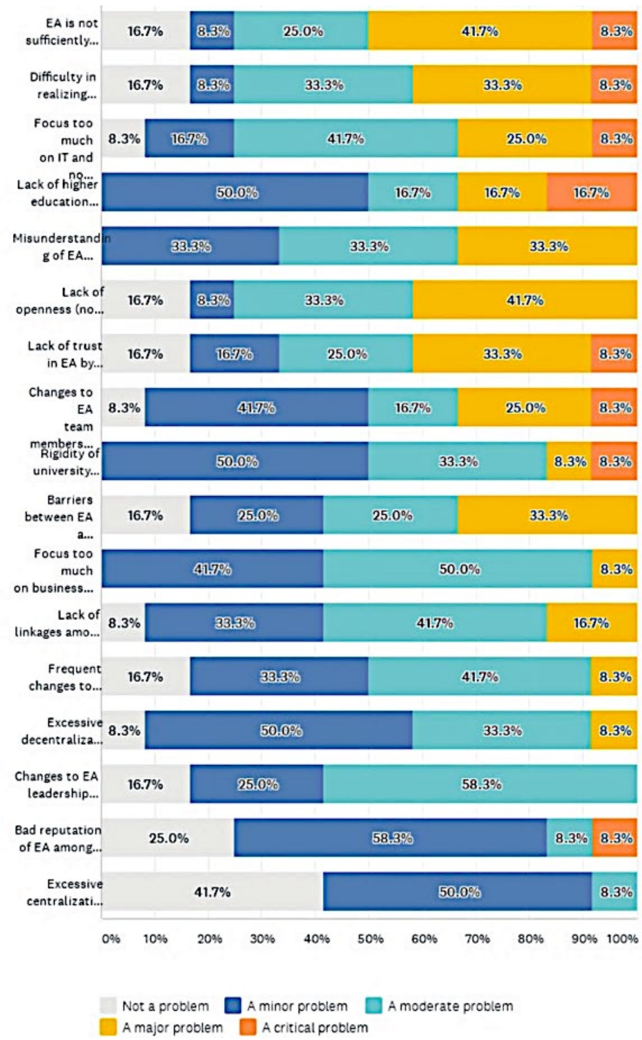

Figure 58 EA adoption challenges in HE institutions (Q18) (Part 2)

between those groups. It also improves the business-IT alignment and interoperability (Seppänen, 2014; Syynimaa, 2015a). Another benefit of EA adoption is making the university agile and adaptive (Oderinde, 2011, 2012; Seppänen, 2014; Syynimaa, 2015a). It is important for any institution to be agile in dynamic environments and to adapt to changes to help maintain sustainability. Another example of EA benefit is that EA helps improve the university processes (Oderinde, 2011, 2012; Seppänen, 2014; Syynimaa, 2015a) by providing a set of methodologies, tools, and models for identifying, analyzing and improving existing business processes in order to meet best quality standards and needs. Additionally, Oderinde (2011, 2012) and Syynimaa (2015a) stated that EA helps reduce the complexity of system and architecture management, which reduces the risks of managing the systems of architecture.

In our study, we sought to understand the linkage between EA and the various aspects of HE institutions and the impacts of EA on these aspects. Therefore, we asked our interviewees a set of questions to first understand the nature of the link between EA and the different aspects of universities. Then we asked them about the impact it has had on these aspects if any. We present the results of the interviews in the next section. Then we added a question to the survey to know the extent of the EA impact on these aspects, whether negative or positive. We provide the result of this question in Section 8.5.2.

8.5.1 Grounded Theory Results

8.5.1.1 The Linkage between EA and Different Aspects of HE Institutions

8.5.1.1.1 The Linkage between EA and IT

To understand the link between EA and different aspects of HE institutions, we first asked our interviewees the following question:

What has been the link between EA and IT?

We analyzed and coded the answers to this question to the following main themes.

No link between EA and IT: a few interviewees said that their EA team did not report to the CIO.

EA is part of IT: some interviewees said that their IT department was responsible for adopting EA at their institution. Some said that their EA team was part of the CIO office or directly reported to the CIO. Others said that the roles of the EA team were created under the direction of the IT department.

EA is performed or supports the central IT unit at university: some interviewees indicated that their EA team had a limited view of what happened within faculties because of the current architecture from the central IT.

EA is performed or supported within a decentralized IT unit: one interviewee mentioned that his EA team had regular meetings with the main groups that run their own IT within the various university departments and set up some of their infrastructures.

The EA function focuses on IT: some interviewees said that EA supported strategic IT planning, ensured that IT services complement the business requirements, identified reusable components and services and facilitated the basis for IT investment optimization.

8.5.1.1.2 The Linkage between EA and Software Purchasing

We also asked our interviewees the following question:

> *What has been the link between EA and the development and purchasing of software?*

The main themes extracted from the answers to this question are:

No link between EA and software purchasing: a few interviewees said they did not have enough resources. Others said that they did not have a future state IT architecture to measure things need to purchase tools, and their experience of considering outsourcing development was not successful.

EA influences decisions regarding software purchases and whether or not to enforce some enterprise-wide standards: some interviewees indicated that their EA adapted as a new procurement decision was made. Others said that their EA helped define what applications to purchase within technical reference models and application and capability models.

EA principles need to be followed when purchasing software: some interviewees talked about following the 'use before buy' and 'buy before build' principles.

Architecture boards are central to EA when purchasing software: one interviewee said that the ARB worked in collaboration with faculties when deciding to purchase software. Others said that their architecture or governing boards mandated reducing expenses when undertaking procurement and purchases by faculties.

EA works closely with the university's IT procurement group: some interviewees mentioned that the EA team and IT unit prepared architecture and security questions to ask any potential vendors, and they reviewed the alignment of purchasing software before providing the approval to a requester to ensure that all new procurements were aligned with EA and IT strategy.

EA provides consultation and support for the procurement unit outside IT: one interviewee said that when there was a need to purchase a product, IT and EA offered proposals and support to the procurement unit for the best purchases that fit the university's needs.

EA suggests procuring off-the-shelf software that does not need any development: one participant indicated that their EA often proposed purchasing off-the-shelf software that only needs some configuration without any development.

EA uses functional requirements and non-functional requirements list when purchasing software: one of our participants said that their software procurement process relied on a good functional requirements list, as many tools in the market meet the university's requirements. Another participant said that EA uses a list of non-functional requirements that may be mandatory or optional when deciding to purchase software from vendors.

EA impacts selecting the solutions for purchase: some interviewees mentioned that their EA targeted the HE's solutions, the bilingual solutions, or the solutions that addressed specific business capability.

8.5.1.1.3 The Linkage between EA and Software Development

We also asked our interviewees the following question:

What has been the link between EA and software development?

The answers from our interviewees to this question were analyzed to the following main themes.

No link between EA and software development: one interviewee said they did not have enough resources for developing software. The other interviewee said that their architecture board was strict with faculties when asked for developing software.

EA inside the IT department is responsible for the software development: an interviewee mentioned that the EA team was responsible for developing the core systems and the associated systems.

EA develops software to comply with standards and principles: some interviewees indicated that their EA team followed the 'use before build or develop' principles when it came to developing software.

EA is involved in developing software because of centrality: one interviewee mentioned that their EA team was involved when faculties developed their software.

EA grows a reliable software development team: one participant emphasized the importance of having a strong development team to develop software that matches the university's needs according to the available resources. One participant also mentioned that EA encouraged in-house software development to build a software product using its resources.

EA defines the review process and artifacts to provide the correct level of detail to the development team: one interviewee indicated that their EA team supported the development team by providing them with necessary details for developing the required software.

8.5.1.1.4 The Linkage between EA and Software Architecture and Modelling

We asked our interviewees the following question.

What has been the link between EA and software architecture and modelling?

We analyzed and coded the answers, and we developed the following main themes.

One interviewee indicated that there is no link between EA and software architecture and modelling process.

Another interviewee said that their EA team was EA designing more artifacts as outputs for discussions at regular meetings.

Another participant mentioned that their EA team communicated with other university groups and requested feedback on artifacts and models.

8.5.1.2 Impacts of EA on the HE Institutions' Different Aspects

We asked our interviewees a couple of questions during the interviews about the impact of EA on various aspects of their institutions, and the answers were varied.

8.5.1.2.1 EA Impact on the IT-Business Alignment

We asked our interviewees the following question:

How did the implementation of the EA affect the alignment of strategic objectives and needs with IT strategies?

The main themes from analyzing the answers are as follows.

<u>No impact of EA on the IT-business alignment</u>: one interviewee said that their university was already very embedded in the business, and there was already a strong alignment in business terms and technology services.

<u>EA has an impact on the IT-business alignment to a limited extent</u>: some interviewees indicated that their EA influenced IT purchases and directions strategies. Another interviewee said they used roadmaps and current state assessments to guide the strategy and align strategic university objectives and EA.

EA has a positive impact on the IT-business alignment: Another interviewee said they used the development of EA took into consideration the alignment of strategic business goals with IT strategy. The university's faculties and IT were responsible for converting students' success factors, student satisfaction, and student experience into the IT vision. Another interviewee mentioned that EA helped develop an integrated strategic plan from the university's objectives, vision and strategic plan to align its needs and objectives with IT. Another participant said that EA was a central work to strategically align IT architecture and EA and help the university to be an architecture-driven organization. Another interviewee mentioned that their EA provided a strategy component that captured the essence of strategic alignment with strategic e-government plans.

8.5.1.2.2 EA Impact on the Decision-Making Process at the University

We asked our interviewees the following question:

How did the implementation of the EA affect the decision-making at the university?

The main themes obtained from analyzing the answers are the following.

<u>No impact of EA on the decision making at the university</u>: a few interviewees indicated that EA had no impact on their university decision making; however, sometimes other faculties asked if the EA team had input into what they were doing.

EA has a limited impact on the decision-making process: some interviewees said that their EA team's participation in decision-making was very limited outside of IT, and hence the impact of EA was limited. Others said EA had different engagement levels in strategic planning, depending on where the university saw the architecture team and on the domain. Another interviewee indicated that EA might impact the response phase more until it got creditably and partners' trust. Others said EA might some influence decision-making but technically after decision point in terms of what the key investment would be. Others said that EA had a few impacts on the decision-making process because when the new investment was added, EA thinking informed that process from an architecture point of view, which helped decision-makers. Another interviewee emphasized that many decisions were made about where IT and EA team would be driven by architecture, using architecture and EA principles and approaches.

EA directly impacts decisions inside IT: a few interviewees said that their EA was integrated into the initial phase of the potential projects before getting accepted into the portfolio. Others said their enterprise architects or senior architects were involved in projects to ensure alignment of project goals with EA.

EA provides insight, oversight, and foresight to make better decisions: one interviewee mentioned that EA provided architecture information supporting decision-making in various areas at different levels. They clarified that some campuses and departments asked the EA team for what they liked, and EA had some effects on this case. Another interviewee emphasized that critical data collection and EA maturity were needed to support the decision-making process.

Increasing the reach of the EA unit and its impact on the business decision-making process outside the IT: one participant explained that the decisions should be discussed and approved by all members in the related committees, and ARB was vital in this process. He said EA was involved in the different boards that affected how the EA team stood internally on their projects inside of IT. He said that EA helped the university drive investment decisions in the strategic portfolio, which was primary any university made decisions through.

EA has an impact on decision making within the central IT department: one interviewee stated that their central IT department adhered to EA guidelines from the information service perspective at which other units should do, and it depended on people to do it. He said that EA enhanced conversations and frequent interactions between EA and software architecture, resulting in better decisions.

EA has an impact on decision making within a decentralized environment: one interviewee indicated that because the decision making at a decentralized university was distributed, they used the EA guidelines at best where EA suggested what other units should do. Another interviewee said the EA works to close the gaps in the procurement and selection decision process was made by each college to solve wasted software and poor software integration. He said EA worked with other campuses regarding adopting new tools, standards, and the integration and use of all tools. He also clarified that EA had good stakeholder management relationships as it participated in proposing or driving any change and ensuring that architecture principles were followed.

EA has a significant impact on the decision-making process when the EA team is more proactive: one interviewee said that changing their team from being active to be proactive could contribute more to the decision making at their university.

8.5.1.2.3 EA Impact on Business Process Improvement

We asked our interviewees the following question:

> *How did the implementation of the EA affect the improvement of the business processes?*

The result of analyzing the answers is the following main themes.

No impact of EA on the university's business processes improvement: one interviewee clarified that their university had other programs to help improve its processes. Other participants said EA had no impact on their university processes because of decentralization and the resistance to change the business processes. Another one stated that their EA function was only within the IT portfolio.

EA has a small and limited impact on improving the university's business processes: some interviewees said that their EA had more impact from the technical side.

EA has a significant impact on improving business processes: a few interviewees said EA simplified business processes and made them easier for all stakeholders, such as reducing the registration periods in the university. Others said EA enforced collaboration and communication between faculties and services and IT to enhance business processes. Another interviewee stated that EA helped see the advantages of business processes. Another participant indicated that the better alignment of new products or projects with EA enabled having fewer parallel projects for the work across processes. One interviewee also said EA helped the business process improvement area to focus on the area's needs rather than giving the guidelines of which work it.

The critical focus of EA should be the business process streamlining and business architecture: one interviewee emphasized that EA should influence the business processes themselves and enhance those with the use of technology.

EA leads to better decision making regarding the improvement of the business processes: an interviewee said that EA had to analyze decisions to define how fits into the enterprise, make the right decision in the context and then go forward.

EA works closely with the business improvement community: a few interviewees stated that their EA team worked with this community where one did the design, and the other understood how the business operated in that area. Another interviewee indicated that EA was involved by making suggestions about process improvements. Others said EA provided a set of architecture reference models to ensure that the business processes were understood and help them know where the team's efforts should be placed.

8.5.1.2.4 EA Impact on the University Budget

We asked our interviewees the following question:

How did the implementation of the EA affect the university budget?

The main themes from analyzing the responses are as follows.

No impact of EA or negative impact on the university budget: one interviewee said that EA could only recommend a budget guide but not establish a common standard drive across the university. Another interviewee said EA might lead to a re-organization in the IT unit where some people left, were hired, and some moved to another architecture role.

EA has an indirect or small impact on the university budget: some interviewees mentioned that EA was indirectly involved in budget decisions or saving budget. They clarified that EA helped put all integrations in place to get more value of all systems that, in the end, increased the value of any investment.

EA has a significant impact on the university budget: a few interviewees said EA helped to reduce the cost of operations, systems and applications, the complexity of integrations, and duplications of services. Others mentioned that EA might provide or request a budget for systems owners based on their plans. They also said that EA might influence how the budget for the strategic portfolio and the technology portfolio were being. Other participants indicated that EA affected the university budget by following principles and managing different stuff. On interviewee said EA helped the top management control the university budget, such as EA development budget, EA management budget, EA training and promotion budget, and EA maintenance costs. He said that EA might increase or realize the university revenue (ROI), which would increase its budget overall. Other interviewees mentioned that EA helped look at ways of saving opportunities and working with stakeholders to help them understand and realize IT's opportunity. Another interviewee stated that EA used roadmaps that directly influenced what budget the EA team asked for from the university every year. Another interviewee said that EA affected what was essential for central IT to communicate up and hence asking for their budget.

8.5.1.2.5 EA Impact on the Integration of the University Units

We asked our interviewees the following question:

> *How did the use of EA contribute to the integration or reorganization of the different organizational units of the university?*

The main themes extracted from the analysis of the interviewees' answers as follows.

No impact of EA on the integration of the university units: one interviewee indicated that their architecture was not high in planning the role of integrating different university units.

EA participates in the organization's change: one interviewee said that EA was involved in merging some departments under a unified administration. Another interviewee said that the ARB integrated individual faculties with university-wide architecture.

EA coordinates the collaboration and effort of the architecture community: one interviewee mentioned that EA helped involve key IT people across the whole university to counter and discuss architecture challenges.

EA works with stakeholders and business directors: a few interviewees said that the EA team worked with different stakeholders to ensure that IT and business know the proposed plans and key investments.

8.5.2 Survey Results

Following the grounded analysis, we created a survey question (Q43) to determine the extent of the impact that the EA team and its work had on the different aspects of the HE institutions. We asked our participants to rate the impact of EA on 13 different aspects on a scale: 'Very negative impact' rated -3, 'Negative impact' rated -2, 'Somewhat negative impact' rated -1, 'No impact at all' rated 0, 'Somewhat positive impact' rated 1, 'Positive impact' rated 2, and 'Very positive impact' rated 3.

We received 65 responses to this question. The result is illustrated in Table 50 and Figure 59. The gray shaded in Table 50 rows show the most interesting statistics. The result shows that EA had a positive impact, on average, on 'The alignment of IT strategies with the university's mission and goals' (i.e., close to 2.0). It received the highest percentage of participants who said that EA had a very positive impact on it with 13.8%. It is then followed by 'Security' with 10.8% who believed EA had a very positive impact on it.

In Table 50, we also show some of the tags that we have been using throughout this thesis relating back to the definitions and motivations for EA. EA has clearly had an impact that aligns with some motivations. Notably absent are change management and agility. Some tags, such as developing a roadmap, formalizing processes, creating a strategic information base, improving leadership and enabling digital transformation are not explicitly in the list, but are probably implicitly present.

Table 50 Basic statistics regarding the impact of EA on different aspects of HE institutions; n=65 (Q43)

Different university aspects that have been impacted by EA	Mean	St. Dev.	95% Confidence Interval of mean		Tags
The alignment of IT strategies with the university's mission and goals	1.45	1.08	1.18	1.71	[Alignment] **[Institution-Wide]**
Security	1.40	0.93	1.17	1.63	**[Security]**
Purchasing of software	1.25	0.98	1.00	1.49	[Business-Operation]
The choices of software that can be used by end users	1.25	0.88	1.03	1.47	**[Ease of use]**
Development of software	1.18	0.98	0.94	1.43	**[Automation]**
Business process improvement	1.12	1.01	0.87	1.37	[Business-Operation] **[Automation]**
Decision making in the university as a whole	1.03	0.90	0.81	1.25	[Better-Decision-Making] **[Institution-Wide]**
Integration of different units of the university	0.98	1.07	0.72	1.25	[Alignment] **[Institution-Wide]**
Student experience	0.97	0.92	0.74	1.20	
The ability of university employees to work efficiently	0.89	0.87	0.68	1.11	**[Stakeholder-Collaboration]** [Cost-Reduction]
University budget (i.e. what has the impact been on the 'bottom line')	0.69	0.86	0.48	0.91	[Cost-Reduction]
Job satisfaction of university employees	0.45	0.87	0.23	0.66	
Purchasing of supplies or assets (other than software)	0.40	0.90	0.18	0.62	[Business-Operation]

The result also shows that most of the other aspects, on average, were somewhat positively affected by EA (i.e., close to 1.0). Specifically, 'Business process improvement' and 'Integration of different units of the university' have high standard deviations (1.01 and 1.07 respectively) compared to other aspects which indicate that the values are spread out over a wider range.

On the other hand, the result shows that EA, on average, had no effect at all on 'Job satisfaction of university employees' and 'Purchasing of supplies or assets (other than software)' as they came at the bottom of ranking (i.e., close to 0.0), with 66.2% and 64.6%, respectively. They also received the lowest percentage of participants who believed that EA had a somewhat positive impact on them.

The result also shows that a small number of participants (3%) believed that EA had a somewhat negative effect on all other aspects of HE institutions, except for 'Security'; as none of the participants believed that EA had a negative impact on security.

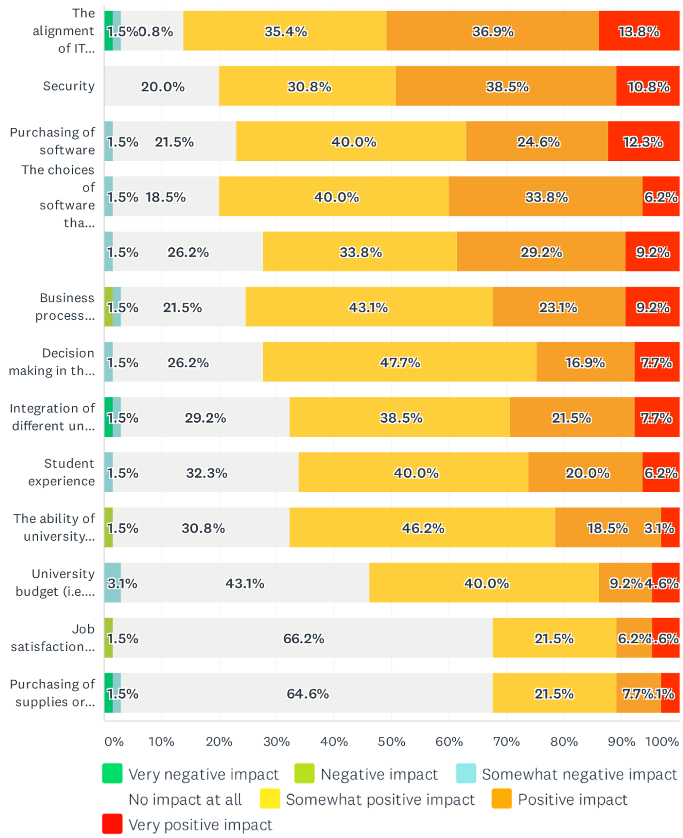

Figure 59 The EA impact on various aspects of HE institutions (Q43)

Among the top six countries, the participants from Saudi Arabia believed that EA had a very positive impact on all the 13 aspects in varying degrees, but ‘Business process improvement’ received the highest percentage of participants with 66.7%.

In addition, the highest percentage of participants from the six countries stated that EA had, on average, a positive impact on ‘Security’ with 44.4% from Canada and 33.3% from Saudi Arabia who thought EA had a very positive impact on it.

On the other hand, ‘Job satisfaction of university employees’ received the lowest percentage of participants from all the six countries who believed EA had a somewhat positive impact. However, 100% of participants from New Zealand thought that EA had no impact on it at all.

Also, ‘Integration of different units of the university’ received the highest percentage of participants with 16.7% from Saudi Arabia who believed that EA had a very negative impact.

8.6 Lessons Learned and Recommendations

The ultimate purpose of this chapter is to suggest some potential improvements regarding addressing the challenges and issues facing HE institutions when adopting EA and raising awareness about the critical factors that lead to its successful adoption. The most important lessons reported here are:

- Most of the EA adoption challenges in the HE institutions listed in this chapter were rated by our participants as major problems.
- 'Resistance to change' was rated by half of our participants as the most critical challenge facing the HE enterprise architects.
- 'Lack of higher education experience by EA leadership or the CIO' and the 'Excessive centralization of the university' were regarded as the least challenging for institutions that adopted EA.
- 'Lack of EA awareness' and 'Lack of understanding of different stakeholders' were also rated as two of the most critical problems facing the HE institutions as they may lead people at the universities to resist implementing EA because they misunderstand their value and benefits.
- We found that some of the challenges we identified in the grounded theory were not mentioned in the literature review. Examples of these challenges include the lack of readiness, the lack of perceived value and benefits, the complexity of EA, the EA immaturity, and the rigidity of university policy. These issues need further study.
- We also found that some challenges were investigated in the literature review but were not mentioned by our interviewees. Examples of these challenges include the use of EA methods, tools, standards and frameworks, and the lack of high-level guidance from ministries of education. We believed that these two issues had an impact on the adoption of EA in HE institutions.
- Enterprise architects should focus on resistance to change and lack of EA awareness when adopting EA in HEIs.
- Enterprise architects should be proactive when dealing with the challenges of EA adoption in HEIs.

- Identifying the issues that pose the biggest challenge for HE institutions helps guide enterprise architects to be proactive and improve their processes to avoid and resolve them.
- There is a lot of consistency among the six countries regarding the EA adoption issues they face.
- All critical success factors of EA in HE institutions were of moderate or higher importance, according to our participants. However, most of our respondents rated 'Support of the university's mission and goals' as the most critical factor.
- The two factors that were rated by the participants as the least important were 'Conformance of the architecture to standards' and 'Following a disciplined EA process.'
- The result of the grounded theory identified 25 additional influencing factors that were not discussed in the literature review. Examples of these factors include collaboration between different groups at the university, supporting the university's mission and goals, adding value to the institution, and data availability.
- We found that 'Support of the university's mission and goals' has the highest percentage of participants who believed it was very important or higher among the six countries. It was followed by 'Adding value to the institution.'
- The factor that was ranked as the least significant among the top six countries was 'Following a disciplined EA process,' where Australia and New Zealand got the highest percentage of participants who thought it was somewhat unimportant.
- Enterprise architects should ensure the work of EA support the university's goals and mission.
- We found that the current literature, as analysed in our systematic review, lacks any studies examining the critical success factors for individual EA team members in the HE sector. Therefore, our study contributes to identifying a list of these critical factors.
- Enterprise architects should acquire good interpersonal skills.

- The critical success factor for the EA team mentioned less during the interviews and received the lowest response rate in the survey was the need for team members to have a background in their institutions.
- Our participants indicated that EA impacts the various aspects of their institutions, whether negative or positive, but mostly the impact they had mentioned is positive.
- EA has an impact on the IT-business alignment in the HE institutions, software procurement and development, decision making, budget, and re-organization of the different units in the universities.
- 'Aligning IT strategies with the university's mission and goals' and 'Security' received the highest percentages of participants who said that EA positively impacted them.
- We found that EA did not affect 'Job satisfaction of university employees' and 'Purchasing of supplies or assets (other than software)' on average.
- Most of the other aspects of institutions were rated by our participants as having been affected by EA, on average, somewhat positively.
- The result also shows that the smallest number of participants believed that EA had a somewhat negative effect on all other aspects of HE institutions, except for 'Security' as none of them said that EA had a negative impact on it.

Chapter 9 Enterprise Architecture Processes in Higher Education Institutions with a Focus on Agility

In this chapter, we present results regarding the processes that enterprise architects follow in HE institutions. We transcribed and analyzed the data collected from interviewees to understand key patterns. Then we converted the grounded theory results into a set of survey questions.

We first provide background regarding this topic. Then we provide the analysis of grounded theory and survey results. Finally, we provide lessons learned and recommendations. Our analysis focuses on key performance indicators (KPIs) and agility in EA for higher education.

9.1 Introduction and Background

Many publications focus on how to create EA or an EA function, but there is a lack of explanatory and empirical research investigating how EA can achieve benefits (how EA practices are conducted in the real world), according to Foorthuis et al. (2016), and this lack is most evident in the domain of higher education. Foorthuis et al. (2016) conducted an exploratory study to understand how EA delivers value to organizations and identifies the most effective EA practices in various industries. Foorthuis et al. (2016) initially provided an overview of claimed EA practices and benefits to stimulate EA's correct use, summarized as follows.

Ensuring management involvement in EA and support is one of these practices. It includes EA's formal approval by management, explicitly linking management to EA with strategic business objectives and management propagation of EA by emphasizing EA's importance and value.

Another practice is EA compliance assessments, and it includes ensuring projects adhere to the EA principles and norms.

Building an active community is also one of the EA practices aiming to exchange EA knowledge between architects and between architects and project members and ensure architects are actively involved in projects.

Another EA practice is to leverage project artifacts' value using a Project Start Architecture (PSA) (Wagter et al., 2005) to encourage the project to comply with EA standards and use document templates to increase architectural conformance and insight.

One of other EA practices is to use incentives and disincentives to stimulate conformance for using EA to push for enterprise thinking and comply with EA.

Compliance assessments, management propagation of EA, and various types of knowledge exchange are identified as the most effective EA practices depending on the results of the Foorthuis et al. (2016) study, while they found that EA's formal approval has a negative impact.

The results of our interviews and the survey identified what EA practices are in HE institutions. The objective was to determine how EA was practiced in these institutions and make proposals on which practices should prioritize.

There also a lack in research that discusses how agile EA is, as currently practiced in HE institutions, and those factors that can lead an organization to become more agile in this context. A few publications discussed the need and benefits of using Agile Enterprise Architecture (AEA) (Rouhani et al., 2008; Kaddoumi & Watfa, 2016; Velumani, 2017). However, none of them focused on the HE domain. AEA is proposed to resolve the issues and problems of traditional EA. However, we did not find any study on AEA that was performed specifically for the HE domain.

Llamosa-Villalba et al. (2014) proposed using agile school architecture, an archetype of EA, to enhance an organizational leadership process in HEIs. Their aim was to use the Agile School model reference to enhance the Teaching-Learning process in HE institutions.

Our study aimed to investigate the different practices that could impact the agility of the EA process in HE institutions. In the following sections, we provide the grounded theory and survey results that identify these aspects and provide our recommendations based on them.

Moreover, there is a considerable gap in the literature about the determination of measures, Key Performance Indicators (KPIs), or criteria to measure the performance and effectiveness of adopting EA in HE institutions. We found that only very few governments have set criteria to measure EA implementation in the public sector, including higher education, such as the Saudi government (E-Government Program (Yesser), 2017). We also found a study conducted by Al-Amiri, Abdullah & Al-Bar (2018b), where they identified ten KPIs to measure EA performance in strategic planning and investments for HE institutions and its impacts on the performance of HEI methodology in DGS. These KPIs are used to measure EA in three areas. The main KPI for the first area, strategic planning, is the percentage of alignment of the university's process with the action plan. The four KPIs identified for the second area, business architecture, are the optimization of business processes, the number of established business units, the number of defined business processes, and manual processes automation. The two KPIs identified for the third area, application architecture, are creating shared applications and upgrading all legacy applications using outdated technologies. The three KPIs identified for increasing the direct value of IT investments based on the architecture of the infrastructure are improving the IT infrastructure by establishing a data warehouse, improving the IT infrastructure by taking advantage of Business Intelligence (BI) platforms, and transforming manual communication in the field of electronic communications. Al-Amiri, Abdullah and Al-Bar (2018b) concluded that identifying other KPIs is necessary to measure EA's effectiveness in the HE domain.

9.2 Grounded Theory Results

As discussed earlier in this thesis, we interviewed 21 participants from 19 countries who fulfilled the role of enterprise architect in universities. One of the topics that we asked our participants about was the changes made to the EA process in their universities. We also asked them if they had a process to evaluate their EA and the criteria or KPIs they used. Moreover, we asked them if they applied an agile approach to their EA process.

We transcribed and analyzed the answers we collected to understand key patterns. Then we converted the grounded theory results into a set of survey questions.

9.2.1 Processes Adopted (Changes to the EA Process)

We asked our interviewees, "*What changes have been made to the EA since its establishment? How do you deal with and handle the changes and specializations to your*

EA?" The aim of this question was to understand the way EA is actually practiced, not figuring out what the best practices are.

Some of our interviewees said they had not made any changes to their EA process since they established it. This may be because they either just started adopting EA or have not adopted it formally yet.

Others said they made minor changes to their EA, such as changing their team members' roles and responsibilities or making some minor changes related to financial issues.

Other interviewees indicated that they made some prominent changes to their EA. For example, one of the most significant changes that had been made was *the push for enterprise thinking into the organizations.* They started to have conversations to show stakeholders that EA spoke their languages (talking not only about IT but also about the business capabilities and goals of the institution and gaps of level). Others said they *became more motivated by visions derived from the business units*. Some participants said that they *increased their ability to share information across different systems*. They became able to launch strategic planning to bring some business vision to IT to help align the architecture where EA tries to go. Another example is that some *used EA to inform decisions* such as technology and business decisions increasingly.

Another change that was made was better *defining EA program needs and goals*, what EA wanted to accomplish with that, and what next in the next planned period of re-scoping.

Another prominent change was to *make the EA process more disciplined* by unifying communication from enterprise and EA points of view. In other words, the point was to use the EA approach to plan for what is current and future states, and transition architecture to get there. Some participants said that they *reviewed the terms of reference*.

Other interviewees said they *set up an architecture board* such as the Architecture Review Board (ARB) and invited more people to participate. Those who already had an architecture board said they *made it open to everyone* by inviting them to participate, which made it a more sophisticated way to increase democracy. Others focused on *building community work closely with other university's departments*. They regularly discussed what was new, what was next, and if the EA team was still on the right track. Others had *more meetings with stakeholders and among team members* to promote EA across the university and start to have strategic communication to talk about how EA helps reach the institution's goal because of looking at a strategic plan.

Some *moved their EA team from being reactive to being proactive* on a high-level. Some of them also *made changes to the EA team's size*, focusing on growing the EA team substantially either on the data side or using the enterprise information architect. Others said they *built virtual groups of architects and business analysts*. Some interviewees also said they *formalized rules and responsibilities*, such as having one in charge of business architecture and one in charge of application architecture and ensuring everybody understands their roles and responsibilities. In other words, every individual should understand their role as a whole and know how their roles fit together and have the ability to show the whole IT and all community the value of the architecture by adjusting the message or information to the EA audience. Some of them also made *a change to their team's skills and acquired new skills*. Some participants said they did *much self-evaluation* as well as *much self-assignment*.

Some participants said that they *adopted a more agile approach to EA* and adapted to what people want (stakeholders' requirements). Others said they adopted a modern software development lifecycle (SDLC) instead of the waterfall approach or formalized the waterfall stages.

Other interviewees said that they *got more support from the university's leadership* and got more appreciation of what EA can offer, and EA adapts to that.

Others increasingly focused on *information and technology management*, and some *increasingly focused on application and technology domains within the IT unit(s)* and touchpoints with other business units and departments.

Some also made sweeping positive changes in overall architecture because of corporate experience and broad knowledge. They worked on *deepening, broadening or increasing the validity of the overall architecture.*

Others have indicated that they were *constantly adjusting their EA* as they *adjusted from working mostly on projects to leading strategies*. Others also *focused more on key* *investments* where solution architects design the number of architectures relating to the solution, and those artifacts get stored in the EA architecture repository. Others said that their *EA tended to work as a service unit*.

We defined a list of these practices and asked our participants in the survey to choose the top ten of them. We discuss the result of the survey later in this chapter (Section 9.3.1).

To summarize, the different EA practices extracted from the grounded theory findings are:

Changing EA team members' roles and responsibilities.	Pushing for enterprise thinking into the organizations.	Adopting a more agile approach to EA and adapting to stakeholders' requirements.
Having more meetings with stakeholders and EA team members.	Motivating by visions derived from the business units.	Getting more support and appreciation from the university's leadership.
Making the EA team proactive at a high level.	Increasing the ability to share information across different systems.	Focusing more on information and technology management, and application and technology domains within the IT unit(s).
Making changes to the EA team size.	Launching strategic planning to bring some business vision to IT to help align the architecture where EA tries to go.	Informing technology and business decisions increasingly.
Building virtual groups of architects and business analysts.	Making the EA process more disciplined.	Better defining EA program needs and goals.
Formalizing rules and responsibilities,	Reviewing the terms of reference.	Deepening, broadening or increasing the validity of the overall architecture.
Making changes to the EA team's skills or acquiring new ones.	Setting up an architecture board and inviting more people to participate.	Adjusting EA from working mostly on projects to leading strategies.
Doing much self-evaluation as well as self-assignment.	Building a community that works closely with other university departments.	Working as a service unit.
Making changes related to financial issues.	Focusing more on key investments.	

9.2.2 Agility in Enterprise Architecture in HE institutions

We asked our interviewees the following question, "d*o you apply any agile approach to your process of EA? If yes, why do you decide to do that? And what benefits do you get compared to the traditional EA process? If no, is there a specific reason for not considering using an agile approach with your EA?*" We received diverse answers to this question.

The definition and application of the EA agility are relative, according to our interviewees. Agility is an area that has many different opinions across university campuses. One of our interviewees said that agility is more than a mindset. People who work on EA at universities need to be as much as possible open-minded and agile. Leadership and communication skills are more critical than using tools to implement EA.

Figure 60 depicts the key themes we extracted from analyzing the various answers to the above question. The green boxes denote the codes drawn from interviewees' responses that supported or confirmed applying the agile approach to their EA process. The gray boxes indicate the codes taken from the answers that mentioned some aspects that may or may not support this point. On the other hand, the red boxes indicate the codes extracted from the answers, which confirmed not applying the EA's agile approach. The red dotted lines indicate some kind of relationship among the different codes whereby some codes drive, include or impact other codes or the attributes of other codes. For example, the line connecting 'EA team is very agile' and 'Have regular weekly, monthly, or quarterly meetings between team's members and with other groups in the university' implies that for the EA team to be agile, they should have regular meetings with each other and with other stakeholders. Below, we discuss all these aspects.

Some of the interviewees told us that they *did not* adopt the agile approach to their EA process. Others said that *their EA processes had some agility aspects* that might contribute to or diminish the agility of EA.

The interviewees provided some reasons explaining why their EA process was not agile. Some said that they did not adopt agile method in their EA because it was *not well-defined yet*. Others said that their EA team was *not very consistent* as they might work in an agile way in some areas, and they did not do so well in other areas. Another reason some

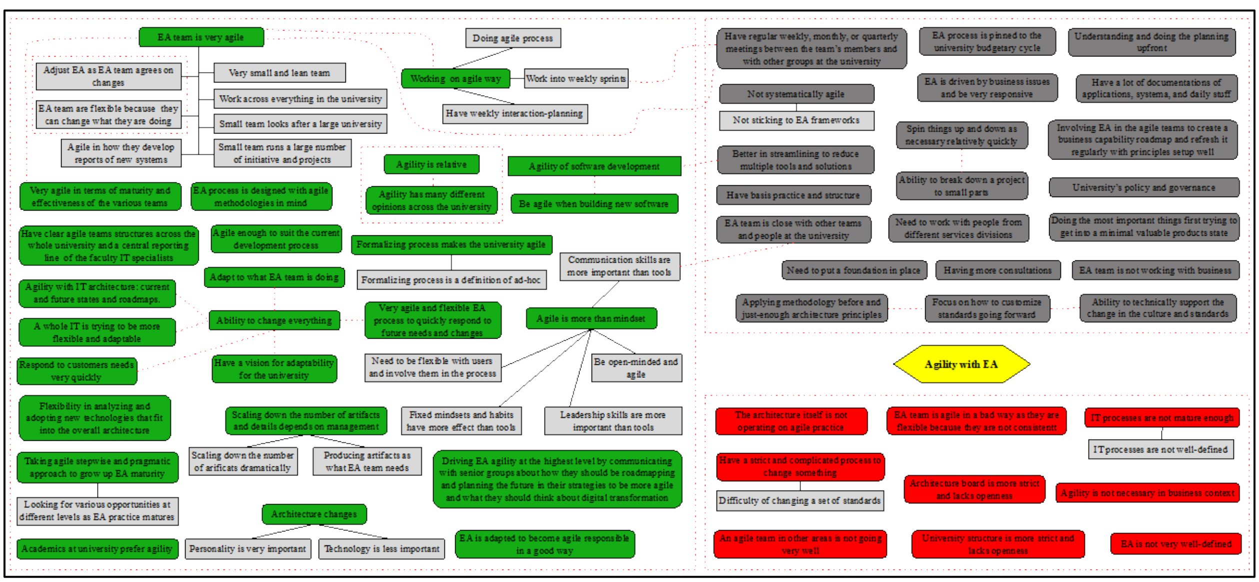

Figure 60 Agility aspects with EA in HE institutions (GT results)

interviewees provided to explain the lack of agility of their EA was that *their IT processes were not mature enough* to become agile (no well-defined) or that *the architecture was not operating on an agile practice*.

On the other hand, some interviewees stated that their *EA process was more secure and strict* across the university because it either *had more consultations* or was *pinned to a university budgetary cycle*, which as a result, detracted from the agility of EA. Others said their universities *were not agile in terms of the policy* as the basic practice and culture are considered a limiting factor for agility. Some indicated that having *more documentation of IT architecture work and applications and integrations between them* was a limiting factor for EA agility. Some other participants believed that *agility is not necessary for the business* context, and some *did not have a process to follow when any changes are made*. Others stated that they *did not apply or embrace the agile principles or values* when adopting EA.

Some other interviewees described some aspects (factors) that impacted EA's agility adopted in their universities, either positively or negatively. One of them is the focus on *responding to customer needs very quickly*. From some of our interviewees' perspective, EA should be adapted rapidly and flexibly to future and urgent needs and changes. Others indicated that their universities *had a vision for adaptability*. For example, a whole IT team tried to be more flexible and adaptable and got people involved in the EA process. Others stated that they *had a process to enable easy change*.

Some said that their EA process was designed with agile methodologies in mind. They *applied the principles of 'methodologies before' and 'just-enough architecture*.' Their EA process was agile enough to suit the current development process.

Another aspect described by some interviewees is the ability to *do quarterly planning and understand and do planning up-to-front*. They put out the building blocks or the guidelines to people within the universities.

According to some of our interviewees, another factor of EA agility is *the frequent review of decisions and directions*. Others said that they were more *agile in how to develop reports on new systems*. They did not need to *do much documentation of everything*.

Some interviewees explained *the agility of their EA team*. They said that their universities *adapted a lot as to what their EA team did*. Their EA team *worked across everything in the university*. For example, they had *a very small and lean team looking after a large university* with a large number of students, staff, applications and technologies. Others said they had *a very small EA team involved in and running many initiatives and projects*. The EA team *worked into sprints* as they had weekly interaction-planning and weekly sprints. They *had regular meetings* as they met weekly or monthly to discuss a significant change of how EA work went through to be reviewed and debated, very quickly.

Some interviewees said they were agile to some extent because they *could work with people from different service divisions*. They *became close to other teams and persons*. They could also *break down a project into small parts instead of working on a big project.* They *embedded in the agile team to provide clear structures across the whole university* and centralize some faculty IT specialists' reporting lines. They also *embedded in the agile team to work closely and flexibly to create business capabilities roadmaps* and refresh them regularly where principles are pretty well set. Some said they influenced driving the EA agility at the highest level by *creating roadmaps and understanding how they should be planning the future in their strategies*. Other interviewees said their EA team *focused on working with IT, not with business*. Some said their EA team was *flexible in analyzing and adopting new technologi*es that fit the overall architecture.

Another aspect discussed by some interviewees is that they *took an agile, stepwise, and pragmatic approach to implement and grow the EA maturity*. In other words, they looked for various opportunities at different levels as EA practice had matured.

Other participants said they *scaled down the number of artifacts they produced dramatically*. They produced artifacts to a point where the EA team was comfortable with the level of risk that might be imposed by missing something or depending on what management wanted. At the same time, others indicated *that business issues drove the artifacts*. They focused on resolving business issues and being very responsive.

Some interviewees stated that there was *a trend towards less policy and more agility from the academic side*. In other words, academics prefer agility according to their opinion, so they adopted a more agile approach to the university processes. Others said that *formalizing EA and IT processes made their university more agile and flexible*.

Other interviewees described *the agility from a technical point of view*. They said their EA had enough agility to *quickly spin things up and down as necessary* when deciding what wanted to do, and how to align people to do it. Others said they were agile in terms that they *did not stick to a specific EA framework*. On the other side, some interviewees indicated that they *focused on how to customize standards* going forward. Other participants stated that they *applied the agile software development process* for developing their software. Other interviewees said they were *agile with IT architecture work* by creating the future and current states, looking at data and business capabilities and developing roadmaps.

Some interviewees indicated that they focused on *doing the most important things first*. In other words, EA does the most important things first, tries to get into a minimal valuable products state, and hands them over to appropriate products dealers who work with all the cyclical basis to continue keeping those products improving.

Some other interviewees said that they *adopted an agile approach to their EA but not systematically*. For example, they did not follow an agile EA framework or methodology.

From these key themes, we identified a list of various aspects that may positively or negatively affect the agility of the EA process in HE institutions. We included this list in our survey and asked our participants to rate how much they would affect the agility of their process if they had any impact.

A list of various aspects that may positively or negatively affect the agility of the EA process in HE institutions are:

Not well-defining EA.	Having more documentation.	Having a vision for adaptability.
Working across everything in the university.	Having a more secure and strict EA process across the university.	Doing quarterly or monthly and up-to-front planning.
Adapting a lot as to what their EA team does.	Having more consultations or pinning to a university budgetary cycle.	Frequent reviewing of decisions and directions.
Embedding in the agile team to provide clear structures across the whole university and work closely and flexibly to create and refresh business capabilities roadmaps.	Creating the future and current states, looking at data and business capabilities and developing and understanding roadmaps.	Being able to quickly spin things up and down as necessary when deciding what wanted to do and align people to do it.

Having not a very consistent EA team.	Having more policy.	Developing reports on new systems.
Having weekly interaction-planning and weekly sprints.	Having a process to enable easy change.	Taking an agile, stepwise, and pragmatic approach to implement and grow the EA maturity.
Being able to work with people from different service divisions.	Designing the EA process with agile methodologies in mind.	Scaling down the number of produced artifacts dramatically.
Not sticking to a specific EA framework.	Not applying or embracing the agile principles or values when adopting EA.	Tending towards less policy and more agility from the academic side.
Having immature IT processes (no well-defined) or the architecture is not operating on an agile practice.	Being flexible in analyzing and adopting new technologies that fit the overall architecture.	Being able to break down a project into small parts instead of working on a big project.
Focusing on responding to customer needs very quickly.	Focusing on doing the most important things first.	Focusing on how to customize standards going forward.
Focusing on working on IT, not business.	Adopting an agile approach to EA but not systematically.	

9.2.3 Criteria Used to Evaluate the EA Process in HE Institutions

We asked our interviewees, *"Do you have a process to evaluate your EA? Please describe this process. (What measures or key process indicators (KPIs) do you use to evaluate your EA?"* The interviews revealed that there was no specific method for systematically evaluating the EA process in most institutions. According to some of our participants, EA process evaluations were often conducted using ad hoc methods depending on the EA teams' expertise. Some interviewees provided criteria used to determine whether EA was successfully adopted or not. These criteria ranged from being key performance indicators (KPIs), metrics, or measures. The interviewees' responses showed that the KPIs or metrics used to evaluate EA are very subjective.

The KPIs are defined as measurable values that indicate the effectiveness in achieving the EA goals and, thus, the institution's goals (Taylor, 2017). On the other side, metrics are defined as quantifiable measures used to track and assess the EA process's status, while measures are defined as numbers or values that can be calculated (Taylor, 2017). Both KPIs and metrics are based on and derive from the measures (Taylor, 2017). In the rest of this section, we illustrate the key codes extracted from the responses to the above question, as depicted in Figure 61.

Some interviewees said that they <u>*did not have a process to evaluate EA in their institutions*</u> nor KPIs or metrics. They explained that they either had an immature EA process or their institutions were immature in KPIs or metrics. Some said they did not have any framework or model or formalized process to evaluate their EA practice systematically. However, they had governance to go through any proposed changes to their EA.

Other participants talked about *the lack of KPIs or metrics in specific areas*, such as all architecture metrics, the EA performance metrics, and the EA efficiency and effectiveness metrics.

Other interviewees talked about *some KPIs or metrics they used to evaluate their EA*. Some said they *developed a continual or continuous improvement process* to improve their services or processes, such as having CRM solutions for managing student life cycles and research initiatives to improve researchers' processes or improve information systems and their interfaces.

Some of the interviewees took some systematic methods to evaluate and assess their EA. *The EA maturity model* is an example of how to evaluate EA according to some of our interviewees. They indicated that they measured and assessed the EA maturity levels bi-annually. The aim was to find out how to build, develop and implement the EA practice. It helped find out where EA practice was, and where the next level of EA would be. To do that, they said they assessed the EA practice against a specific maturity framework or model.

Others said they *used COBIT's key processes* or *used other frameworks* to measure EA successes.

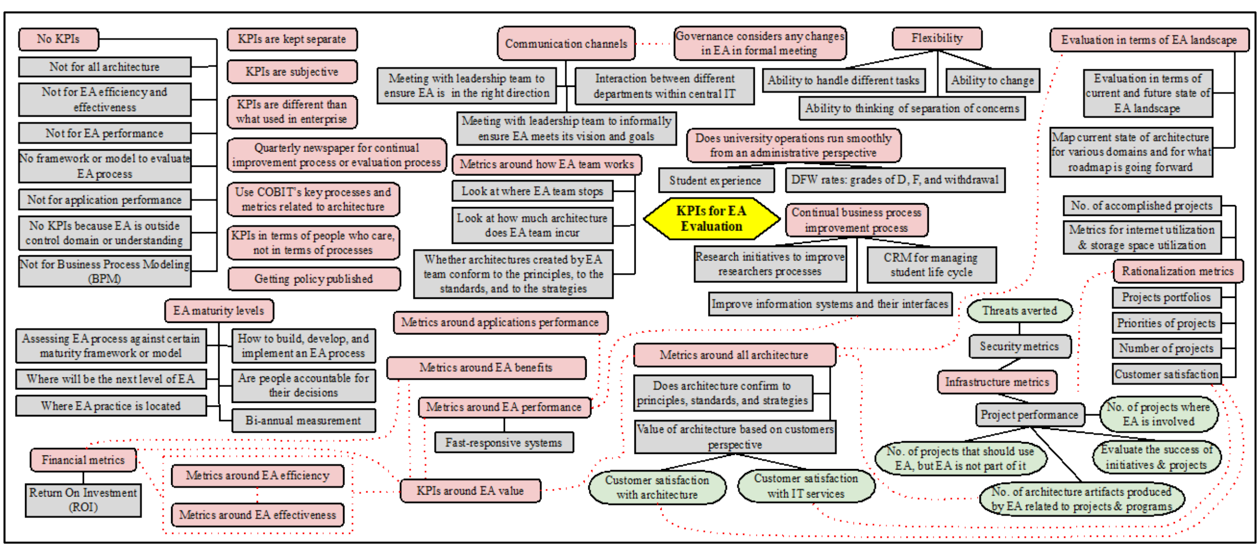

Figure 61 Key Themes of the criteria used for evaluating the EA process in HE institutions (GT results)

Another interviewee explained that they used *specific KPIs developed by their government* to evaluate their EA process.

Some participants talked about specific metrics for evaluating their EA. For example, some used *financial metrics* such as *ROI* or *the extent to which EA had reduced costs*. Other examples of metrics were the *rationalization metrics* (indicators of rationalization: project portfolio, what projects, priorities of projects, number of finished projects), the *security metrics* (indicators of security: threats averted), *metrics around EA performance* (fast-responsive systems), *metrics for all architectures* (how much architecture do to incur, and number of architecture artifacts produced by EA related to projects & programs), *metrics for EA efficiency and effectiveness*, *metrics around application performance*, *infrastructure-related metrics* (internet utilization and storage space utilization), and *metrics around EA value and benefits*.

A set of interviewees stated that they used *key architecture-related metrics*. They measured their EA practices' success by *whether the produced architectures conformed the principles, standards, and strategies*. Other participants used specific metrics to measure *the extent to which their customers were happy* is an important metric to evaluate their EA practice. They wanted to determine how their customers were happy with IT services and any value to create architecture. Another interviewee stated that they evaluate their EA in terms of *EA's current state landscape*, not holistic what map the world, and what was most important to set. They mapped the current state architecture for various domains that became important and at what was the roadmap going forward.

Some other interviewees said that they used the quantitative benefits from EA to evaluate the success of their process such as by the initiatives and projects by the *number of the successful projects and initiatives EA was involved in and the number of projects where they acquired EA to be involved*, but it was not part of them.

Some other interviewees used specific KPIs to evaluate their EA according to *what goals and visions were met*, and *to publish the university's policy*.

Other participants indicated that they evaluated their EA by *how the EA team would correctly solve the architectures* they created in terms of processes, standards, and consistency. They talked with the leadership team to *ensure that the EA team was in the right direction* and looked at whether they stopped.

Another interviewee said they measured their EA by its *ability to change and thinking of separation of concerns or handling tasks*, while another indicated they *made sure their university operations run smoothly from an administrative perspective*.

The findings of the grounded theory about the EA process evaluation can be summarized into four main opinions:

1. No use of a process to evaluate EA nor KPIs or metrics (because of the immaturity of the EA process or KPIs)
2. No use of a *specific* method for systematically evaluating the EA process; EA process evaluations are often conducted using ad hoc methods (because there is no framework or formalized process to evaluate it systematically or there is a lack of KPIs or metrics in specific areas).
3. Application of *some* systematic methods to evaluate EA (using the EA maturity model or using COBIT's key processes and other frameworks).
4. Conducting EA process evaluations using KPIs or metrics. Examples of KPIs or metrics used to evaluate their EA are financial metrics, rationalization metrics, security metrics, EA performance metrics, metrics for all architectures, metrics for EA efficiency and effectiveness, metrics around application performance, infrastructure-related metrics, and metrics around EA value and benefits. Other metrics for evaluating the EA process are how satisfied the customers are with IT services and any value for building the architecture, the use of specific KPIs developed by governments, the current EA status landscape, evaluated according to goals and visions that have been achieved, how architectures have been resolved correctly, the number of successful projects and initiatives that EA has been involved in or acquired by, or ensuring that university operations run smoothly from a management perspective.

9.3 Survey Analysis

As we had done for other themes of our research, we used the grounded theory results to construct a set of survey questions related to the EA process in HE institutions in terms of the changes that had been made to it since its establishment and the agility aspects if it had any of them. In this section, we summarize the results of this survey.

9.3.1 Processes Adopted (Q44)

In Question 44 of our survey, we asked *"Pick up to 10 of the most prominent changes that have been made to EA at your university since its establishment"*. We listed a total of 28 process changes derived from the grounded theory (See Table 51) and presented these as selectable answers.

We elected to have respondents select only up to 10 of the changes for the following reasons. If we had asked them to select all the changes they have made, some might have selected almost all options even if they had only performed the tasks in a minor way, while others might have just picked their top few, resulting in an inconsistency. Similarly, if we had asked for a smaller number of prominent changes, we would have likely obtained data that was too sparse from very active EA teams. Asking up to 10 and using the word 'most prominent' forced them to think about which were actually the most significant.

This question does not explicitly elicit the 'best practices.' We want to learn the way EA is actually practiced, not the way participants think EA should be practiced. That said, it is likely that there is some correlation between what practices have been adopted and what actually works. We leave making a deeper dive into best practices to future work.

The 60 participants selected an average of 8.3 of the responses. Two of the participants selected 'No changes have been made', so the remaining 58 selected an average of 8.6 of the responses.

As Table 51 shows, three responses were selected by over 50% of the participants. The vast majority have pushed for enterprise thinking. Most have focused on sharing information across systems, as well as informing business and technology decisions. These clearly are practices that others should therefore consider prioritizing too.

Almost half of the participants reported setting up an architecture board. The architecture board is primarily responsible for high-level decisions and governance of EA, according to TOGAF (The Open Group, 2018). The architecture board could be considered one of the best EA practices in the HE context, according to almost half of our participants' opinions.

TOGAF defines the architecture board as “a cross-organization Architecture Board to oversee the implementation of the strategy” (The Open Group, 2018); the board governs and manages EA and the EA work. The architecture board represents all the key stakeholders in the architecture and a group of executives (The Open Group, 2018). Foorthuis et al. (2016) identified building an active community to share EA knowledge as an effective EA practice. The architecture board could be considered a small community representing members from different university departments to share knowledge regarding EA and contribute to making necessary decisions regarding architecture. The members review and maintain the overall architecture and approve the proposed changes. The architecture board also helps meet changing business needs and take advantage of new technologies (The Open Group, 2018) and exchange information and enhance communication between members. The establishment of an EA program, misalignment between business and IT, and the rapid growth or significant change in business are reasons that lead to the establishment of the architecture board (The Open Group, 2018).

Three participants wrote in their own write-in responses, which we quote, as they are illuminating:

“Participating in strategy formulation process”

“Since the creation of an EA group in 2010 through to its execution at the end of 2016 all of the items above were experienced. With a change in CIO all of this was thrown out.”
This sensitivity of the process to the current management is something that we heard from several participants in both our grounded theory and survey work. It suggests that greater effort must be made to educate all levels of management about EA, so EA becomes more widely understood in higher education culture more generally.

“The adoption of Cloud resources (PaaS, SaaS) is reducing the need for technology architecture and increasing the need for business architecture.”

Table 51 Changes made to EA – reflecting key practices (Q 44)

Response Text	Percent Selecting	Tags
1. Pushing for "enterprise thinking"	71.7	[Institution-Wide], [Stakeholder-Collaboration], [Effectiveness], [Leadership], [Learning], [Recognizing-Interdependence], [Value-Delivery]
2. Increasing ability to share information across different systems	61.7	[Institution-Wide], [Recognizing-Interdependence], [Effectiveness], [Value-Delivery], [Automation]
3. Increasingly informing technology and business decisions	53.3	[Better-Decision-Making], [Recognizing-Interdependence]
4. Setting up an architecture board	45.0	[Better-Decision-Making], [Stakeholder-Collaboration], [Institution-Wide]
5. Making the EA process more disciplined	38.3	[Formalizing], [Effectiveness], [Systematic]
6. Formalizing rules and responsibilities	38.3	[Formalizing], [Systematic], [Reflection]
7. Adopting a more agile approach to EA	35.0	[Careful-Focus], [Adapting and agility], [Stakeholder-Collaboration], [Value-Delivery] [Effectiveness]
8. Increasing focus on Information and technology management	35.0	[Management], [Effectiveness], [Careful-Focus]
9. Better defining EA program needs and goals	33.3	[Formalizing], [Value-Delivery], [Careful-Focus], [Reflection]
10. Moving from being reactive to being proactive	31.7	[Effectiveness], [Leadership]
11. Building community to work closely with other university's departments	31.7	[Stakeholder-Collaboration], [Institution-Wide]
12. Adjusting from working mostly on projects to leading strategies	30.0	[Leadership]
13. More support from leadership of the university	28.3	[Leadership]
14. Increasing focus on application and technology domains within IT unit(s)	28.3	[Careful-Focus]
15. Growing the EA team substantially	26.7	[Expanding]
16. Acquiring new skills	25.0	[Effectiveness], [Learning]
17. More meetings with stakeholders	25.0	[Stakeholder-Collaboration], [Better-Decision-Making]
18. More focus on key investments	25.0	[Careful-Focus], [Reflection]
19. Working as a service unit	25.0	[Stakeholder-Collaboration], [Careful-Focus]
20. Building virtual groups of architects and business analysts	25.0	[Stakeholder-Collaboration]
21. Deepening, broadening or increasing the validity of the overall architecture	23.3	[Effectiveness], [Learning]
22. Becoming more motivated by visions derived from business units	21.7	[Stakeholder-Collaboration], [Effectiveness]
23. Making an architecture board open to everyone	18.3	[Stakeholder-Collaboration]
24. More meetings among team members	15.0	[Stakeholder-Collaboration], [Reflection]
25. Doing a lot of self-evaluation	13.3	[Reflection]
26. Reviewing the terms of reference	10.0	[Reflection]
27. Doing a lot of self-assignment	8.3	[Reflection]
28. Other (write-in)	6.6	
29. No changes have been made	3.3	

There were some important differences by country in the responses to Question 44.

Although 'Pushing for enterprise thinking' ranked high in all of our 6 key countries, New Zealanders chose this 100% of the time, and US respondents only chose it 50% of the time.

87% of Australian respondents reported ‘Setting up an architecture board’, whereas 0% of New Zealand respondents reported this.

71% of Canadian respondents reported ‘Building community to work closely with other university’s departments’, whereas only 8% in the United States reported this.

9.3.1.1 Discussion Regarding Q44

There is a lack of studies in higher education that identify the EA practices and clarify the most effective ones. In our study, we aimed to investigate the EA practices followed in HE institutions. The grounded theory and survey results that we conducted in this study identified some of the EA practices. Based on the findings, pushing for enterprise thinking, sharing information across systems, as well as informing business and technology decisions are the practices that should be taken into consideration when using EA in higher education institutions. Although pushing for enterprise thinking was not identified as the most effective practice by Foorthuis et al. (2016), our participants in the HE institutions paid great attention to this practice based on our results. Enterprise thinking is described in detailed by Nightingale (2009). Essentially, it boils down to always considering the institution as a whole with its full breadth of stakeholders and their value propositions, rather than just a particular group or project. It also emphasizes effectiveness (more than efficiency), understanding interdependencies, value delivery, institutional leadership and institutional learning. Together with the EA views, enterprise thinking provides a holistic way to think about and analyze enterprises.

Setting up architecture board and building a community to work closely with other university departments are among the practices that have gained the participants’ attention. These practices imply exchanging knowledge between architects and other stakeholders and enhancing communication between them. Building a community to exchange EA knowledge is defined by Foorthuis et al. (2016) as an effective practice for using EA.

Our participants did not mention EA compliance assessments or projects complying with EA principles and standards as EA practices, even though they are identified by Foorthuis et al. (2016) as effective EA practices.

We applied the tags we have been using throughout this thesis to Table 51. The tags associated with Enterprise Thinking covered a lot of ground: Adopting enterprise thinking seems to enable most of the other practices. Once again 'Stakeholder Collaboration' is central to many of the practices.

9.3.2 Agility in Enterprise Architecture (Q45 and Q46)

In question 45 of the survey, we asked the question, *"To what extent do you feel your EA process is agile (agility means that the models can be easily changed, and that the EA can help the organization make rapid changes if needed)?"* We decided to give a concrete definition of agility to avoid ambiguous answers.

A total of 64 enterprise architects responded to this question. 14.1% consider their EA processes to be agile, answering either 'Extremely agile' (just one response) or 'Very Agile' (8). A slight majority (51.6%) were neutral, responding 'Moderately Agile' (33 responses). The remaining 34.4%, consider their process relatively unagile, responding either 'Slightly agile' (18) or 'Not agile at all' (4).

There were some interesting country-specific differences 63% of Canadian EAs reported their process to be unagile and 0% consider it to be agile. In Australia, it was balanced with 12.5 reporting agile and another 12.5 unagile. Saudi Arabia was also balanced, with 33.3% reporting agile, and 33.3% unagile. For New Zealand 40% reported agile, and 20% unagile.

In question 46 we gave a list of factors (aspects) that may contribute to or detract from agility of the EA. These aspects were derived from our grounded theory study. The aspects were presented in an order that was randomized among participants. 60 participants responded to this question.

The participants were asked, *"For the following aspects, please indicate how each of them affects the agility of EA at your institution?"* Participants were asked to rate each as 'Decreases agility a lot' (scored -2 in our analysis), 'Decreases agility a little' (-1), 'Has no effect on agility, or is not a factor at this institution' (0), 'Increases agility a little' (1) and 'Increases agility a lot' (2).

Table 52 shows the factors that increase agility of EA the most according to the participants. We have selected the items that scored at least a mean of approximately 0.3 or higher. The same data is shown graphically in Figure 62. Table 53 and Figure 63 show the factors that decrease agility of EA the most; for this table we have selected the items that scored a mean of -0.3 or lower. In both cases the standard deviations were all similar.

Together this data suggests that the key EA practices that can improve agility can be boiled down to:

- Avoiding doing too much: In particular, focusing on a limited portfolio of applications, technologies, projects, documentation, policies and processes.
- Being responsive to stakeholders by collaborating with them and making small changes for them quickly.
- Being pragmatic about how to proceed, rather than trying to follow very formal processes with strict deadline.
- Work with other stakeholders, particularly management and software developers, to educate them about how to be agile.

Table 52 Factors contributing most to agility (Q46)

Aspect/Factor	Mean	St. Dev	Tags that might help overcome
The EA team applies the "just-enough architecture" principle to limit the volume of information they manage, or scale it down	0.76	0.92	[Careful-Focus], [Pragmatism]
New software developed in the university is created using agile software development methods	0.64	0.77	[Adapting and agility], Careful-Focus], [Value-Delivery], [Systematic], [Pragmatism], [Effectiveness], [Stakeholder-Collaboration]
EA frameworks are used as a guide but do not need to be followed closely	0.62	0.91	[Pragmatism], [Adapting and agility]
EA is driven by business issues and responds quickly to the needs of business units	0.52	0.82	[Stakeholder-Collaboration], [Quick Change], [Value-Delivery]
EA is developed in a stepwise and pragmatic manner	0.47	0.80	[Pragmatism], [Systematic]
The EA team has a vision for adaptability in the university	0.45	0.75	[Adapting and agility], [Institution-Wide]
EA team works in sprints	0.33	0.79	[Careful-Focus], [Systematic], [Quick Change], [Value-Delivery]
The EA team works towards a more streamlined process with fewer tools	0.31	0.73	[Careful-Focus], [Systematic]
The EA team carefully prioritizes tasks	0.31	0.88	[Careful-Focus], [Systematic], [Value-Delivery]
There is a flexible mindset regarding adoption of new technologies that might fit into the overall architecture	0.28	0.94	[Adapting and agility]

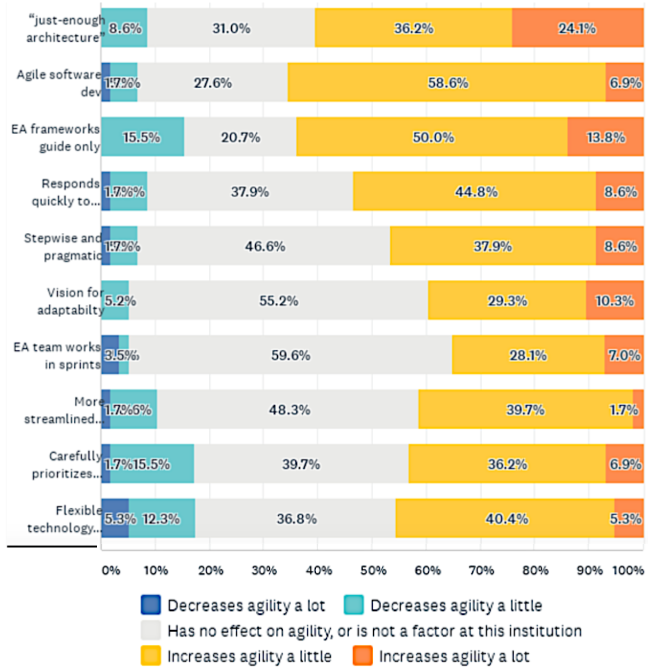

Figure 62 Factors Increasing Agility of EA (Q46)

Table 53 Factors detracting most from agility of EA (Q46)

Negative Aspect/Factor	Mean	St. Dev	Tags that might help overcome
The EA team must consider a large number of applications and technologies	-0.84	0.81	**[Careful-Focus]**, [Value-Delivery]
There is resistance to change in university management	-0.77	0.81	[Management], **[Learning]**, **[Leadership]**
The university is very large	-0.76	0.78	**[Careful-Focus]**, **[Institution-Wide]**
The EA team is involved in a large number of initiatives and projects	-0.74	0.87	**[Careful-Focus]**
Requirements for considerable consultation before making changes	-0.70	0.98	**[Careful-Focus]**
The university has a large number of policies, or complex policies	-0.68	0.85	**[Careful-Focus]**
Security concerns regarding information and IT infrastructure	-0.66	0.86	**[Security]**
IT processes are not mature	-0.63	1.04	**[Learning]**
No process has been developed for how to perform EA in an agile manner	-0.56	0.86	**[Learning]**
Formal and strict EA process	-0.43	1.01	[Pragmatism]
There is a large amount of documentation to maintain	-0.41	0.85	**[Careful-Focus]**
The EA framework(s) used do not support agility	-0.38	0.64	[Pragmatism]
The EA process is pinned to the university's budgetary cycle	-0.36	0.87	[Pragmatism], **[Leadership]**
EA team works across every aspect of the university	-0.31	0.90	**[Careful-Focus]**

One participant commented on this question indicating that the adoption of the Scaled Agile Framework (SAFe) led to weaken the role of their EA team due to the lack of interest in the architecture requirements:

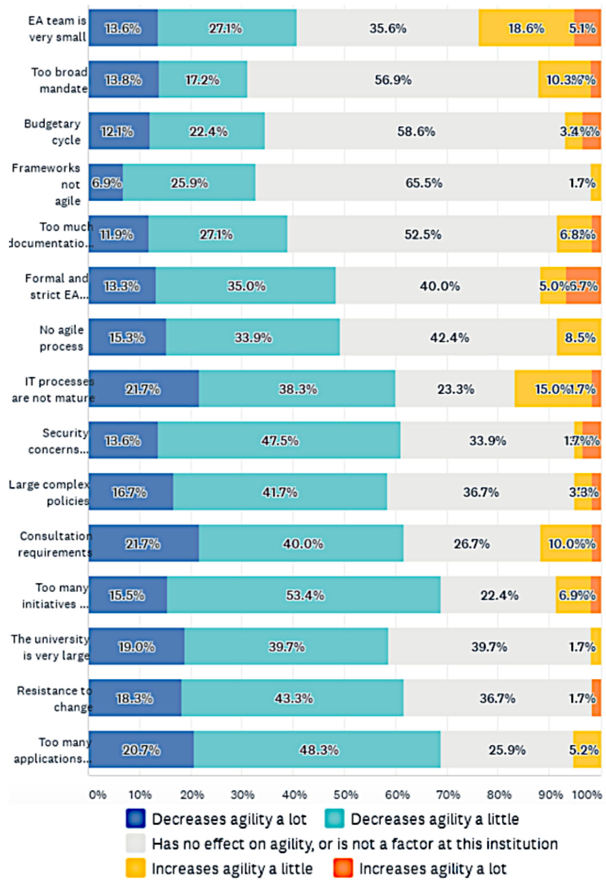

Figure 63 Factors Decreasing Agility of EA (Q46)

"In part it was the adoption of Safe Agile that saw the demise of the EA team. Senior leadership were entranced by the 'pivot' aspect of agile and blind to the architecture runway requirement."

The Scaled Agile Framework (SAFe) is a well-known framework covering the current agile and lean principles. Scaled Agile Inc. released it in 2011, and it targets large companies and large-scale agile projects (Leffingwell et al., 2016). SAFe shows four levels of organization: team, program, value stream, and portfolio (Leffingwell et al., 2016).

SAFe includes architecting like other agile methods. However, organizations still have difficulty adapting their architecture function to an organization that has become more agile because the support related to architecture guidance to develop guidelines for agile development that match the maturity of the organization is still little in this type of agile methods (Duijs, Ravesteyn & van Steenbergen, 2018).

SAFe also provides a number of role definitions. For EA, SAFe describes that enterprise architects should work and communicate with business stakeholders and other architects, and they are also responsible for guiding the EA strategies (Leffingwell et al., 2016). The portfolio level expresses the area of interest of enterprise architects. They should be positively engaged in the portfolio level while ensuring that the enterprise-wide architectural systems, platforms, and infrastructures exist (Leffingwell et al., 2016). The managers and senior leadership find these role definitions are comfortable. Nevertheless, many architects and users consider SAFe too complicated and heavy because it includes all best practices but does not show instructions on scaling them down (Leffingwell et al., 2016).

9.3.2.1 Discussion Regarding Q45 and Q46

The findings of question 45 show that most surveyed institutions consider their EA process either very or moderately agile (with 65.6% of respondents). There is an interest in adopting the agile approach to EA, but some limitations still need to be overcome.

The finding of question 46 identifies the factors contributing most to or detracting most from the agility to the EA process in HE institutions.

The results indicated that the main EA practices that can improve the agility of the EA process in HE institutions could be summarized as:

- Avoiding doing too much and apply the principle of "just-enough architecture" to limit the volume of information to be managed or scale it down by focusing on a limited set of applications, technologies, projects, documentation, policies and processes.
- Using agile software development methods to develop new software at the university
- Not following EA frameworks closely but rather using them as a guide.
- Responding to stakeholders by collaborating with them, making small changes for them quickly, and responding quickly to business units' needs.
- Educating other stakeholders, management and software developers on how to be agile.
- Being pragmatic about how to proceed.

The results also identify some EA practices that could reduce the agility of EA in HE institutions, namely:

- Dealing with a large number of applications and technologies and not focusing on a limited set of them, participating in a large number of initiatives and projects, and having a large number of policies or complex policies.
- Resisting changes from university management, which leads to not responding quickly to requirements and changes. Additionally, there were requirements for considerable consultations before making the changes.
- Having very large universities.
- Increasing the security concerns regarding information and IT infrastructure
- Having immature IT processes.
- Not developing a process for how to perform EA in an agile manner.

9.4 Lessons Learned and Recommendations

The most important lessons from the study reported in this chapter are:

- The grounded theory and some of our questions identify a set of EA practices that are actually followed in HE institutions, but not considered the most effective practices. It identifies which EA practices were, in fact, the most frequent in HE institutions, and it gave us an idea of the way EA has been actually practiced in these institutions, not the way it should be practiced. Other questions help define best practice by indicating the participants' opinions about what has worked well and what has not, particularly regarding agility.
- When deploying EA in HEI's enterprise architects should consider pushing for enterprise thinking, sharing information across systems, and informing business and technology decisions.
- Enterprise thinking focuses on always considering the institution as a whole, with its full breadth of stakeholders and their value propositions, emphasizing effectiveness (more than efficiency), understanding interdependencies, value delivery, institutional leadership and institutional learning, and organizational leadership, and organizational learning.

- Setting up an architecture board and building a community to work closely with other university departments are also practices that should be taken into consideration.
- EA compliance assessments or projects complying with EA principles and standards were not among the practices reported by our participants.
- There were some significant differences by country regarding the EA practices undertaken by HE enterprise architects.
- A slight majority of our participants were neutral regarding the flexibility of their EA process as they said it was moderately agile. There were some interesting country-specific differences in this regard.
- Some aspects contribute to increasing the agility of the EA process in universities, and some aspects that decrease it.
- To increase the agility of the EA process, enterprise architects should avoid doing too much, respond quickly to requirements and needs, and avoid too many different applications and technologies.
- Among aspects that were detracting from EA's agility are resisting changes, dealing with large applications and technology, and having very strict policies in the university.
- The grounded theory results identified some criteria or metrics used to evaluate the EA process in HE institutions, but overall, there is no consistent, systematic process for evaluating EA in HE institutions.
- Enterprise architects should use the list of KPIs we obtained from grounded theory findings to evaluate their EA process
- Examples of criteria or metrics used to evaluate the EA process in HE institutions are following the EA maturity model, using specific KPIs developed by governments, or using some types of metrics, whether financial, rationalization, security, or metrics for all architectures, efficiency and effectiveness of EA, or about the value and benefits of EA. Other examples of the criteria include whether the produced architectures confirmed the principles and standards, the extent to which the customers are happy, and the number of successful projects and

initiatives EA was involved in and the number of projects they acquired EA involved.

Chapter 10 Conclusion

Our preliminary research, and systematic literature review showed that there is a lack of research about EA in the HE domain. In this thesis, our op-level objective was to obtain a deeper understanding of how EA is applied in HEIs and to make recommendations on improving EA practices in this domain. To do this, we followed a sequential mixed methods research process by first using a grounded analysis to explore this area and then constructing a survey to obtain quantitative findings.

Figure 64 illustrates the most important topics we covered in this study.

Our grounded analysis was extensive, and involved many hours of analysed interview transcripts, that generated a rich set of codes for our qualitative results. Our quantitative survey was also extensive, ensuring confidence in our results. We received 115 responses to our survey from 30 countries worldwide: Canada, the USA, the UK, Australia, New Zeeland, Australia, Netherlands, Saudi Arabia, Switzerland, Sweden, Denmark, Cyprus, Spain, South Africa, Finland, Germany, Ireland, India, Iceland, Qatar, Bahrain, Jordan, Lebanon, Singapore, Pakistan, Malaysia, Philippines, Hong Kong, South Korea, and Brazil.

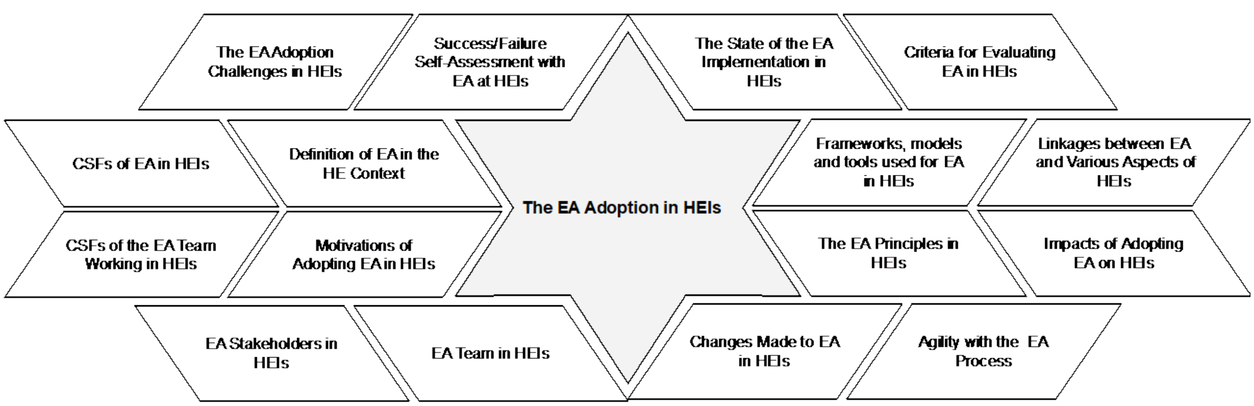

Figure 64 Main themes discovered in this thesis

10.1 Answers to Research Questions

In this section, we provide summaries of the answers to the research questions we asked in Chapter 1. We have three main research questions, each with sub-objectives as below:

Q1. How is EA being used in HEIs, specifically to drive IT strategy, software development or procurement, business processes, and decision-making?

To address this question, we divided it into seven objectives. We summarize the answers to each of them separately through our interviews and survey. Details of the findings can be found in individual chapters.

*a. **Better understand the patterns of usage or development of EA in various institutions***

We achieved this objective in Chapter 5, where we first obtained demographic information about HEIs participating in our study, and their teams, as well as information about the types of institutions and the levels of development and success of their EA work.

Our data confirm the well-established fact that that Enterprise Architecture is widely used in higher education, especially on larger campuses and in countries where it is mandated (such as Saudi Arabia). We received most of the responses from public institutions (91.1%), and most of the institutions are multi-campus (73.5%). Specifically, 34% were from very large universities in the top six countries (based on the number of participants), indicating that they likely need an EA program.

In general, half of our respondents have a full EA program (50.9%). Other participants adopt at least some aspects of EA (30.4%), which indicated the need to have EA in the HE institutions. More than half of the participants said EA has a positive effect, but it is still being actively developed (53.0%). Very few participants said that EA has a significant impact (3.6%).

The sizes of EA teams vary considerably among institutions has an EA team with people between 2 and 3 (36.1%). Regarding the status of the IT team in these institutions, half of the institutions in our survey have a central IT team (50.6%), but some of the EA work is distributed to departments, units, or campuses. None of the top six countries have almost all their IT work distributed.

An EA team can be a virtual architecture team, a distributed team, a team with dedicated and partial members, a more centralized team, and a small and lean team.

The roles played by each member of the EA team are varied. A member of the EA team often has a job title that doesn't specifically say 'EA' even though they are doing EA work. Many members, for example, are simply given the title of architect or senior architect. Some of the architects play multiple roles. External consultants or external enterprise architects do some EA work. Academics or senior administrators also do EA work in some institutions.

EA stakeholders identified in HE institutions are of many types, including CIOs, senior managers, EA managers, IT directors, EA team members, business managers and staff, academic community members, students, strategic partners, individual stakeholders in projects, as well as various boards, committees, and offices.

An important finding is that most institutions participating in our survey plan to put *increasing* effort into EA (68.7%), while only small number of them expect to wind their EA work down (4.8%).

We provided to our participants six potential definitions of EA that can be applied in the HE context. Most of these definitions somewhat apply to EA at the participating institutions. However, the highest percentage of participants agreed that the EA definition from The Open Group (2011) ("A process of understanding the different enterprise elements") most strongly applies to what EA means in the HE domain (30.1%).

b. Determine the motivations and objectives of using EA in HEIs.

Facilitating the alignment of projects with the university's goals and the alignment of business and IT sectors are the most important motivations that stimulate enterprise architects to adopt EA in HE institutions. They also want to enable digital transformation and reduce duplication and leverage of assets. Hardly any of the organizations have an EA mandated by their governments, the exception being in Saudi Arabia. Other important motivations are improving decision-making and reducing the risk of project failure.

Success of EA implementation in EA is best determined by the extent to which communication between different parties in a university improved, and there are tangible benefits, such as reducing costs.

According to interviews, having outdated roadmaps and models, having an immature EA, and not developing or following standards indicates failed implementation of EA in HEIs.

Not thinking seriously about EA and having staff that are too busy with other tasks are reasons why EA may not be implemented in some HE institutions. On the other hand, EA's failures or experiencing them were not perceived to be sufficient reason for not using or implementing EA.

c. ***Explore the use of EA in HEIs to align business needs and IT, support decision-making processes, improve business processes, and enhance both business and software modeling.***

The third objective is to explore the use of EA in HEIs to align business needs and IT, support decision-making processes, improve business processes, and enhance both business and software modeling. We achieved this objective in Chapter 8. We first asked our interviewees a couple of questions to understand the nature of the link between EA and the different aspects of universities.

As to the linkage between EA and IT, we defined five main themes, showing that the linkage varies considerably:

1. There is no link between EA and IT.
2. EA is part of IT.
3. EA is performed or supports the central IT unit at the university.
4. EA is performed or supports within a decentralized IT unit.
5. The EA function focuses on IT.

As to the linkage between EA and software purchasing, we identified nine key themes, showing how this varies among institutions:

1. There is no link between EA and software purchasing.
2. EA influences decisions regarding software purchases and whether or not to enforce some enterprise-wide standards.
3. EA principles need to be followed when purchasing software.
4. Architecture boards are central to EA when purchasing software.
5. EA works closely with the university's IT procurement group.

6. EA provides consultations and support for the procurement unit outside IT.
7. EA suggests procuring off-the-shelf software that does not need any development.
8. EA uses functional requirements or non-functional requirements list when purchasing software.
9. EA impacts selecting the solutions for purchase.

As to the linkage between EA and software development, we identified six key themes, once again showing considerable diversity:

1. There is no link between EA and software development.
2. EA inside the IT department is responsible for software development.
3. EA develops software to comply with standards and principles.
4. EA is involved in developing software because of centrality.
5. EA grows a reliable software development team.
6. EA defines the review process and artifacts to provide the correct detail level to the development team.

As to the linkage between EA and architectural models, we identified three key themes, again showing some diversity:

1. There is no link between EA and the software architecture and modelling process.
2. The EA team designs more artifacts.
3. The EA team communicates with other university groups and requests feedback.

Overall, the diversity in the above indicates that EA in HE, as a discipline, is nowhere near a state where common agreement has been reached.

d. Determine the methods (including frameworks, models and tools) used in EA currently, along with their strengths and weaknesses.

The fourth objective is to identify the methods used to develop EA in HEIs, along with their strengths and weaknesses. We achieved this objective in Chapter 6.

EA is widely used in higher education, especially where there is a well-tailored framework (CAUDIT for Australia and New Zealand and NORA for Saudi Arabia). Most institutions used the TOGAF framework to some extent, although the Gartner approach and CAUDIT

Higher Education Commons also have a significant influence. Some HE enterprise architects also use customizable frameworks adapted from various existing EA frameworks, whereas a few participants do not follow specific frameworks for EA. Knowing which EAFs used in HEIs should help guide enterprise architects in improving their processes and guide tool developers in improving their products.

Some participants mentioned additional frameworks used to develop EA in their HE institutions. Examples include the IT Infrastructure Library (ITIL) framework, HORA, the UCISA EA capability framework and reference models, the PEAF framework, the IAF framework, GEMMA, the Finnish public sector recommendation JHS-179, Visual Architecting Process (VAP), BCS (the Chartered Institute for IT) reference model, IT4IT, and ArchiMate.

The most important models managed by most teams are application models, capability models and data models. This suggests that these are the types of models upon which framework developers and tool developers should most focus. Enterprise architects also tend to make moderate use of the business process models, service models, security models and enterprise models. Following specific EA frameworks may lead to increased use of the models specified by those processes. Other models mentioned by our participants that were not on our survey list include information exchange models, application integration models, operating models, and delivery models.

Notations used for EA modeling include Business Process Model and Notation (BPMN), Unified Modeling Language (UML), the CAUDIT Higher Education EA Reference Architecture, and ArchiMate.

The top four tool types used to represent enterprise architecture, among those who responded to our survey, are presentation tools (e.g., PowerPoint), spreadsheets (e.g., Excel, Google sheets), text editors or word processors (e.g., Word, Google docs, Wikis), and generic drawing or diagramming tools (e.g., Visio, Lucidchart). They are very generic tools that can only describe data, not model it at a deep semantic level. ArchiMate is an EA-specific tool but is used only moderately; the other specialized EA tools are used very little. This suggests that considerable work needs to go into improving tools so as to make them as accessible and usable as basic ‘office’ applications.

Other tools reported by our participants that were not listed in the survey are Essential by the Essential Project, LeanIX, BarometerIT by Changepoint, Configuration Management Database (CMDB), Software AG ARIS (2 users), Visual Paradigm, QPR EA, ProVision by OpenText, Mind Maps, Essential Cloud, SharePoint Repository and ITSM Tools.

Regarding the strengths and weaknesses of EA tools and frameworks used in HEIs, it is clear that HE enterprise architects are looking for frameworks that align with higher-education needs. They are motivated by a desire to facilitate the alignment of business and IT and associated projects. They also want to enable digital transformation, reduce duplication and leverage assets. Some participants used specific frameworks because they are required to do so, such as the NORA framework.

The most common aspects of tools that are considered advantageous for their adoption and use are: ease of use, cost effectiveness, and the ability to support collaboration. All four of the office suite tools were liked roughly equally for these three reasons.

The least liked aspects of the most-used tools (i.e., office tools) are 1) the absence of validation of models and diagrams, 2) the inability to manage EA-specific representations, 3) lack of integration with a central repository, and 4) lack of support of EA standards. Key difficulties of EA tools of all types are that a) it tends to be hard to keep models up to date, b) there is a lack of automatic population of data to help ensure architectural models are accurate, c) there is a lack of integration among tools, d) there is a lack of a central repository, and d) there is a lack of data validation. All four of the office suite tools were disliked roughly equally for these reasons.

One of the most important recommendations from our research is that tool and method developers must address the above weaknesses and dislikes while improving or maintaining the advantageous aspects of tools. There is a significant opportunity to develop such tools, or perhaps enhance existing tools (such as Archi or Enterprise Architect), so they have the desired qualities.

Q2. How well does EA work for HEIs and what are the tangible and intangible results of implementing EA effectively in the HE context?

To address this question, we divided it into three objectives and responded to each of them separately.

a. Determine the impacts of using EA in HEIs.

The first objective for this research question is to determine the benefits and impacts of using EA in HEIs. We achieved this objective in Chapter 8. We identified the benefits of adopting EA from the literature review in Table 4, Chapter 3. Below is a summary of the main benefits of EA to HEIs mentioned in two or more studies, which are:

- EA helps senior management make better-informed decisions.
- EA enables different groups at the university to speak a common language.
- EA improves business-IT alignment and interoperability.
- EA makes the university agile and adaptive.
- EA helps improve the university processes by providing a set of methodologies, tools, and models for identifying, analyzing and improving existing business processes.
- EA helps reduce the complexity of system and architecture management, which reduces the risks of managing the systems of architecture.

EA also affects various aspects of HEIs, whether positive or negative, but the impact that participants in our qualitative and quantitative studies reported is mostly positive. Significantly, EA impacts the IT-business alignment in the HE institutions, software procurement and development, decision-making, budget, and re-organization of the universities' different units. Most of the participants said that EA positively affects the alignment of IT strategies with the university's mission and goals, and its security. EA did not significantly the purchase of supplies or assets (other than software).

b. Identify the challenges and critical success/failure factors of using EA in HEIs since implementation.

The second objective is to identify the challenges and critical success/failure factors of using EA in HEIs since implementation. We achieved this objective in Chapter 8. Half of our participants consider resistance to change the most critical challenge facing HE enterprise architects. The participants also consider the lack of awareness of EA and the lack of understanding of the different stakeholders among the most critical problems facing HEIs. After all, they may lead people at the universities to resist implementing EA because they misunderstand the value and benefits. Identifying the EA adoption challenges helps guide HE enterprise architects to be proactive and improve their processes to avoid and resolve them.

The lack of awareness and readiness, the lack of perceived value and benefits, EA complexity, EA immaturity, and university police rigidity are among challenges we identified in our empirical studies that were not highlighted in prior literature.

The use of EA methods, tools, standards and frameworks, and the lack of high-level guidance from ministries of education are among the challenges mentioned in the literature review but were not mentioned by our interviewees.

The majority of our participants consider supporting the university's mission and goals as the most critical factor in EA's success in HEIs.

Collaboration between different university groups, support for the university's mission and goals, the added value of the institution, and availability of data are additional influencing factors that have not been discussed in the literature review.

The literature we examined in our systematic literature review lacks any studies investigating the critical success factors for individual EA team members in HEIs. Our study contributes to identifying a list of these critical factors. The most prominent factor for the EA team's success is that the EA team members should have good interpersonal skills.

c. Investigate the changes that might be made to improve the process of EA in HEIs.

We achieved this objective in Chapter 9. A set of EA practices are widely followed in HEIs, but some are not considered the most effective practices. the top practices that enterprise architects should consider when implementing EA in HE institutions include pushing for enterprise thinking, sharing information across systems, and informing business and technology decisions. Setting up an architecture board and building a community to work closely with other university departments are also practices that should be taken into consideration.

Q3. Is the agile approach being adopted to the traditional Enterprise Architecture in HEIs? What the aspects that contribute to increasing or decreasing the agility of EA?

To address this question, we divided it into three objectives and responded to each of them separately. First, we found that some participants have adopted certain aspects of the agile approach in their EA process. From our grounded theory findings, we summarized the main themes that describe the various aspects impacting the agility of the EA process in HEIs, as shown in Section 9.2.2.

Based on the survey results, we came to the conclusion that the slight majority of participants are neutral regarding the flexibility of their EA process and they consider it to be only moderately agile. Among aspects contributing to increased agility of EA are avoiding doing too much, focusing on responding quickly to requirements and needs, communicating and collaborating with stakeholders, and being pragmatic. Among aspects detracting from EA's agility are resistance to change, dealing with large applications and technology, as well as having overly-rigorous university policies.

In addition to answers to our core research questions, we uncovered several other threads of knowledge in our research. These are outlined in the next subsections.

10.2 Other Themes discovered in Our Thesis

10.2.1 EA principles in HEIs

We addressed this topic in Chapter 7. We define three categories of EA principles to guide the EA process at HE institutions: General, data management principles, and technology management principles.

The alignment of decisions and architecture with the university's strategic mission, vision, and values and increasing the benefits to the university' are the most important general EA principles in HEIs. All other general EA principles are applied either formally or informally because they are similar to the list of EA principles that HEIs have, or they are very important.

One of the general EA principles is being agile. It is applied by more than half of the participants, which indicates the importance of having an agile EA.

Moreover, HE enterprise architects applied all the 8 data principles on a different scale. They guide and govern data used within the HEIs and inform how to process, manage, store and access the data.

The two principles that are the most important data principles in HEIs are ‘Data is kept secure, and security risks are managed’ and ‘Data is an asset.’ ‘Data is reused: duplication of data should be avoided’ is an important data principle that is not found in the literature review despite its importance.

Besides, one of the most critical technology management principles applied by most HEIs is to ensure the interoperability of technological components. Using cloud-based technology first is also an important technology management principle. The least important principle is to prefer open solutions to commercial solutions.

The seven new principles added by our participants are:

1. An EA Team should operate as an advisory board and business owners should make decisions.
2. A risk-based process should be followed when making decisions.
3. User experience should drive whole ecosystem system approach.
4. Data should be analyzable.
5. Process change should be considered before technology.
6. The life cycle perspective should be considered in information technology.
7. COTS (Commercial-Off-The-Shelf) and SaaS landscape (Software as a Service) should be obtained to interoperate.

We identified seven main general reasons that made people in universities resist following EA principles from the participants’ point of view. They are the lack of understanding of EA and the EA principles, the lack of management support, the independence of work and decision-making in departments and faculties, the failure to apply and interpret EA principles correctly, the misalignment of designs with business goals, constraints, and risk mitigation, the misalignment between business and IT, the resistance to comply with standards and policies, and the lack of resources.

We also identified some examples of resistance of the technology and application principles by some of our participants, which are: resistance to the 'buy before build' principle, resistance to the 'comply to technical standards' principle, resistance to the 'common use applications' principle, resistance to the 'good enough solutions' principle, unwilling to get committee or board's approval, use of the vendor-supported products, and use of the quick win solutions.

The EA principles do not reduce the flexibility of an architecture; on the contrary, the highest percentage of respondents believed that EA principles would increase the architecture's flexibility.

10.2.2 Criteria used to evaluate the EA process in HEIs

We address this topic in Chapter 9. We asked our interviewees if they used any method to evaluate their EA process. The findings revealed that there was no specific method for systematically evaluating the EA process in most institutions. However, some of our interviewees used various criteria, KPIs, or measures to evaluate their EA process. We summarized the findings of the grounded theory about the EA process evaluation can be summarized into four main opinions, as we provided in Section 9.2.3.

10.3 Validation of Research Results

A number of forms of validation are built into the grounded theory methodology itself such as the constant comparison method and the collection of data until saturation. Our grounded theory itself was internally validated by reaching saturation. Few new points were being received from broad coverage of institutions. As for coding, it is a subjective process that depends on the experiences, expectations, and perceptions of the coders who interpret the transcripts of the interviews. In our study, we applied coding for an exploratory purpose, and the coding was implemented by the student and verified by the supervisor as a means of internal validation to increase the reliability of the theory during its building. Codes were not validated with interviewees themselves. However, we later designed the survey based on the grounded theory findings. Then we distributed the survey to a larger group of participants around the world, including most of those with whom we conducted interviews, to validate the results of the grounded theory.

10.4 Tags Created During This Study

We have created a set of tags based on the definitions of enterprise architecture, motivations, practices or changes, enterprise-thinking, and agility. These tags are also applied to other questions in the survey. The purpose of the tags is to find cross-cutting issues that connect various questions we asked and to assist in drawing further conclusions.

Table 54 shows the tags with the highest frequencies among others in this study: ‘stakeholders-collaboration’ as implied in the definitions of EA and the proposed EA practices for HEIs. Also, considering the EA stakeholders and their needs and collaborating with them contributes to increasing EA agility in HEIs. The second most frequent tag is ‘value delivery,’ which indicates how EA adds value to the enterprise. It was repeated in the definitions of EA, EA practices, and the factors that contribute to or detract from the agility of EA in HEIs. ‘Institution-wide’ and ‘effectiveness’ come third in terms of the highest frequencies.

Table 54 Tags extracted from the EA definitions, motivations, practices or changes, enterprise-thinking, and agility

Tag	Details	Frequency				
		Table 17*	Table 18**	Table 52***	Table 53****	Table 54*****
Institution-Wide	The meaning of is ‘institution-wide’ is the carrying out of work throughout an institution. This term has been used for ***the definition of EA*** as it means understanding the different interrelated elements of the enterprise and leading the enterprise responses proactively and holistically. It has also been used to describe ***the changes made to EA*** as it describes pushing for “enterprise thinking,” sharing information across different systems, setting up an architecture board, and building a community to work closely with other university departments. It has also been used to describe ***factors that contribute most to EA’s agility*** as having a vision for adaptability for the whole university and having a very large university with multiple departments increase agility.	2	0	4	2	0
Strategic-Information-Base	This term is used for ***the definition of EA*** as it implies a strategic information asset base that digitally representing the business and IT landscape of the institution to support its competitive strategies.	2	0	0	0	0

Tag	Details	Frequency				
		Table 17*	Table 18**	Table 52***	Table 53****	Table 54*****
Recognizing-Interdependence	The meaning of 'recognizing-interdependence' is the recognition of the interdependence between the different elements of the enterprise. This term is used for ***the definition of EA*** as it is describing the interrelated elements of the enterprise. It has also been used to describe ***the changes made to EA*** as it describes pushing for "enterprise thinking," increasing the ability to share information across different systems and increasingly informing technology and business decisions.	1	0	3	0	0
Stakeholder-Collaboration	This term is used for ***the definition of EA*** to imply that EA is acting as collaboration force between various aspects to meet the institution's stakeholders' goals. This term is also used to describe ***the changes made to EA***, including pushing for "enterprise thinking," setting up an architecture board and making it open to everyone, building virtual groups of teams of architects and business analysts that working as a service unit, having more meetings with stakeholders and team members, building a community to work closely with other university departments, becoming more motivated by visions derived from business units, and adopting a more agile approach to EA. This term is also used to describe ***the factors contributing most to EA's agility***, including working in an agile way and considering stakeholders when developing new software and being driven by business issues and responding quickly to the different business units' needs.	2	0	10	2	0
Value-Delivery	'Value delivery' is how EA adds value to the enterprise. This term is used to ***define EA*** as EA is used to create value in the organization and achieve the desired vision and outcomes. It is also used to describe ***the changes made to EA***, including pushing for "enterprise thinking," increasing the ability to share information across different systems, adopting a more agile approach to EA, and better defining EA program needs and goals. It is also used to describe ***the factors contributing most to the EA agility***, including depending on business issues and responding quickly to the business units' needs, using agile software development methods to develop new software, having the EA team working sprints and carefully prioritizing tasks. It is also used to describe ***the factors detracting most to the EA agility***, as the EA team considers many applications and technologies that may cause delayed results and thus not deliver the desired value.	2	0	4	4	1
Effectiveness	This term 'effectiveness' denotes that EA helps achieve the business goals and the collective goals of the enterprise. It is used to describe ***the changes made to EA***, including becoming more motivated by visions derived from business units, pushing for "enterprise thinking," increasing the ability to share information across different systems, making the EA process more disciplined, adopting a more agile approach to EA, increasing focus on information and technology management, moving from being reactive to being proactive, acquiring new skills, and deepening, broadening or increasing the validity of the overall architecture. It is also used to describe ***the factors contributing most to the EA agility*** as the EA team uses agile software development methods to develop new software which increases the EA effectiveness.	0	0	9	1	0

Tag	Details	Frequency				
		Table 17*	**Table 18****	**Table 52*****	**Table 53******	**Table 54*******
Better-Decision-Making	EA is used to improve the decision-making process by enabling it to be data driven. Some of ***the changes made to EA*** to improve the decision-making process are increasingly informing technology and business decisions, setting up an architecture board, and having more meetings with stakeholders.	0	1	3	0	0
Automation	The 'automation' is used for ***the definition of EA*** as EA is a digital representation of the institution's IT and the business, is a strategic information asset base, and acts as a collaboration force between business planning, business operations, and automation. One of ***the motivations*** for using EA is to enable digital transformation and improve automation. This term is also used to describe ***the changes made to EA*** as it increases the sharing of information across systems by improving automation.	3	1	1	0	0
Learning	This term 'learning' is used for ***the definition of EA*** as it means understanding the different elements of the enterprise. It is also used to describe ***the changes made to EA***, including pushing for "enterprise thinking," acquiring new skills, and deepening, broadening, or increasing the overall architecture's validity. It is also used to describe ***the factors detracting most from the EA agility*** as there is resistance to change in university management, IT processes are not mature, and EA is not developed in an agile manner.	1	0	3	0	3
Change-Management	The term 'change-management' is used for ***the definition of EA*** as it implies managing the changes between the current and future states, using new technologies to respond to the change of mission needs, and identifying and analyzing the execution of change toward desired business vision and outcomes.	3	0	0	0	0
Quick Change	The term 'quick change' is used to describe ***the changes made to EA*** by adopting a more agile approach to EA. It is also used to describe ***the factors contributing most to the EA agility*** by using agile software development methods to develop new software, working in sprints, and responding quickly to business units' needs.	0	0	1	3	0
Flexible-Adaptable	The term 'flexible-adaptable' is used to describe ***the changes made to EA*** by adopting a more agile approach to EA to be more adaptable and flexible. It is also used to describe ***the factors contributing most to the EA agility*** by being more flexible in following EAFs, having a vision for adaptability in the university, and having a flexible mindset regarding adopting new technologies.	0	0	1	3	0
Pragmatism	The term 'pragmatism' implies accomplishing goals in less time with fewer resources. It is also used to describe ***the factors contributing most to the EA agility*** by applying the "just-enough architecture" principle to limit the volume of information managed or scale it down, using agile software development methods to develop new software, not following EAFs closely, and developing EA in a stepwise and pragmatic manner. It is also used to describe ***the factors detracting most to the EA agility*** as following a formal and strict EA process, using EAFs that do not support agility, and linking the EA process to the university budget cycle is not a pragmatic way to develop EA.	0	0	0	4	3

Tag	Details	Frequency				
		Table 17*	**Table 18****	**Table 52*****	**Table 53******	**Table 54*******
Leadership	The term ‘leadership’ is used to ***define EA*** as EA leads enterprise responses to disruptive forces. It is also used to describe ***the changes made to EA*** by pushing for “enterprise thinking,” moving from being reactive to being proactive, adjusting from working mostly on projects to leading strategies, and getting more support from the university’s leadership. It is also used to describe ***the factors detracting most to the EA agility*** because there is resistance to university management change due to the lack of understanding EA. Also, the EA process is pinned to the university’s budgetary cycle, which reduces learning resources.	1	0	4	0	2
Management	The term ‘management’ is used to describe ***the changes made to EA*** by increasing the focus on information and technology management. It is also used to describe ***the factors detracting most from the EA agility*** because there is resistance to change in university management.	0	0	1	0	1
Systematic	The term ‘systematic’ is used to describe ***the changes made to EA*** by making the EA process more disciplined and systematic and formalizing rules and responsibilities. It is also used to describe ***the factors contributing most to the EA agility*** by using agile software development methods to develop new software, developing EA in a stepwise and pragmatic manner, working in sprints, working towards a more streamlined process with fewer tools, and carefully prioritizing tasks.	0	0	2	5	0
Formalizing	The term ‘formalizing’ is used for ***the definition of EA*** because EA is a formal description of the current and future state(s) of an organization. It is also used to describe ***the changes made to EA*** by making the EA process more disciplined, formalizing rules and responsibilities, and better defining EA program needs and goals.	1	0	3	0	0
Reflection	The term ‘reflection’ is used to describe ***the changes made to EA*** by formalizing rules and responsibilities, better defining EA program needs and goals, focusing more on key investments, having more meetings among team members, doing a lot of self-evaluation and self-assignment, and reviewing the terms of reference.	0	0	7	0	0
Careful-Focus	The term ‘careful-focus’ is used to describe ***the changes made to EA*** by adopting a more agile approach to EA, increasing focus on IT management and on application and technology domains within IT unit(s), having more focus on key investments, better defining EA program needs and goals, and working in sprints. It is also used to describe ***the factors contributing most to the EA agility*** by applying the “just-enough architecture” principle to limit the volume of information managed or scale it down, using agile software development methods to develop new software, working in sprints, working towards a more streamlined process with fewer tools, and carefully prioritizing tasks. It is also used to describe ***the factors detracting most to the EA agility*** by considering a large number of applications and technologies, having a huge university, involving in a large number of initiatives and projects, requiring considerable consultation before making changes, having a large number of policies, or complex policies, having a large amount of documentation to maintain and working across every aspect of the university. 18	0	0	6	5	7

Tag	Details	Frequency				
		Table 17*	Table 18**	Table 52***	Table 53****	Table 54*****
Expanding	The term 'expanding' is used to describe ***the changes made to EA*** as the aim is to grow the EA team substantially.	0	0	1	0	0

* Table 17 refers to the definitions of EA in HEIs.
** Table 18 refers to the motivations for undertaking EA in HEIs.
*** Table 52 refers to the changes made to EA.
**** Table 53 refers to the factors contributing most to agility of EA.
***** Table 54 refers to the factors detracting most from agility of EA.

10.5 Summary of Contributions

The main contributions of this thesis are to provide a descriptive analysis of the use of EA in HEIs and to make some recommendations about how EA could be improved.

The results of this thesis discover the various aspects of the EA adoption in the HE institutions, including:

- The most appropriate definition of EA in the HE domain.
- The motivations and objectives for using EA.
- The frameworks, tools and models used to develop EA in HEIs, with recommendations about where improvements could be made.
- The challenges and obstacles for the EA adoption in HEIs, which should lead to efforts to overcome the challenges and obstacles
- The factors that lead to the successful EA adoption in HEIs, which others should emulate to have success.
- The factors that help the EA team members to succeed.
- The EA practices in HEIs, so new HEIs embarking on EA can better understand what they need to do.
- The factors contribute to or detract from the agility of EA in HEIs, leading to ideas for teams to follow in order to improve their agility.
- The criteria or measures used to evaluate EA in HEIs, which could be adopted by teams to evaluate their EA.
- The indicators of the successful/failure implementation of EA in HEIs.

We provide a set of recommendations and lessons learned in each chapter of this thesis to help HE enterprise architects realize the strengths and weaknesses of implementing EA in their institutions.

10.6 Threats to Validity

As discussed earlier, we followed an exploratory sequential mixed methods design (interviews and survey) to conduct this research. We chose this research design because of the lack of research in the field of EA in HEIs. As well, the research problem is more qualitatively oriented because we wanted to obtain more complete and corroborated results by using a combination of qualitative and quantitative data.

Zohrabi (2013) identified the four areas of threats to validity that may face researchers who conduct mixed-method research. The following are some of the threats to validity to be taken into consideration.

10.6.1 Content Validity

To achieve content validity, it would be necessary to ensure that we have comprehensively covered each topic such that we are achieving consistent results and have not left important gaps by not talking to a sufficiently diverse set of people or by asking questions that only cover some aspects of a topic.

To ensure this, we conducted interviews with a wide variety of people responsible for EA in their HE institutions and distributed the survey a very broad possible group of the targeted audience.

The interview questions were carefully prepared in advance, based on our literature review results. The questions were reviewed, and potentially unclear and ambiguous questions were reformulated, and other questions were deleted or added. During the interviews, we reinterpreted questions that proved to be unclear, and we asked additional questions to ensure we understood the interviewees' views of points. During the interview phase we updated the questions between interviews to obtain better clarity, as is a normal tactic in the grounded theory approach.

The scope of questions in the survey was derived directly from the interviews, so should have good content validity.

There is still some residual threat to content validity: The set of topics is very broad, and we may not have been able to cover every angle. Indeed, in freeform answers to the survey, some of the participants added answers that we had not considered. But this did not occur extensively.

Moreover, it might be that the people who talked to us in our interviews and responded to our surveys have perceptions about their practice that might not be accurate if measured using objective measures.

10.6.2 Internal validity

Internal validity ensures that the research results are consistent with reality; in other words, we need to be sure that our findings are not affected by systematic bias. The following methods were applied to enhance the internal validity of the research data and tools:

1. ***Triangulation to enhance the validity of data and results***

We collected qualitative and quantitative data using various sources, interviews, and surveys to confirm our findings. In the discussion section at the end of each chapter, we clarified how the qualitative and quantitative data we collected corroborated our research results.

2. ***Member checks***

We created the survey based on the interviews' results and distributed it to most of the interviewees, plus many others.

3. ***Peer examination***

The research data and results were reviewed and commented on by the research supervisor, who was familiar with the topic under study and had sufficient background information.

4. ***Researcher bias***

We conducted interviews with 21 participants from different countries. We needed critical mass to obtain sufficient information to build a grounded theory, and the number of our interviewees (21) was sufficient. Creswell and Plano Clark (2011) suggested that it would be typical for the grounded theory to have between 20 and 30 participants. In the second phase, we distributed the survey to 229 HE institutions worldwide, and we received responses from 115 participants, including most of our interviewees.

The researcher tried to collect, analyze and interpret the data with the greatest possible impartiality, and the results were discussed and reviewed with a second party (the research supervisor) to ensure that the researcher was not biased.

10.6.3 External Validity

External validity means, "the applicability of the results to other places or with other topics," according to Zohrabi (2013). The question is that: can we generalize our research findings to a broader population? In other words, if our work has external validity, then people in institutions other than those involved in the interviews or survey should be able to consider it likely valid for them

Our study is intended to provide people who work on EA in the HE context with useful and accurate information to improve their EA process in their HE institutions.

Higher education institutions are similar in three core activities: learning, teaching and research, and they differ in other aspects such as their size, centralization, number of departments, colleges and campuses, whether they are private or public, and others. Accordingly, the adoption of EA in HE institutions may differ, and the problems they might face during that and the benefits they obtain also differ.

In this thesis, the survey covered a wide range of universities in several important world regions. Its validity was enhanced by the balance among countries, campuses of different sizes and various other factors. However, we were not able to reach universities in south and east Asia or Africa. We sent them emails and tried to contact them but got no response. There are also important country-specific differences in some parts of the survey. We focused on comparing the results from six countries: the US, the UK, Canada, Saudi Arabia, Australia, and New Zealand because we received significant responses from the HE institutions there in addition to our ability to interview people from these countries. We provided confidence intervals to compare the responses in particular countries. We provided an archive "Enterprise Architecture in Higher Education Institutions Survey Data Summaries" of the statistics of this study to the readers to do a more in-depth analysis and verify our results (Alghamdi & Lethbridge, n.d.). Hence, we can say that this study's results can be generalized to other HE institutions with slight limitations.

10.7 Future Work and Recommendations

The work presented in this thesis could be extended in several directions.

We suggest defining the most important aspects of similarities and differences in higher education institutions from various countries around the world and creating a general framework that contains all the important results of adopting EA that we obtained from this study and testing its effectiveness by circulating it to a number of HE institutions around the world that intend to adopt EA soon. For example, we noticed that all Saudi HE institutions that participated in our survey (100%) have a full EA program and plan to increase efforts in this area, whereas, in Canada, only 40% have a full EA program so far. That could be because the Saudi institutions were mandated by the government to adopt EA, as 67% said that this motivation is very important or absolutely essential. In Canada, only one (10%) said it is a very important motivation. The Saudi institutions also follow the NORA framework developed by the government to implement EA to enable the digital transformation. 100% of NORA users (all in Saudi Arabia) said they use it because they are required to. In contrast, none of the Canadian HE institutions said they were required to use a specific framework.

Our research results identified the most important tools used by HE enterprise architects to develop EA. In the future, we suggest developing these tools based on our findings that clarify the most important characteristics that are desired and not desired by the participants. More specifically, we recommend tool vendors to:

- Make their tools work as well as or integrate well with spreadsheets, generic drawing tools, word processors and presentation tools. We found that these are by far the most commonly used tools for managing and documenting EA in HE institutions (see Section 6.2.3 and Section 6.3.1.3).
- Ensure ease of use, cost-effectiveness, and collaboration when developing tools for use by enterprise architects in HE institutions (see Section 6.2.3 and Section 6.3.1.3).

- Develop tools that ensure the ease of keeping the models up-to-date, enhance the automatic population of data, improve integration between tools, provide a central repository, and ensure data validation for HE enterprise architects (see Section 6.2.3 and Section 6.3.1.3).

The grounded theory results do not focus on the types of analyses of models performed by EA tools. In the future, it would be good to focus on this.

We suggest building, partly extending, changing, or validating a domain-specific EA framework tailored for HEIs based on the literature review and the findings of this study. This common EA framework should include a set of reference models/templates of the different layers of HEIs, a method of developing and creating EA, and a set of tools and notations to be used. Oderinde (2010) stressed the need for doing more research on "the feasibility of formalized frameworks and components of EA specifically tailored to suit the structure of HEIs." Then, we suggest arranging for the adoption this framework by a number of HE institutions to test its effectiveness; this would presumably need to be co-ordinated by a government agency or university consortium, since an individual research team would not be able initiate such an intervention.

The results of this study identified the most important EA principles applied in HE institutions (see Section 7.2.2), their impacts on architecture, and the most important reasons for resisting applying them. We suggest doing more research on this topic.

In the first stage of this research, we found some criteria to evaluate the EA process in the HE context. We suggest further evaluation of it.

We identified the most important models frequently used by HE enterprise architects. It will be useful in the future to focus on comparing the models from more than one HE institution and trying to produce models that may be used as a reference for HE institutions with the possibility of changing them.

We presented the most reliable definition of EA by HE institutions. The highest percentage of our participants strongly apply the definition of EA provided by The Open Group (2011) into their institutions: 'A process of understanding the different enterprise elements.' It will be useful to do more research on this topic in the future.

One of the important topics that we dealt with in this study is the agility of EA in HEIs. We determined the most important aspects that may contribute to the agility of EA, including avoiding doing too much by applying the principle of, “just-enough architecture,” using agile software development methods to develop new software at the university, and not following EA frameworks too closely (see Section 9.2.2 and Section 9.3.2.1). We also defined the most important aspects that may detract from the agility of EA, and hence should be addressed by management. These include dealing with too many applications, technologies, and policies, as well as resistance to change from university management. Being a very large university also detracts from agility, as would be expected; however, nothing can be done about size.

In the future, it will be useful to create, adapt and validate an adoption method for Agile Enterprise Architecture (AEA) that is applicable for HEIs based on the literature review and the findings of our research.

We suggest conducting several case studies in different countries to validate the outcomes of our studies.

In this thesis, we did not address other domains such as finance companies, governments, nor did we compare them and the domain of HE. However, it may be useful in the future to conduct similar surveys in these other domains as this would provide a reasonable basis for comparing the extent to which enterprise architects work in similar manners in different industries.

We encourage communication, exchange of experiences, collaboration, and having more meetings between enterprise architects in the HE domain, especially between HE institutions that have a strong EA program and disseminating research on this regard to learn and be better in this field.

We have in preparation and aim to submit papers on:

- Enterprise Architecture Processes in Higher Education Institutions with a Focus on Agility.
- Towards a systematic approach to compare and select the EA frameworks.
- Systematic literature review on the state of using EA in HEIs.

- The Enterprise Architecture Principles Applied by Higher Education Institutions.
- The Outcomes, Challenges, and Critical Success Factors of Adopting EA in Higher Education Institutions: Exploratory Mixed Methods Research.

Glossary

Terminology	Definition	Reference
Postsecondary Education	"Formal education at a higher level than secondary school. In Canada, includes both degree and non-degree education," quoted verbatim from (CICIC, 2011)	(CICIC, 2011)
Higher Education	"Higher education is divided into three levels of study: 1. The first level (or undergraduate level, usually completed over three or four years) generally leads to a bachelor's degree. 2. There are two types of second, or graduate, levels: a. A master's degree issued following completion of a program that usually takes one to three years of study. b. A diploma or certificate program that usually takes one year to complete. 3. The third level (minimum three years of full-time study) introduces students to scientific research and prepares them for a career in research. Students can obtain a doctorate (Ph.D.)," quoted verbatim from (CICIC, 2011)	(CICIC, 2011)
Higher Education Institution (HEI)	"An institution of higher education that grants its own degrees and normally undertakes the creation and extension of knowledge through research and scholarly activity, and the dissemination of knowledge through teaching, publication, and presentation," quoted verbatim from (CICIC, 2011)	(CICIC, 2011)
Institute	"An organization for carrying out particular work, as of literary, scientific, or educational character. Often it is a research organization or a professional body, or part of a university or other institution of higher education, either as a group of departments (similar to a faculty) or an autonomous educational institution," quoted verbatim from (CICIC, 2011)	(CICIC, 2011)
Enterprise Architecture (EA)	"(i) A formal description of the current and future state(s) of an organisation, and (ii) A managed change between these states to meet organisation's stakeholders' goals and to create value to the organisation," quoted verbatim from (Syynimaa, 2015a)	(Syynimaa, 2015a)
	"(iii) The various structures and processes of an organization, including both technical structures and processes as well as business/domain structures and processes," quoted verbatim from (Ambler, 2009)	(Ambler, 2009)
Enterprise Architecture Framework (EAF)	"A logical structure for classifying and organizing the descriptive representations of an Enterprise that are significant to the management of the Enterprise as well as to the development of the Enterprise's systems."	(Zachman, 1996)
Agile Enterprise Architecture (AEA)	"A flexible, easily extended, and easily evolved collection of structures and processes upon which your organization is built" quoted verbatim from (Ambler, 2015)	(Ambler, 2015)
Enterprise architect	"Someone who is responsible for identifying, communicating, and evolving the enterprise architecture," quoted verbatim from (Ambler, 2015)	(Ambler, 2015)
Enterprise architecture model (EAM).	"A representation of those structures and processes. A good enterprise architecture model will depict the organization both as it is today and as it is envisioned in the future and will map the various views representing the architecture to one another. These views include both business-oriented perspectives as well as technical perspectives. In many ways enterprise architecture models are a communication bridge between senior business stakeholders and senior IT professionals," quoted verbatim from (Ambler, 2015)	(Ambler, 2015)

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Appendix A Electronic Databases Used in Systematic Literature Review

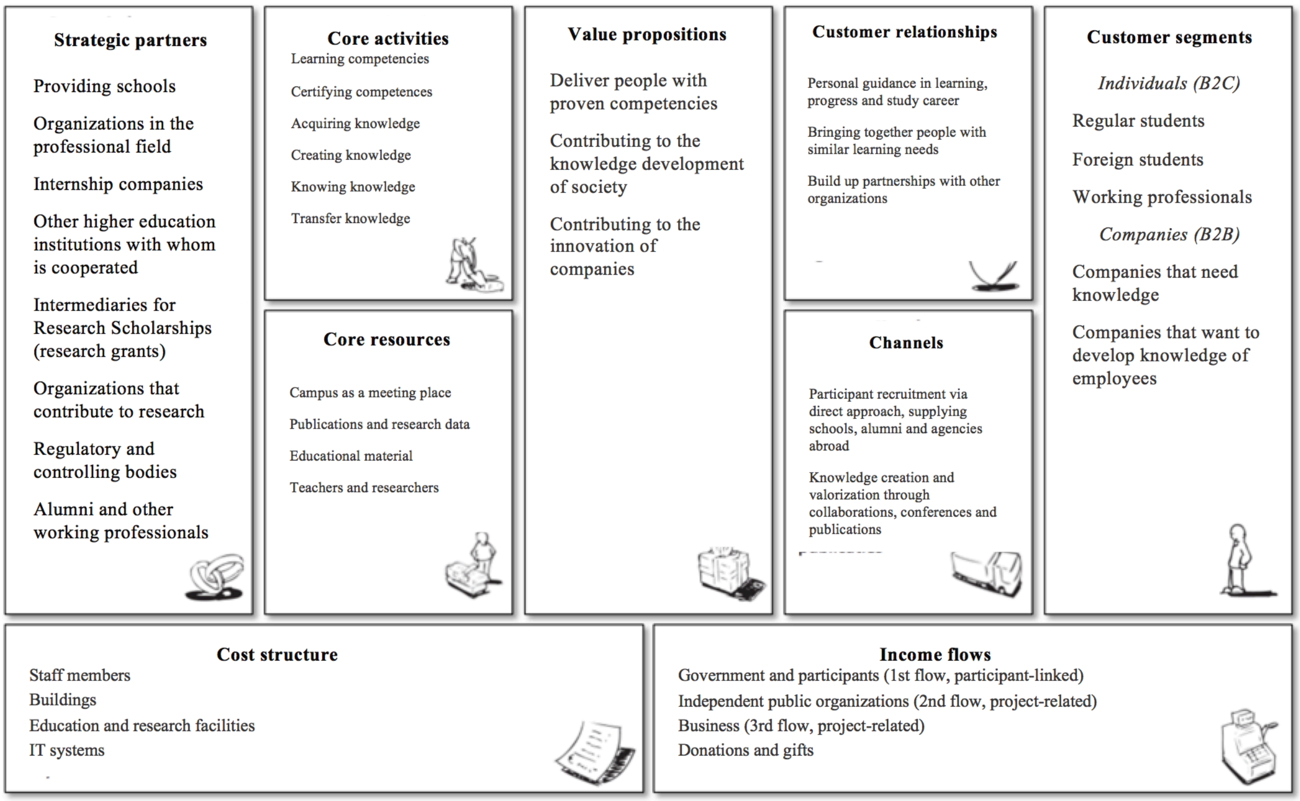
Table 55 Digital libraries used in SLR

Database	Address
Science Direct (Elsevier)	http://www.sciencedirect.com
ABI/Inform (ProQuest)	http://proquest.umi.com
IEEEXplore	http://ieeexplore.ieee.org
Scopus	https://www-scopus-com
Google Scholar	http://scholar.google.com
SpringerLink	https://link.springer.com
Web of Science (ISI)	http://www.isiknowledge.com
ACM	http://portal.acm.org
EBSCOhost	http://search.ebscohost.com
JSTOR	http://www.jstor.org

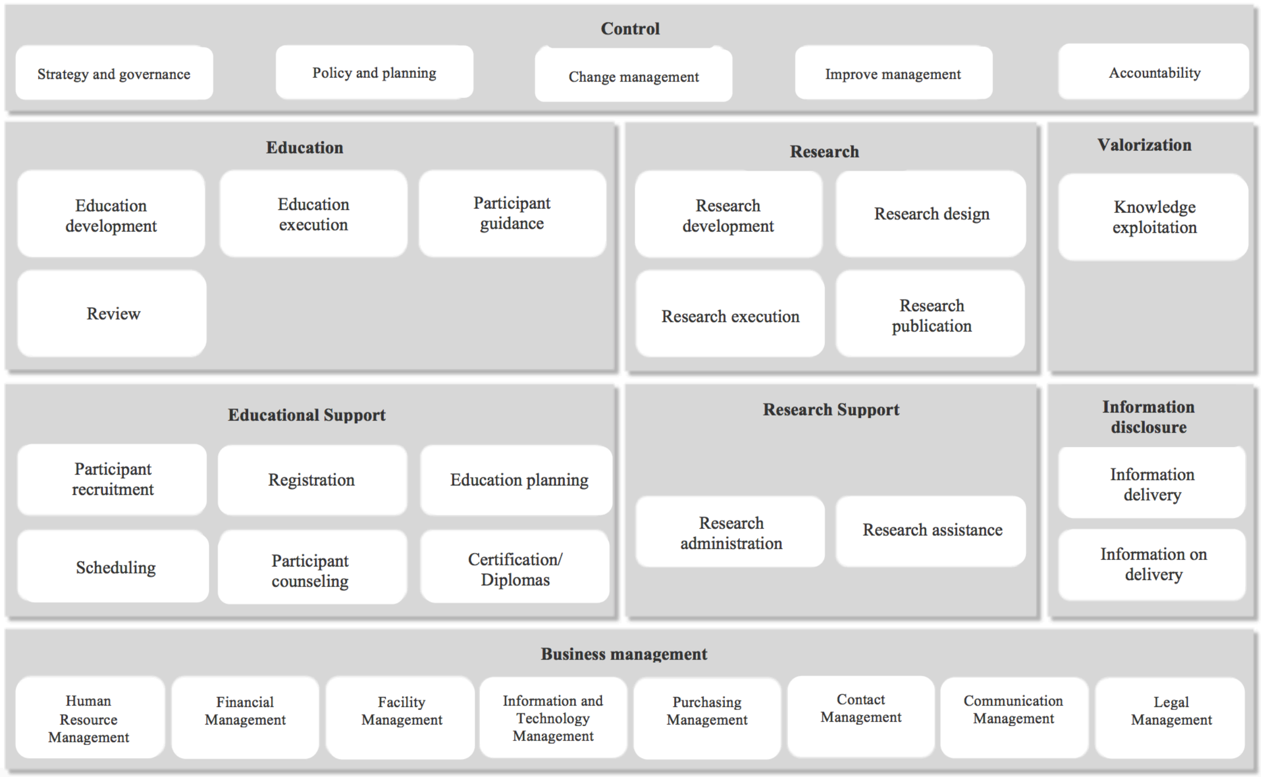
Appendix B Reference Models (translated from SURF, 2013)

B.1: Reference models of the business architecture (translated from SURF, 2013)

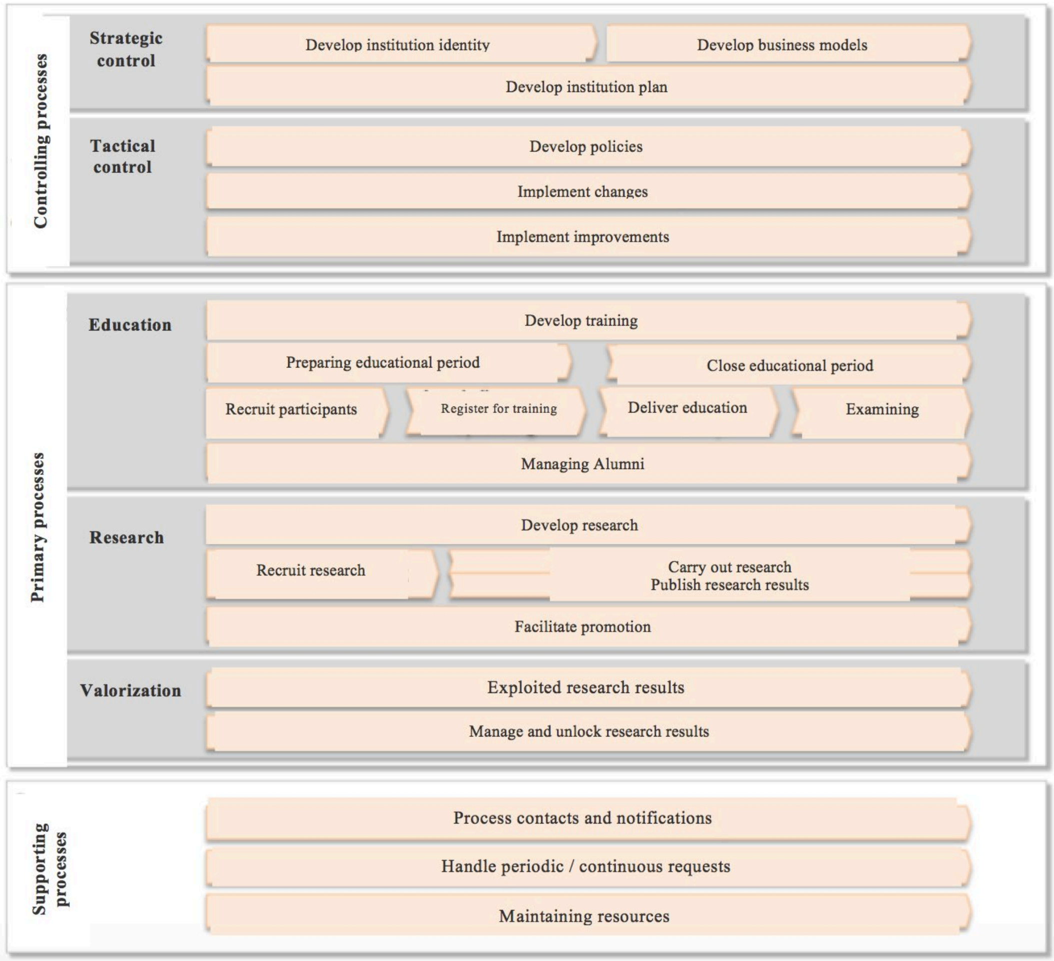
B.1.a. Business model ("Business model canvas of a higher education institution")



B.1.b. Business function model

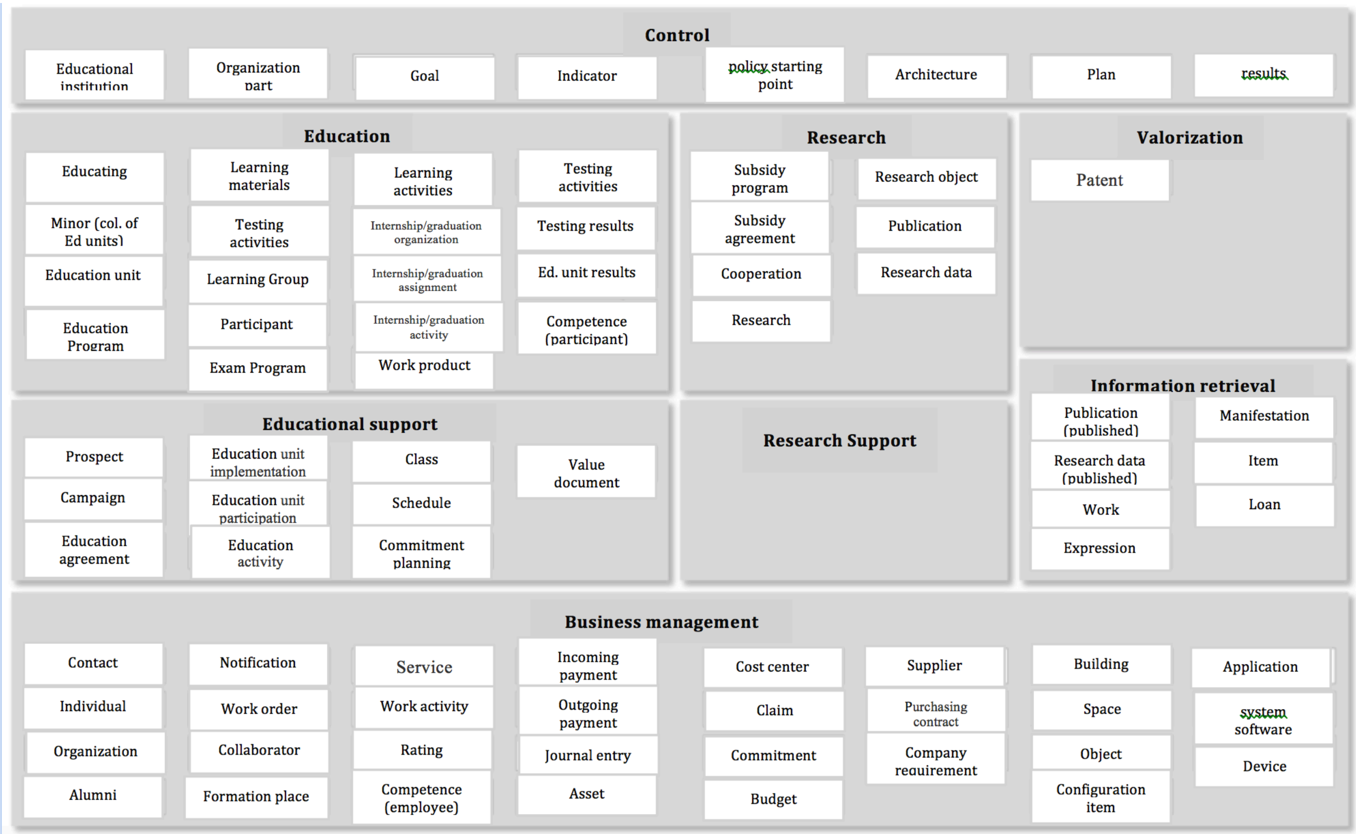


B.1.c. Business process model



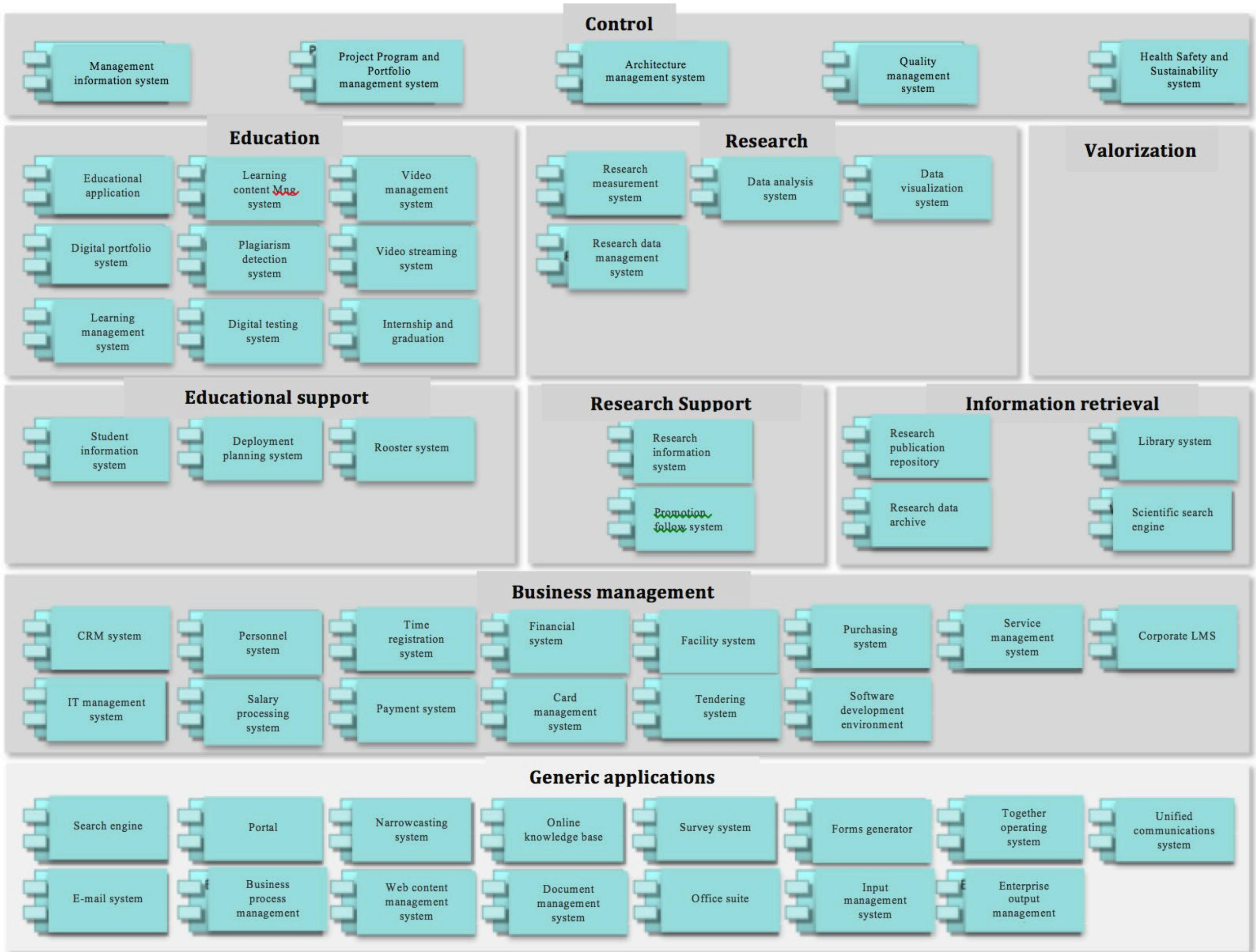
B.2 Reference models of the information architecture (translated from SURF, 2013)

B.2.a. Information model

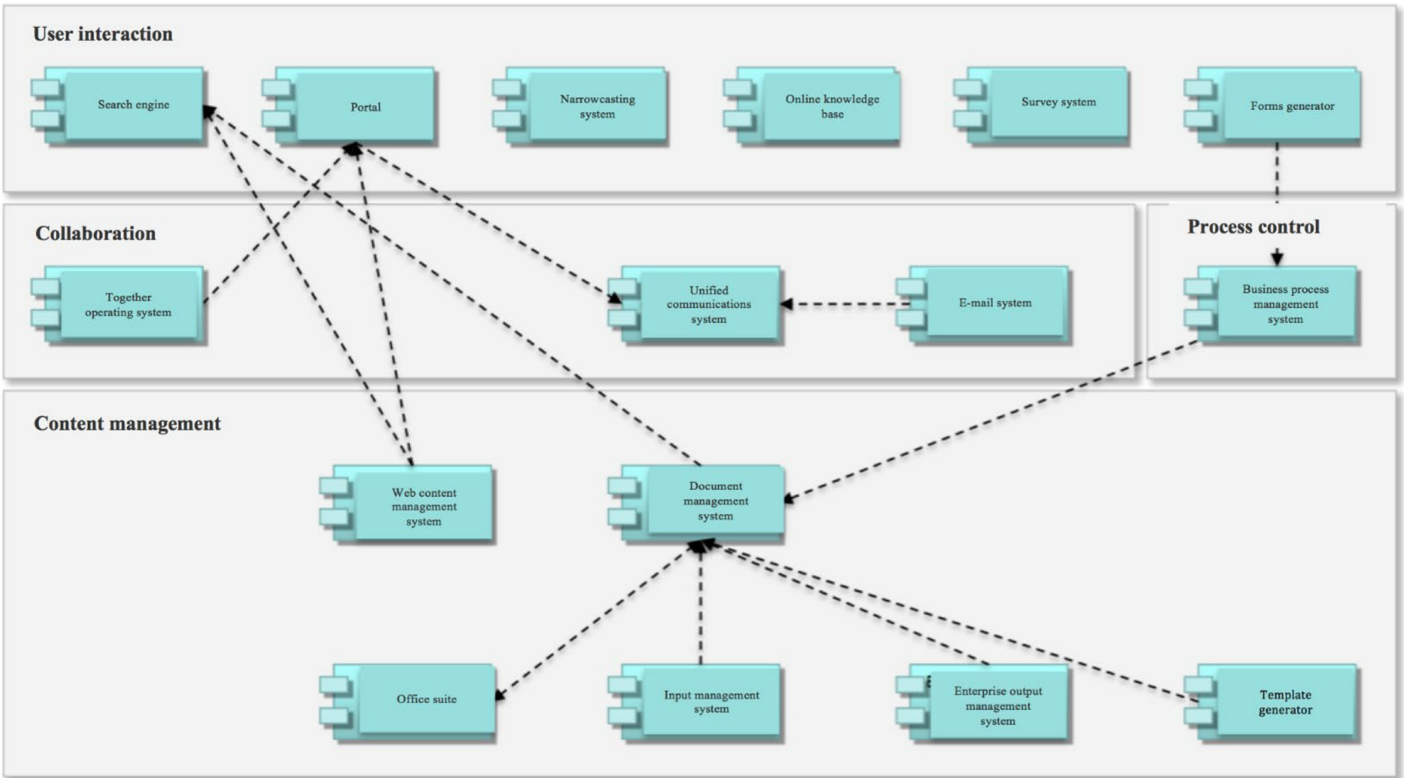


B.3 Reference models of the application architecture (translated from SURF, 2013)

B.3.a. Application model

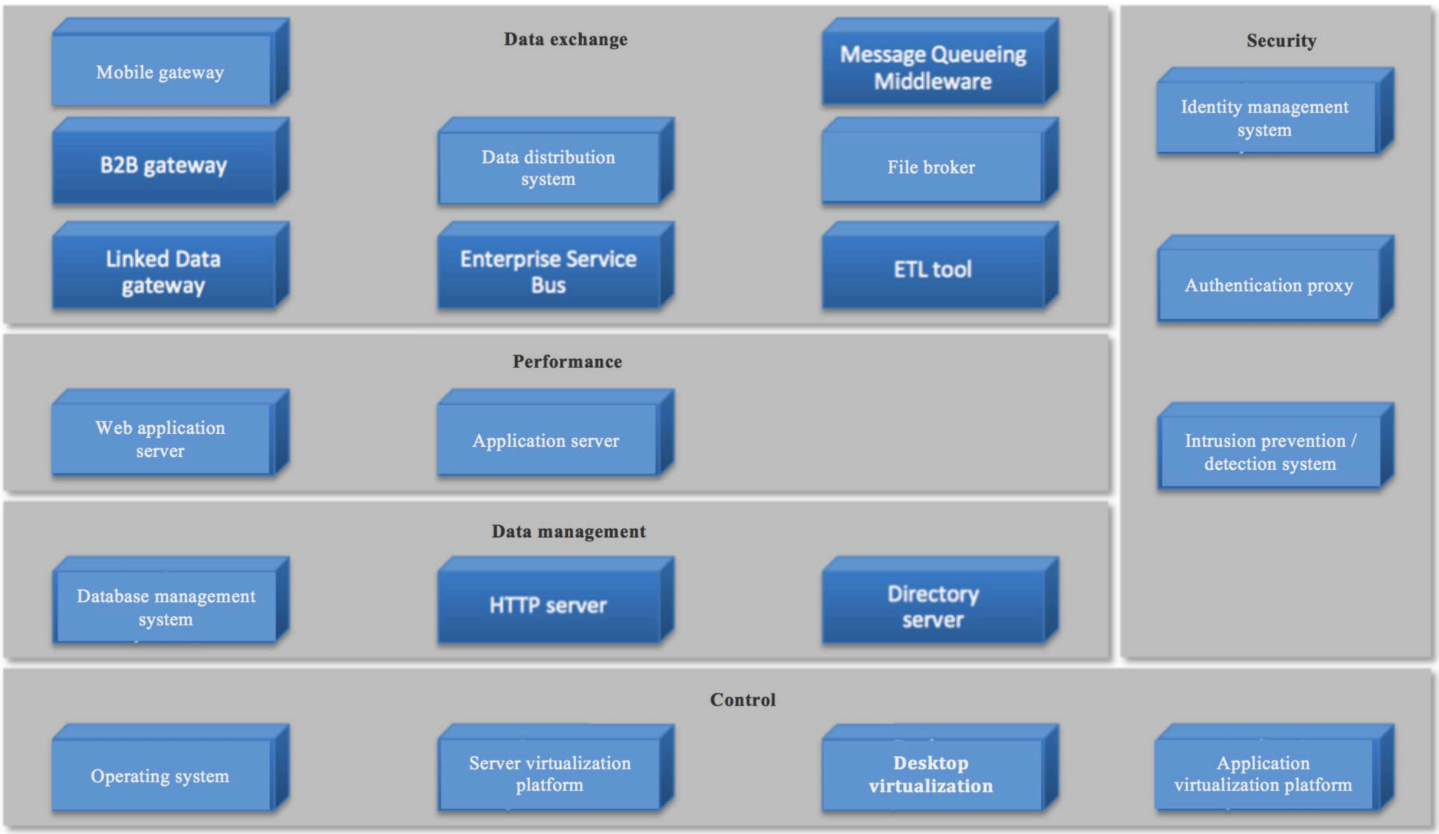


B.3.b. Generic applications



B.4 Reference models of the technology architecture (translated from SURF, 2013)

B.4.a. Application platform model



Appendix C Initial Interview Questions

List of initial questions for EA interviewees

The questions in parentheses were optional; the questions marked with a * were key questions that we focused on, with the others being subject to time availability.

1. * Could you explain your role in the EA team you work with? Who are the other team members and how was the team formed and chosen?
2. * What are the reasons or motivations behind the use of EA?
3. * What are the objectives, goals or vision set by your university or institute for using EA?
4. * When did you start adopting EA? Did you complete the adoption/ implementation of the EA?
5. * What were the EA frameworks and methods you used if any?
6. * Did you use any specialized EA framework for higher education? If yes, what is it?
7. * If you used a framework, did you follow it closely? If not, why not, and what changes or adaptations did you make?
8. * What were the EA tools that you used to support EA?
9. What were the requirements or criteria you employed for selecting these tools?
10. To what extent did you adapt existing tools or develop new tools?
11. How long have you been using these tools?
12. * What do you like about these tools? To what extent have these tools supported the EA frameworks and methods you chose?
13. * What did not you like about these tools? (What problems did they have?) What improvements would you like to see?
14. What linkages have been made between EA tools and other infrastructure such as modeling tools, repository tools, communication tools, analysis tools, decision support tools and so on?
15. * What modeling notations/standards did you use? Why did you choose them?
16. * What models did you build (e.g., enterprise models, business process models, data models, system models, etc.)?
17. * To what extent are these models being used? E.g., are they being used for structuring the organization, procurement, software development, etc.?
18. What improvements in the models would you like to see?
19. How did these models help in the implementation of the EA?
20. * What milestones did you establish in your process of EA implementation?
21. * What milestone have you reached? (Have you reached the final stage?)
22. * Has the EA been implemented in all faculties or services of the university or implemented in specific ones only?
23. * What has been the link between EA and IT?
24. * What has been the link between EA and software architecture and modeling?
25. * What has been the link between EA and development and purchasing of software?
26. * How did the implementation of the EA affect the alignment of strategic objectives and needs with IT strategies?
27. * How did the implementation of the EA affect the decision-making at the university?

28. * How did the implementation of the EA affect the improvement of the business processes?
29. How did the implementation of the EA affect the university budget?
30. How did the use of EA contribute to the integration or reorganization of the different organizational units of the university?
31. How have you managed the EA?
32. * What changes have been made to the EA since its establishment?
33. How do you deal with and handle the changes and specializations to your EA?
34. * To what extent does your EA allow the organization as a whole to manage change and adjust itself in an agile manner?
35. * Do you have a process to evaluate your EA? Please describe this process? (How frequently do you do this evaluation?) (Sometimes this is called continual improvement process)
36. (What measures or key process indicators (KPIs) do you use to evaluate your EA? What thresholds for these have you established as goals and to determine success?)
37. * To what extent has EA been successful or failed? What goals have you met or not met?
38. (If you judge EA to have been a success, what have been the critical success factors for EA in your university?)
39. (Since implementation, what are the benefits that have accrued? What decisions and business processes have been enabled?)
40. (What were the most critical challenges that you encountered during the implementation of your EA process? Can you classify them?) (Do you have any ‘war stories,’ or ‘things you wish you knew’?)
41. (How did you resolve or address the obstacles you faced?)
42. * Do you plan to continue the EA process, or do you think the organization might wind it down or ignore it?
43. (If you wind it down, what would be the reasons for this decision?)
44. * Do you apply any agile approach to your process of EA?
45. If yes, why do you decide to do that? What benefits do you get compared to the traditional EA process?
46. If no, is there a specific reason for not considering using an agile approach with your EA?
47. (Are there any resources or documents we have not discussed yet that you think we should read to help us understand your EA?)
48. (Are there any other people in the organization that you would recommend we talk to, in order to deepen our understanding of your EA process? (no need to ask at this stage)
49. Is there anything else you would like to tell us?

Appendix D Final Interview Questions

Questions added to the initial interview questions

1. * Let's talk about the EA principles in your institution. Do you have a set of EA principles? … Could you describe them?
2. Who are your stakeholders at the university? Does the EA team have any kind of interactions with them or any architecture review board?
3. Do you have any kind of regular meetings with stakeholders...?
4. As the EA team, do you have any regular meetings or ARB meetings or something like that?
5. Do you apply EA at the multiple campuses of university, or each campus has its own EA?
6. * In your opinion, what are the critical success factors for EA?
7. * What are the critical success factors for individual members of EA team?
8. * Let's talk about a few potential challenges that EA might sometimes address ... Does EA help in managing information storage and preservation? ... Is document management addressed by EA? ... Does EA help the university develop policies?
9. * Let's talk about challenges that EA might face, do you encounter any critical challenges during the adoption of EA? ... Does EA receive good support from higher-level management?
10. Are there any little case studies you could share where enterprise architecture really helped your university? Are there any 'war stories' or bad experiences you have had managing the EA?
11. (Is there anything you wished you had done differently or known before developing the EA / taking the EA job?)
12. If you would provide a definition for EA, what would be?

Appendix E Survey Questions

Examples of survey questions. The rest of questions can be retrieved from https://www.eecs.uottawa.ca/~tcl/gradtheses/aalghamdiphd/Survey/Survey_Questions_EA_in_HEIs.pdf

* 1. Do you consent to participate in this survey? By clicking Yes, you consent that you are willing to answer the survey, but you always retain the right to withdraw at any time.

  - Yes
  - No

General Information

* 2. What is your country?

* 3. Is your institution public or private?

  - Public (obtains core funding from a government, and is subject to government regulation)
  - Private

* 4. How many students (undergraduate and graduate) are enrolled in your institution?

  - Less than 5,000 (Small)
  - Between 5,000 and 15,000 (Medium)
  - Between 15,000 and 40,000 (Large)
  - More than 40,000 (very large)

* 5. Is Enterprise Architecture (EA) implemented in your institution?

  - Yes, it is known as Enterprise Architecture
  - Yes, but it is known with a different name
  - Maybe, partially or unsure: Aspects of Enterprise architecture may be in place
  - No, but we have a plan to adopt it
  - No, and we do not have a plan to adopt it

6. Please indicate the extent to which each of the following is a factor explaining why your institution is not planning on adopting enterprise architecture?

	Not a factor	A minor factor	A significant factor	A major factor
Senior management does not support it	○	○	○	○
IT team(s) do not support it	○	○	○	○
Other potential stakeholders do not support it	○	○	○	○
The university is too decentralized	○	○	○	○
University finances are too limited	○	○	○	○
The university has other processes in place to manage its assets, information and processes	○	○	○	○
There is a desire to keep the amount of administrative work as small as possible	○	○	○	○
Nobody has seriously thought about it	○	○	○	○
Relevant people have not yet learned enough about it	○	○	○	○
Staff are too busy with other tasks	○	○	○	○
The university is too small, so it is considered unnecessary	○	○	○	○
We have heard about failures of EA (or experienced them)	○	○	○	○
We are unable to hire sufficiently knowledgeable staff	○	○	○	○
Other (please specify)				

General Overview of Your Institution

* 7. How centralized is your institution?

- o Single campus
- o Single campus but with independent colleges (or similar)
- o Multi-campus

* 8. How centralized is your institution with regarding to its Information Technology (IT) team?

- o There is a central IT team that does most of the IT work
- o There is a central IT team, but some of the work is distributed to departments, units, colleges or campuses
- o There is a central IT team but most IT work is distributed
- o Almost all IT work is distributed

Definition of Enterprise Architecture

9. In your opinion, to what extent do each of the following definitions will apply to EA in your institution? Each of these definitions come either from the literature or from our interviews with Enterprise Architects. Enterprise Architecture is:

	Does not apply at all	Somewhat applies	Strongly applies
A digital representation of the organization's business and information technology landscape	○	○	○
A process of understanding the different elements that go to make up the enterprise and how those elements are inter-related.	○	○	○
A master plan that "acts as a collaboration force" between aspects of business planning, business operations, automation, and enabling technological infrastructure.	○	○	○
A discipline for proactively and holistically leading enterprise responses to disruptive forces by identifying and analyzing the execution of change toward desired business vision and outcomes.	○	○	○
A strategic information asset base, which defines the mission, the information necessary to perform the mission, the technologies necessary to perform the mission, and the transitional processes for implementing new technologies in response to changing mission needs.	○	○	○
A formal description of the current and future state(s) of an organization, and of managed change between these states to meet organization's stakeholders' goals and to create value in the organization.	○	○	○

Appendix F Grounded Theory Results on EA principles in HEIs

Table 56 List of main categories with their subcategories of EA principles in HEIs

#	Category	Concepts
Main Category: General Principles		
#	**Category**	**Concepts**
1	Maximize the benefits to the university	Maximize benefits to the university
		Maximize the benefits to the university, and then from it got statement of rationale and alignment and engagement
		Maximize benefit to the university
2	Align decisions and architecture with the strategic mission, vision, and values of the university	Maximize the benefits to the university, and then from it got statement of rationale and alignment and engagement
		Align decisions and architecture with the university's strategic plan.
		Align decisions and architecture with the strategic mission, vision and values of the university.
3	Enable holistic approach	Design and decide based on an institutional approach
4	Protection of intellectual property	Protection of intellectual property
5	Enhance simplicity and reduce complexity	Enhance simplicity
		Minimize duplication and reduce complexity.
		Avoid strategic compromises during tactical projects
6	Be agile in terms of technology, business processes, and IT solutions	Be agile
		University will be agile, proactive, and innovative in its use of technology
		Business processes and associated IT solutions will be sufficiently modularized and flexible allow greater agility and rapid implementation of changes to business processes
7	Support quick and accurate decision making strategically	Take a strategic 'big picture' viewpoint when making decisions.
		Align decisions and architecture with the university's strategic plan.
		Align decisions and architecture with the strategic mission, vision and values of the university.
		Quick, accurate decision-making support
		Make decisions based on the classification and value of assets.
8	Compliance with Law	Compliance is designed-in
		Secure and legally compliant: uphold security, confidentiality, and legal requirements
		Compliance with law
9	Enable a single federated enterprise-wide architecture.	Enable a single federated enterprise-wide architecture.
10	Enhance sustainability	Make things maintainable, manageable and measurable.
		Design for monitoring, logging, run-time tuning and diagnostics.
		Make decisions based on the full lifecycle of things.
		Design for extensibility
		Make things testable
		Document knowledge needed by others
11	Manage university and information security risks	Make decisions based on the classification and value of assets.
		Secure the boundaries between architectural components.
		Consider malicious threats and accidental misuse.
		Manage University risk
		Optimize management of information security risk
12	Performance and effectiveness	Effectiveness and performance oriented
		Continuously improve
		Enable measurement of system performance
13	Efficient use of resources	Efficiency of using resources
14	Digitally integration	Digitally integrated
Main Category: Business Principles		
#	**Category**	**Concepts**
15	Optimize and align investments with strategic goals	help business stakeholders understand better which sort of projects and initiatives that they should be supporting over which others
		Optimize investments

		IT investments will be aligned with strategic goals through a planning and architecture process to implement appropriate enterprise solutions
16	Service orientation	Service Orientation
		Service Orientation
		Service Oriented architecture
		Business architecture is based on a design of services with mirror real-world activities
		Accurate and timely user service provision
		Deliver modular, reusable, and loosely coupled services
		Define boundaries to enable separation of concerns.
		Design modular components; create building blocks not monoliths.
		Design services and messages to have well-defined interfaces and data models.
		Enable reuse of data and functionality.
17	Enable value-driven design solutions	Design solutions that are 'good enough' that will minimize costs and maximize value
18	Primacy of principles	Apply the information management principles to all organizations within the enterprise
19	IT Responsibility	The IT organization is responsible for owning and implementing IT processes and infrastructure.
20	Business continuity and recovery	Business continuity is designed-in
		Ensure the continuity and recoverability of mission critical solutions
		Business continuity
21	Understand process architecture	Understand process architecture
22	Information management is everyone's concern	Information management is everyone's concern
23	Support long-term business-driven capabilities	Support long-term business-driven capabilities
24	Activate a partnership between faculties and business units and ITS	A partnership will be activated between faculties and business units and ITS
		EA principles document brings different stakeholders (Bus and IT) on common ground
25	Have documented owners for business processes, data, and supporting	Business processes, data, and supporting applications will have documented owners
Main Category: Data Principles		
#	**Category**	**Concepts**
26	Data is under the control of a trustee	Data trustee will be responsible for the quality of the data
27	Data is accessible, available and discoverable	Information is available
		Make data available and discoverable.
		Data is accessible
		Information's easy accessibility oriented
		Data are accessible
		Manage authoritative data as a single source of truth.
		Timely accurate and complete decision support information will be made available to authorized users
		Applications will access data through defined interfaces
28	Data governance	Govern data according to university policies and data management guidelines.
29	Data is an asset	Data is an asset
		Manage information and data as an institutional asset
		Data are assets
		Information is a corporate asset
30	Data is shared	Data is shared
		Data is shared as university asset
		Data is shareable between faculties and administrative units
		Information sharing extension
		Data are Shared
31	Common vocabulary and data definitions should be available	We use a common vocabulary
		Common vocabulary and data definitions
		Enrich data with well-defined metadata.

32	Data is secure	Data is secure
		Data security
		Maintain coherent identity for all of our users: avoid any practices that will ruin the identity
		Protect information according to university policies using cost-effective access controls.
		Ensure confidentiality, integrity and availability of information.
		Control access using authentication and authorization.
		Single system of record
		Information security is everyone's business
33	Data reuse	No duplication of data should be allowed at all
		Enable reuse of data and functionality.
Main Category: Application Principles		
#	**Category**	**Concepts**
34	Enhance reusability	Enhance reusability
		Reuse first then buy then develop
		Reuse existing components before acquiring new ones
		Enable reuse of data and functionality.
35	Avoid duplicated applications and services	Common use applications rather than multiple similar applications
		Common use applications and services
		Implementation of applications used across the enterprise is preferred over the implementation of duplicate or similar applications for particular groups
36	Prefer open solutions over commercial solutions	Prefer open source s/w over commercial s/w whenever it is feasible to use one
37	Produce flexibility	Produce flexibility
		System flexibility securement
38	Buy before build	Components should be purchased rather than custom built
39	Reuse before build before custom	Leverage and reuse existing solutions than purchasing new solutions than building custom solutions
40	Configuration before customization	Configuration before customization
		Minimize application customization
41	Usability & Convenience	Enhance usability from a user experience
		User utilization oriented
		User convenience oriented
		Convenient to use
		Make things as simple as possible but no simpler.
		Follow well-defined patterns and blueprints
		Ease of use
		Make things easy to use
		Make things easy to understand
42	Solution operationalization	Ensure that solution design will consider operational requirements
43	Supported technology	Proactively manage the lifecycle of technological solutions
44	Cloud first	Use virtualization and Cloud to meet unexpected or spiky demand
		Cloud first
45	Deliver applications through intranet and internet	Future applications will be delivered through intranet and internet
46	Managing applications implementation through roadmaps	Implementation of applications will be managed through defined roadmaps
47	Platform independent	Platform independent
48	Define and design solutions	How define and design solutions
49	Assess and select the solutions	Assess and select the solutions
50	Enable scalability	Strive for statelessness
		Communicate asynchronously between services; accept some data inconsistency
		Make services and messages discoverable.
		Define boundaries to enable separation of concerns.
		Design scalability into solutions from the start
		Enable distribution of workload
		Design solutions to scale horizontally out, not up

		Avoid single points of failure; a system is only as reliable as its weakest link.
		Define and design for target availability levels.
		Design for fault tolerance and graceful failure.
51	Architectures and solutions must be fit for purpose	Fit- for-purpose
52	A design-first style should be followed	Design first
53	Standards-based	Standardize to reduce needless diversity.
		Adherence to a standard guideline
		Embrace industry and community standards.
		Prefer open standards, architectures, and systems over closed, proprietary ones.
Main Category: Technology principles		
#	**Category**	**Concepts**
54	Technology independence	Technology independence
		Technology Independence
		Avoidance of dependency on specific technology
55	Controlled technical diversity	Controlled technical diversity
		Control technical diversity
		Control Technical diversity
		Technological diversity is controlled based on a defined set of standards and policies
56	Interoperability	Interoperability
		Interoperability
		Ensuring the interoperability of technological components
		Interoperability
57	Requirements-based change	Requirements-based change
		Requirements-based change
58	Responsive change management	Responsive change management
		Responsive change management

Table 57 EA principles used by HE institutions

EA Principles Main Categories	Categories
General principles	Maximize the benefits to the university
	Align decisions and architecture with the strategic mission, vision, and values of the university
	Enable holistic approach
	Protection of intellectual property
	Enhance simplicity and reduce complexity
	Be agile in terms of technology, business processes, and IT solutions
	Support quick and accurate decision making strategically
	Compliance with Law (Ensure compliance with laws, standards and policies)
	Enable a single federated enterprise-wide architecture.
	Enhance sustainability (Ensure the architecture is maintainable - Ensure elements of the architecture are measurable)
	Manage university and information security risks
	Performance and effectiveness (Focus on the performance of the organization)
	Efficient use of resources
	Digitally integration
Business principles	Optimize and align investments with strategic goals
	Service orientation (Orient the architecture to provision of services)
	Enable value-driven design solutions
	Primacy of principles
	IT Responsibility
	Business continuity and recovery (Ensure the continuity and recoverability of critical university operations)
	Understand process architecture
	Information management is everyone's concern
	Support long-term business-driven capabilities
	Activate a partnership between faculties and business units and ITS
	Have documented owners for business processes, data, and supporting
Data principles	Data is under the control of a trustee
	Data is accessible, available and discoverable
	Data governance (There are policies and data management guidelines for data)
	Data is an asset
	Data is shared
	Common vocabulary and data definitions should be available
	Data is secure
	Data is reused
Application principles	Enhance reusability
	Avoid duplicated applications and services
	Prefer open solutions over commercial solutions
	Produce flexibility
	Buy before build
	Reuse before build before custom
	Configuration before customization
	Usability & Convenience (Applications must be easy to use - Ensure end users can perform their work as efficiently as possible)
	Solution operationalization
	Supported technology
	Cloud first
	Deliver applications through intranet and internet
	Managing applications implementation through roadmaps
	Platform independent
	Define and design solutions
	Assess and select the solutions
	Enable scalability
	Architectures and solutions must be fit for purpose (Design solutions such that they are 'good enough' in order to minimize costs and maximize value)
	A design-first style should be followed

EA Principles Main Categories	Categories
	Standards-based
Technology principles	Technology independence
	Controlled technical diversity
	Interoperability
	Requirements-based change (Base change on careful requirements analysis)
	Responsive change management (Be responsive to stakeholders as their needs change)

Appendix G Grounded Theory Results on the Motivations of EA in HEIs

Table 58 List of subcategories and concepts for the motivations of using EA at HE institutions

Sub-Categories	Concepts
Align each project with the university's goals.	Enable each project to fit in the whole enterprise well and to align each project with overarching goals. Enable each project to fit into the whole enterprise well. Complement the portfolio planning process to ensure all project operations are aligned with an overall EA plan. Enable each project to fit in the whole enterprise well and to align each project with overarching goals.
Align people in the strategies between the business &IT strategy.	Align business and enterprise mission with IT for a university. Identify clear direction and vision from the business side with respect to IT and needs. Define business requirements in the context of the university and fit that with the goals of the university-driven down to what the technology to be needed to support that. Get people to be aligned in the strategies between the business and IT strategy.
Be more adaptable	Build a data-driven adaptable enterprise that focuses on business outcomes.
Be data-driven	Make better utilization of data. Make an informed decision. Make data accessible and easily available for business users and decision-makers. Raise awareness of sharing data in a decentralized environment. Build a data-driven adaptable enterprise that focuses on business outcomes. Improve data quality and security across the university.
Be ready for the digital transformation and improve automation	Improve the efficiency of business processes by better managing the information within and through automation.
Build strategic roadmaps to move the institution forward	Get more roadmaps around solutions. Define and document applications and technology capability roadmaps. Get value from EA roadmap information and provide analytics-driven information. Provide a stakeholder-centric and/or enterprise view of EA roadmap information. Link applications and technology capability roadmaps to IT strategic and operational plans. Have a clear view of what current architecture is, what future state of architecture might be, the options between, and understanding the gaps, and how we draw roadmap at the high level between them.
Enable sharing and reuse	Improve access to the required information across the university. Establish clear decision-making rules and processes for shared assets. Improve response to a request for information.
Improve efficiency and cost-effectiveness	Improve efficiency and cost-effectiveness in university information and data management. Financial reasons.
Reduce duplications and triplications	Ensures where standardization of infrastructure services is not duplicating capabilities. Remove or reduce duplication of effort and capability by introducing integration practice. Prevent and remove data duplication.
Improve the compliance to legislation and policies	Standardize university data, applications and technology alignment to the business. More governance and process with the IT team.
Better leverage assets	Improve stewardship of the university IT assets

Sub-Categories	Concepts
Define and describe EA practices and processes	Promote successful, repeatable architecture processes. Develop and implement the EA blocks. Develop an EA plan.
Recommend looking for missing capabilities based on consultation	To get more of a sense of what EA team have and how things integrate and what capabilities are supporting the institution To define business capabilities in the organization and lo line up services that EA offer to those capabilities in a pure cross-institution manner
Provide directions for technology function going forward	More coordination or consistency about how the technology organization responds to meet business needs or invest in.
Support better-informed decision-making	
Improve EA-maturity level	
EA is mandated by the government for public sector	
Rationalization and Simplification	
Improve service delivery and customer satisfaction	
Invest in university's EA to achieve knowledge economy	
Get a holistic view of customers, suppliers and/or employees	
Provide a robust and contemporary IT infrastructure	
Create and maintain an efficient architecture repository for application and technology landscape	
EA needs to have more of service mentality (service-before-self for central IT)	

Table 59 Preliminary list of main categories for the motivations of using EA at HE institutions

Main Categories
EA is mandate by government for public sector
To align business and mission with IT strategy for a university
To enable each project to fit in the whole enterprise well and to align each project with overarching goals
Rationalization and Simplification
Reduce duplications and triplications
To be data driven
To be more adaptable
To be ready for the digital transformation and improve automation
Create strategic roadmaps to move institution forward
Better leverage assets
Better decision-making
Provide directions for technology function going forward
Recommend looking for missing capabilities based on consultation
Reduce costs: improve efficiency and cost-effectiveness