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ICT in Business and the Public Sector

A STUDY OF ENTERPRISE ARCHITECTURE FOR SECONDARY VOCATIONAL EDUCATION INSTITUTIONS

A lightweight enterprise architecture framework

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Abstract

Due to the scale of expansion of secondary vocational education institutions and the need of digitization in education, many mid-sized schools are facing significant challenges. Far-sighted leaders started to seek for solutions through the development of enterprise architecture for their organizations to align IT with business, reduce 'isolated information islands', and eventually provide students with a superior education service. However, very often, those organizations are quite struggling with enterprise architecture because of factors such as lack of experience, workforce or support from the top management.

In light of this the main research question in this paper is "How can secondary vocational schools start to build enterprise architecture to gain benefits for long term development", which is further divided into four sub-questions that address problems like whether the school needs EA, what is their EA maturity level, what is the school's demands for EA, and how do schools deploy EA in practice. Furthermore, the purpose of this research is to propose an enterprise architecture framework as a guide for mid-sized educational institutions.

The Multiple-case study is the main research method to find the final answer. Eight mid-sized secondary vocational schools, located in different areas in the Netherlands, have contributed to this research by providing internal architecture documents and allowing in-depth interviews with their experts. They have provided a reliable and significant data foundation for the effectiveness of this study. All interviewees are experts working in the educational field as information manager, advisor or enterprise architect.

After combining the results of literature and multiple case studies, the architecture demands of mid-sized education institutions became clearer. Based on them, a lightweight enterprise architecture framework is proposed to organizations as a simple guide to start an enterprise architecture. The framework includes the primary architecture development processes, essential artefacts, and some helpful strategies for deploying enterprise architecture.

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Acronyms

ACMM:	Architecture Capability Maturity Model
ADM:	Architecture Development Method
AOC:	Agricultural VET Colleges
BPMN:	Business Process Model and Notation
CMM:	Capability Maturity Model
DERA:	Digital Heritage Reference Architecture
DoD:	United States Department of Défense
EA:	Enterprise Architecture
EAF:	Enterprise Architecture Framework
FEA:	Federal Enterprise Architecture
GEMMA:	Municipal Model Architecture
HAVO:	Higher General Continued Education
HORA:	Higher Education Reference Architecture
IT:	Information Technology
MBO:	Middle Level Applied Education
MIT Centre:	Massachusetts Institute of Technology centre
NORA:	Dutch Government Reference Architecture
OMB:	Office of Management and Budget
PSA:	Project Start Architecture
ROC:	Multidisciplinary VET Colleges
SABSA:	Sherwood Applied Business Security Architecture
SME:	Small and Middle-Sized Enterprises
SWCM:	Software Contract Management
TAFIM:	Technical Architecture Framework for Information Management
TOGAF:	The Open Group Architecture Framework
TRM:	Technical Reference Model
UML:	Unified Modelling Language
VMBO:	Pre-Vocational Education
VWO:	Preparatory Scientific Education

CHAPTER 1 INTRODUCTION

1.1 Research Background

In today's world, the relation between information technology and business has connected than ever. It is undeniable that IT exerts an enormous impact on an organization's development, not only in the short term but also long run (Bernaert et al., 2014).

However, when information technology helps enterprises to automate the production process, enhance communication efficiency and reduce implementation cost, it also brings many troubles. Some problems may only affect a company's business temporarily, but some can even cause a fatal effect which decides the survival of an organization (De Haes & Van Grembergen, 2009). Therefore, how to better employ and manage IT resources in the company has become a significant task that organizations must consider in the current information era.

Nearly all enterprises have their way to organize IT assets, but many of them only see IT resources as separated onefold assistant tools. They use different applications, platforms, databases to deal with the instant demand coming from various business departments. Using this method seems the fastest way to respond to business needs, whereas it brings many underlying problems to organizations, such as technology incompatibility, overlapping investment, ineffective internal and external communication. In this case, IT cannot indeed contribute to the company but causes obstacles (Tallon, 2007). Then many large companies took the lead and started to introduce the concept of enterprises architecture (EA).

Previous researchers have found that all type of firms can get benefits from EA, but only very few investigated the application of EA on Small and mid-sized enterprises (SMEs). The truth is that SMEs are significantly crucial to the European economy, occupying 99% of the total amount of businesses. They provide 85% of the new jobs and two-third of the private sector employment (European Commission, 2019). Therefore, their existence is the key to economic growth and social stability.

Moreover, among all size of companies, mid-sized organizations brought the most positive impact on economic growth, in particular in higher-income European countries, because they are small enough to adapt to the changeable environment, and also large enough to compete with large firms without the hindrance of redundancy that big company often suffer (Endeavor insight, 2015). Therefore, the study of enterprise architecture for medium-sized enterprise is meaningful and important. Unfortunately, the research on this area is insufficient, especially for mid-sized education institutions.

1.2 Research Gap

Enterprise architecture (EA) is a subject regarding managing IT resources wisely and making a better alignment between business and IT for the organization. EA provides companies with a robust conceptual framework and a strategic blueprint scientifically to enhance their business capability (Schmidt et al., 2015).

More than 30 years ago, EA was introduced to the market and had been used and enhanced by many major companies in recent decades. A significant number of researchers indicated that enterprise architecture not only suits for large organizations but also for small and middle-sized firms. However, as I mentioned before, the focus of EA research is still mainly for large firms.

After reading more literature and talking with an experienced enterprise architect, I have realized the needs for researching EA on non-large organizations especially middle-sized educational group because they have a considerable demand for EA and there is not much research about it.

Only a few researchers attempted to investigate the use of EA for SMEs (small or middle-sized enterprises) in general or large education institutions. Therefore, in this research, I will address problems regarding the needs of EA for the middle-sized education institution, more specifically secondary vocational education institutions (MBO schools) in the Netherlands because compared to the scale of higher education institutions (HO/WO university), MBO schools are better represented to mid-sized organizations.

1.3 Definitions

Two key terms in this research are ‘enterprise architecture’ and ‘secondary vocational education institutions’ (refers to MBO schools in Dutch education). In order to better understand the research question and scope, I will first review the definition of these two subjects.

1.3.1 Definition Of Enterprise Architecture

“Enterprise Architecture” is the first important term used in the research question.

The first word “Enterprise” has been defined as “*a company or business*” in the dictionary of Collin.¹ Merriam Webster dictionary explains it as “*a unit of economic organization or activity, especially a business organization*”.² To merge the meaning of the word ‘enterprise’, I define it as a unit of the organization, including all sizes and type of organizations.

The second word is “Architecture”. In the explanation of encyclopaedia Britannia, architecture is “*both the process and product of planning, designing and constructing buildings and any other structures*.”³ Merriam Webster dictionary added architecture is “*Formation or construction resulting from or as if from a conscious act*”. “*A unifying or coherent form or structure*”.⁴ To merging those explanations in this research, I define the word “Architecture” as a top-level design that describes organizations structure and system process through conscious and logical methods or plans.

Currently, there is no unified definition for the word “Enterprise architecture” while a significant number of organizations have given this term meanings through the conclusion of years research and practice. Below, selected definitions can be found. Those explanations are selected because they gave a good description of EA and emphasizing its purpose and focus.

The Gartner Group defines EA as a process that transforms business vision and strategy to the future state of the organization through building and managing critical principals and models. It sees enterprise architecture as a process that bound IT and business together in a strategic and structured way. The ArchiMate Foundation believes the critical components of enterprise architecture is regarding consolidated principals, methods and models that are used to plan, build and maintain an

¹ <https://dictionary.cambridge.org/dictionary/english/enterprise>

² <https://www.merriam-webster.com/dictionary/enterprise>

³ <https://www.britannica.com/topic/architecture>

⁴ <https://www.merriam-webster.com/dictionary/architecture>

organization's business, IT and the whole structure. MIT Centre added that EA reflects an organization's needs for the integration and standardization of its operating model.⁵

To conclude the listed description above, I define 'Enterprise Architecture' as a structured and well-organized process that provide organizations with a series of principles, models, strategies to achieve their vision through better business-IT alignment. Because the scope of enterprise architecture can be very broad, in this research, I mainly focus the most important process on deploying EA, critical EA artefacts and strategies when doing EA.

1.3.2 Definition Of MBO Schools

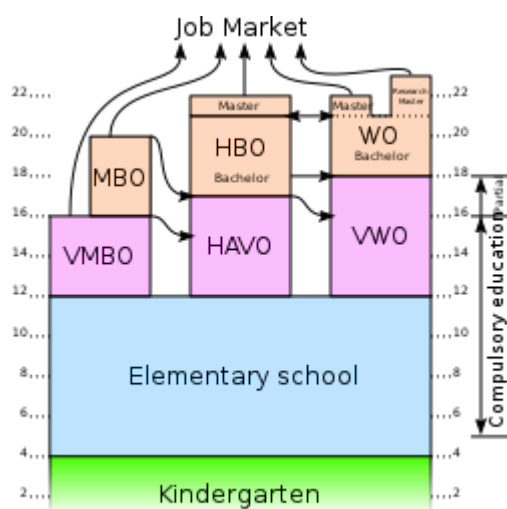


Figure 1. Dutch education system⁶

“Secondary Vocational Education Institution” or “MBO School” is the second important word used in the research question, and it is also the general term of the target study group. To better explain this concept, we will first briefly go through the basic structure of the Dutch education system.

The graph above shows the structure of the Dutch education system. Based on it, we can see that in the Netherlands, after kindergarten, there are three levels of education: elementary, secondary and higher education. Children often go to elementary school from the age of 4 to 12, then directly go to high school, which offers secondary education (MBO/HAVO/VWO). The secondary education further leads students to three different paths at a higher level based on student's needs and background (XPAT, 2018).

In secondary education, VMBO is “Pre-Vocational Education” that focuses on vocational training with theoretical education. Around 60% of the students from age 12 to 16 will attend to VMBO. After finishing this program, students can access MBO schools, which are vocationally orientated institutions where teachers will bring society a large number of skilled workers (UNESCO, 2012). MBO school is the type of organization that are studied in this research and represent mid-sized vocational education institutions.

⁵ <https://www.ariscommunity.com/users/koiv/2009-08-20-10-definitions-enterprise-architecture-which-corresponds-yours>

⁶ https://upload.wikimedia.org/wikipedia/commons/0/03/Dutch_Education_System-en.svg

HAVO “Higher General Continued Education” is also an option in secondary education. It offers students a five years program and leads them to HBO level (higher professional education). And the third path that student can follow in the secondary education is VWO, “preparatory scientific education”, which consist of 6 years study and provides students to go to research universities after 18 years old (XPAT, 2018).

1.4 Research Question

To fill in the research gap, the main question in this research is:

“What are the essential process steps and core artefacts to build an enterprise architecture for secondary vocational education institutions?”

Four sub-questions are formed to find the answer of the main research question:

1. Do MBO schools need enterprise architecture?
2. How is the current use of enterpriser architecture in MBO schools?
3. Why do MBO schools need enterprise architecture?
4. How do MBO schools build enterprise architecture in practice?

At the end of this research, we will find answers to all questions. And a lightweight framework with strategies regarding schools’ focus will be proposed to give a simple guide for the mid-sized group to start enterprise architecture.

1.5 Research Objective And Contribution

The purpose of this research is answering the questions listed above and fill in the research gap in the use of EA for secondary vocational education institutions in Europe.

Several groups will be beneficial for this research. The first beneficial group is schools in the Netherlands or other European countries which expect to facilitate the organization’s long-term development with EA. They would know what the general situation and problems Dutch MBO schools are facing and what efforts they are making. Secondly, this paper is particularly meaningful for mid-sized organizations who do not have a large budget and experience for building EA. What’s more, by reading this research, information managers could quickly get an overview of the basic EA developing process and the most important components. Finally, this document can also be served as an educating material for group leaders who do not have a technical background but are interested in applying EA in the organization.

1.6 Thesis Structure

This paper mainly consists of six parts. A general introduction is given in the first chapter in order to help readers understand the research background, gap, questions, the purpose of this study, and what the readers can expect for.

In the second chapter, the research methodologies that were applied in the study are described. It explains how this research was conducted, what approaches, and methods were used to gather and analyse data and the reasons to use them.

Then, literature review is discussed in the third chapter in which readers would get to know the concepts that are relevant to the research topic. Some parts of this chapter are also used as input to find the research answer.

Chapter four is the presentation of data analysing and the result, which followed by a proper discussion of this research. Finally, chapter six will make a conclusion of this paper.

CHAPTER 2 RESEARCH METHODOLOGY

To determine suitable research design and methods for this study, I will follow the general research procedure that is developed by Saunders in 2009, the 'Research Onion'. The 'Research Onion' includes six layers, namely philosophies, approaches, strategies, choices, time horizons, techniques and procedures (Saunders, 2009). By going through each layer, the most effective research methodology is identified to find answer of the research question.

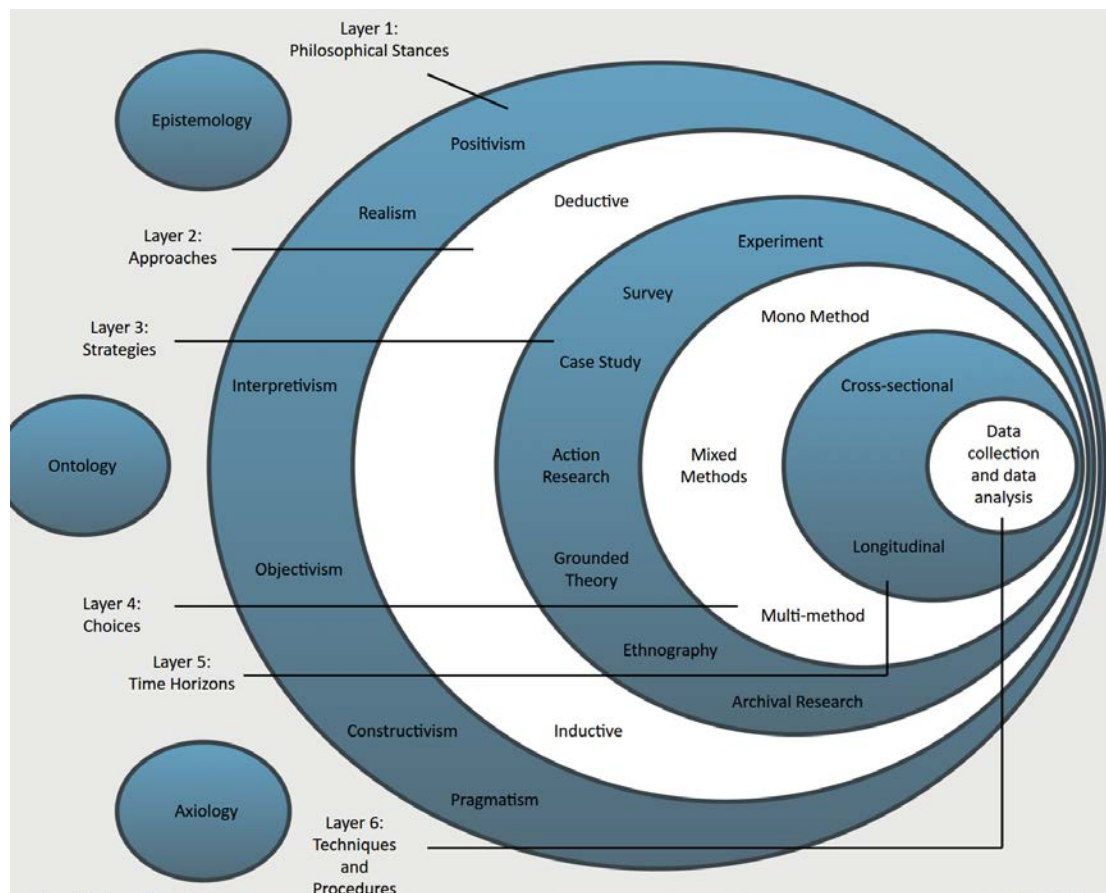


Figure 2. The research onion⁷

2.1 Research Philosophy

The type of investigated knowledge in the research determines the selection of the research philosophy. Positivism and interpretivism are two main philosophies that are often applied in the research. May believes that no research philosophy is superior to another; it often depends on the goal of the research and which methods are suitable to reach the goal (May 2011).

In this study, interpretation is used as the research philosophy because the research question is mainly based on the experts' opinion and experiences. Interpretation believes that individuals do not only react to the external social forces but also create the external environment (Thompson, 2015). The point of this research is to gain an in-depth insight into the respondents about how MBO schools get

⁷ <https://www.ukdissertationwriters.com/wp-content/uploads/2019/04/Saunders-Research-Onion-UK-Dissertation-Writers.png>

started to develop an enterprise architecture. Therefore, people's involvement and different factors in the real working environment are considered when finding answers for the research question.

2.2 Research Approach

An inductive approach is a move from specific to general. It attempts to find patterns from observation and develop an explanation for the result. The opposite is the deductive approach which starts from general to specific. This method is commonly used when there are existing theories (Miessler, 2018). In this research, I aim to find what are the essential process steps and core artefacts to build an enterprise architecture for secondary vocational education institutions. Since there is no unified method that addresses this question from the previous reference, studying cases to find patterns would be a logical process to follow. The inductive approach is considered a more suitable method to use in this study.

Also, since the research topic is about enterprise architecture, which is difficult to measure by numbers. The qualitative research method is applied to gain a better understanding of the topic and to dive deeper into the main problem.

2.3 Research Strategy

Based on the 'Research Onion', a significant number of strategies can be used in the research, such as survey, action research, experiment. And among all, case study is seen as the best strategy to apply in this qualitative analysis.

A case study is an intensive investigation and in-depth analysis of a unit; the unit can be an individual, a family, an institution. It is a very flexible research strategy and can gather information from various means such as interview, observation or documents. A case study focuses on depth understanding rather than breadth (Kothari, 2014). Since in this research, the research question needs to be answered through a deep understanding and analysing of the topic, by doing a case study, we could expect to have a good quality result.

Furthermore, compared to study of a single case, multiple case study is seen as a better strategy to apply. Because the research question is to know what the essential process steps and core artefacts are to build an enterprise architecture for MBO schools, this needs to gather information for a phenomenon and find methods that suit for schools in general. Therefore, studying only one school that contain interesting facts seem unable to develop high-quality theory while the analysis of more cases would make the result more robust and generalizable (Lewis-Beck, Bryman, & Futing Liao, 2012). And when conducting the case study, I will use a mixed approach, including interview and document review to guarantee the depth of the study.

2.4 Case Selection Strategy

The case selection strategy differs between single and multiple case study. When doing multiple case study, replication logic should be applied to gather a more generalizable finding because the purpose of the multiple studies needs to ensure external validity of the case inquiry (Creswell, 1994). According to Yin (1994), literal replication and theoretical replication are two strategies to build replication logic. The strategy of literal replication is used when cases have similar settings and expect to have a similar result, while theoretical replication is contrary (Yin, 1994).

Based on the research question, “What are the essential process steps and core artefacts to build an enterprise architecture for secondary vocational education institutions?”, normal cases are more suitable to study because they have more in common and the result can be easily generalized and apply to a broader group. Therefore, the literal replication strategy was used when selecting cases.

In this study, eight MBO schools in the Netherlands were selected for doing multiple case study. They are all public secondary vocational education institutions with a similar number of students and employees, as well as a quite semblable EA maturity and business process. At least one or few schools in each main districts of the Netherlands has been selected as cases to make the final result more comprehensive.

In terms of the selection of interviewees, two types of people are seen as suitable candidates to participate in the study. They are enterprise architect and information manager who have rich work experience in both educational and IT industry; ideally, they are also knowledgeable in enterprise architecture.

2.5 Data Analysis And Validation

Data collected from the interviews were transcribed into text, and the framework analysis technique was used to analyse the data. Relevant themes were collected and grouped. A coding schema was presented in the form of graph to show themes and their relationship. A more detailed description of data collection and processing can be found in chapter 4.1.

After analysing data, a summary regarding interviews, document review, along with a proposed framework, have been sent to the expert from school that are participated in this study in the form of a questionnaire for validating data.

Experts gave their opinions when reviewing the usability of the proposed framework. New comments and advice were used to enhance the quality of the result.

2.6 Research Steps

There are mainly eight steps to follow when doing the research (excluding literature review).

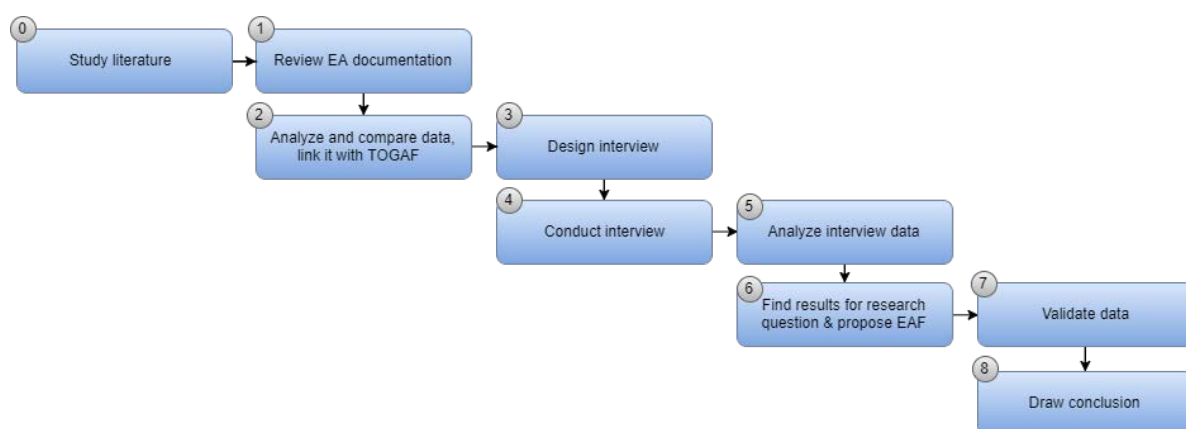


Figure 3. Research steps

Step 0: In the initial step, relevant literature was studied, and a solid theoretical foundation for answering the research question was established.

Step 1&2: EA documentations from MBO schools has been collected and through comparing data, a general idea about how MBO institutions organize their EA in practice is formed and aligned with professional method. Based on that, a better-quality interview design is made.

Step 3&4: According to the findings in the last step, an interview design has been done, eight respondents from selected MBO schools were invited to conduct the interview.

Step 5&6: Voice records of interviews were transcribed in the textual form. Through analysing data, the result from literature and interviews, along with a proposed EA framework will be given to answer the research questions.

Step 7: Data was validated by the experts who work for the case school and participated in the interview session.

Step 8: A conclusion of this study was drawn, and the research questions were answered in the end.

CHAPTER 3 LITERATURE REVIEW

Relevant concepts about the research topic will be introduced in this chapter.

3.1 Enterprise Architecture

3.1.1 Benefits Of Enterprise Architecture

One of the challenges that every organisation must face is how to manage and response to changes intelligently. In this aspect, enterprise architecture specialises in solving this problem.

Enterprise architecture can provide companies with robust EA processes, products and services. It helps firms to transform ambiguous business strategies into practical plans and eventually achieve their business goals (Stacie, William & Ephraim, 2008). It allows companies to understand the business driver and let them know which areas need more attention and resource (Niemi & Pekkola, 2019).

Identifying the benefits of EA can help us to understand the essential needs for it, especially when school leaders consider spending time and budget for constructing it. Since the build of EA can be affected largely by the motivation of the top management, getting their approval and support would be a concern to a successful EA project (Banaeianjahromi,2018).

Niemi and Pekkola have researched the realising benefits from enterprise architecture for companies and have selected the most notable 40 benefits out of 250. Those critical EA benefits are listed on the table below (Niemi & Pekkola, 2019).

Enterprise architecture benefits synthesized from the literature	
Document knowledge on the enterprise	Improve resource quality
Identify resource dependencies	Improve return on investments
Identify resource synergies	Improve situational awareness
Identify suboptimal resource use	Improve solution development
Improve alignment with partners	Improve stability
Improve change management	Increase agility
Improve compliance	Increase economies of scale
Improve customer satisfaction	Increase efficiency
Improve decision-making	Increase growth
Improve employee satisfaction	Increase innovation
Improve enterprise-wide goal attainment	Increase market share
Improve information quality	Increase resource flexibility
Improve investment management	Increase resource reuse
Improve measurement	Increase resource standardization
Improve organizational alignment	Increase revenue
Improve organizational collaboration	Provide a high-level overview
Improve organizational communication	Provide directions for improvement
Improve resource alignment	Provide standards
Improve resource consolidation	Reduce costs
Improve resource integration	Reduce complexity

Table 1. Enterprise architecture benefits synthesized from the literature⁸

Those identified EA benefits are observed to make a direct or indirect contribution to the company's long-term development. They are mainly reflected in the following six areas.

- **Adding more IT values**

First of all, EA contributes to the system's design and development by increasing the efficiency in resource allocation (Bucher et al., 2007). By minimising redundant and repetitive IT infrastructure in different business apartments, it helps the organisation to reduce systems' implement and operational cost (Ross & Weill, 2005). Furthermore, with solid EA principals and governance, the IT cost and complexity can be further reduced by the consolidation of data and systems (Kappelman et al., 2008).

Another advantage of EA is that it can enhance data accessibility and transparency so that the organisation can have a more open and responsive IT environment. Also, with more transparent IT

⁸ <https://www.researchgate.net/publication/333883422/figure/tbl1/AS:771668888780802@1560991608852/Enterprise-architecture-benefits-synthesized-from-the-literature.png>

environment, the organisation can identify business risk easier that caused by security breaches and system failures, thereby EA can improve the management of IT risks as well (Pulkkinen et al., 2007).

To combine all, EA enables the organisation to enforce disciplines and standardisation of IT planning and facilitate a better IT management and decision-making process for the organization (Bucher et al., 2007).

- **Standardising organisation's business process**

EA guides the organisation to plan their business process through a series of rules and disciplines. It enhances the work efficiency by consolidating, reusing and integrating the processes (Varnus & Panaich, 2009).

- **Enhancing collaboration and communication efficiency**

With EA's support, employees in the organisation will be provided with the same 'language' to have more efficient communication. Terms are well defined and often means specific things therefore it reduce the waste of time and resource caused by a misunderstanding of the project scope and deliverables (Nilsson, 2008).

- **Identifying requirements**

The new requirement can appear anytime in the changing environment, but it is often not easy to identify them rapidly. Delayed or missed respondents for requirements can cause the organisation a lot of loss and pain. However, through publishing EA documentation, the enterprise can not only speed up the process of requirement elicitation but have a more clear and accurate definition for requirements (Engelsman et al., 2009).

- **Contributing to the decision-making**

EA enables a better decision-making process through providing clear work priority, system design, structured implementation and maintenance guidance. General speaking, everything EA makes, in the end, is for a better decision because that can bring the company more business values and maintain a sustainable and healthy operating environment (Bucher et al., 2007).

- **Designing organisation structure**

Last but not least, EA helps organisations to design and redesign their structures; it visualises the aerial views from the top to let stakeholders gather a comprehensive perspective of the whole organisation. No matter it is a global organisation change or big transition such as merging or acquisition, with good use of EA, the organization can expect a smooth and reassuring revolution (Nilsson, 2008).

3.1.2 Enterprise Architecture Maturity Model

It is an undeniable fact that if enterprises can manage changes effectively, they can be more successful and have a more promising future than their peers. Nevertheless, the truth is that although many organisations knew the importance of change management, they still do not know how to do it. They either have not paid enough attention to process improvement or spend too much energy on an area

that is not as important (Gene, 2009). Therefore, the demand for evaluation of an organisation's practice called the technique 'capability maturity model (CMM).

This model is initially developed for a software SWCM in the early nineteen eighties. It first achieved success in software engineering. Since the increasing interest people have in enterprise architecture, it started to represent the current status of an organisation and helped with the process management. This model indicates an organisation's maturity level in different areas and lets people understand which part the critical focus is to maximise the benefits in return.

In TOGAF, the ACMM (architecture capability maturity model) is introduced to assist internal assessment of the organisation. ACMM uses CMM scorecards and presents the typical characteristics of the operational process for each maturity level. This model can set a benchmark when comparing different organisations. Therefore, in this research, architecture capability maturity model is applied to evaluate the general EA maturity of case schools (The Open Group, n.d.). The model consists of six maturity levels from 0 to 5. In TOGAF 45.3.3, it gives the characteristics for each level definitions.⁹

Level 0: None

Level 1: Initial

Level 2: Under Development

Level 3: Defined

Level 4: Managed

Level 5: Measured

3.1.3 Enterprise Architecture Layers And Relevant Definitions

The purpose of enterprise architecture is to apply and manage technology to fulfil the business needs of an organization. It aims to contribute business efficiency by describing organizations' architecture and having a better decision-making process on different aspects (Winter & Fischer, 2006). Since the publication of Enterprise Architecture Planning in 1993, enterprise architecture has been often recognized by four domains or layers: Business layer, data layer, application layer and technology layer (Steven & Hill, 1992). Each domain in enterprise architecture is a broad view of an enterprise or a facet of a system that represents concerns of several stakeholders and interact with other domains directly or indirectly.

- **Business architecture**

Business architecture describes the structure and behaviour of the business system of an organization. It addresses things like business vision, strategy, governance, critical business processes, capability and roles that executives the business service (The Open Group, n.d.).

In the representation of business landscape, (a way to visualize business architecture), business functions and process are often connected and mapped to the data or application they need (Valverde & Talla, 2012).

- **Data architecture**

⁹ https://pubs.opengroup.org/architecture/togaf9-doc/arch/chap45.html#tag_45_04

Data architecture describes the structure of logical and physical data of an enterprise, the data that is stored or used by business and application layers. It helps to manage organizations' data assets and evolve the business process.

- **Application architecture/ Information system architecture**

Application architecture describes the structure and behaviour of applications used in an organization (Gopala, 2017). This layer provides a blueprint for the management to see all applications they have, and how systems interact with each other to support the core business processes (The Open Group, n.d.). Many EA frameworks combine data and application domains into one layer, below the business architecture (Winter & Fischer, 2006).

Views describe a different slice of the system and show the picture what we see from a particular perspective (Josey et al., 2018).

- **Technology architecture/Infrastructure architecture**

Technology architecture describes the structure and behaviour of the IT infrastructure and describes the logical software and hardware capabilities which support the other three layers. Technology architecture records technical components such as network, middleware, communications. Thereby, it is the foundation domain in enterprise architecture (The Open Group, n.d.).

- **Current and future architecture**

The current, or 'AS IS' architecture sets up a baseline for the organization's initial architectural work. It describes an organization's current assets of architecture. By understanding the status of the current architecture of the organization, group members can identify demand easily, make better change schema and reduce the risk that caused by not knowing the actual group situation (WebAgeSolution, n.d.).

After establishing current architecture, the future architecture or target architecture should be built to present the blueprint of an organization's architecture (Simon, 2017). Future architecture is a more advanced plan of application architecture, data architecture and technology architecture. Although the target architecture cannot provide a detailed solution, it points out the direction where this organization should go (Paitce, 2008).

Moreover, when transforming baseline architecture to target architecture, a gap analysis should be made, and there might be a transition architecture in the middle to elaborate intermediate state (Philippe & Gilbert, 2014).

The graph below shows the typical construction of a baseline/current architecture and a future/target architecture, and the process to develop the migration plan to make this transition.

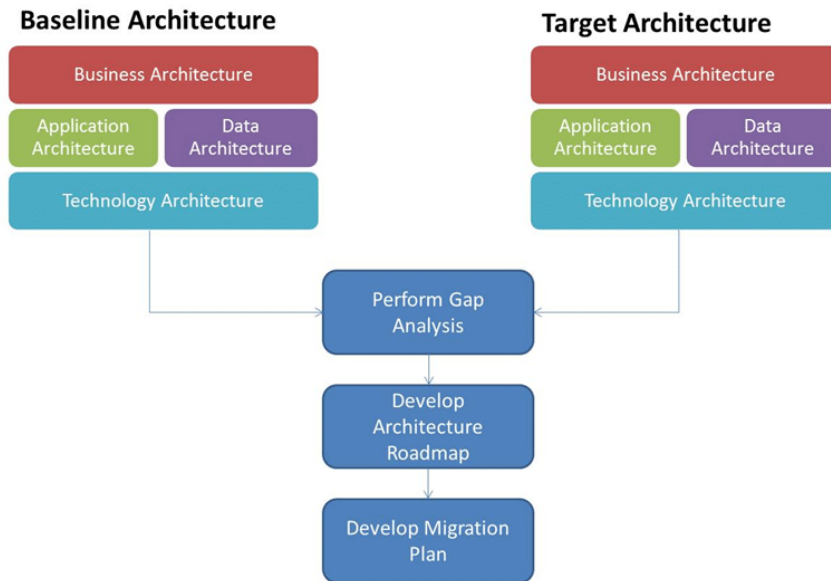


Figure 4. Baseline and target architecture¹⁰

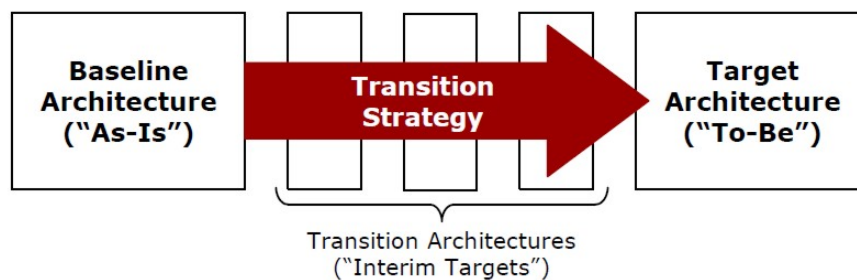


Figure 5. Transition architecture¹¹

3.2 Enterprise Architecture Framework

3.2.1 Enterprise Architecture Framework

The Open Group defines enterprise architecture framework (EAF) as a detailed methodology to develop and governate the enterprise architecture of an organization. EAF often includes a set of structured processes, reference models, standards etc. Also, it provides a common vocabulary for designing and implementing enterprise architecture (The Open Group, 2018).

With a well-designed EA framework, organizations can decide on the systematic design on all blocks of the system and describe how those blocks get connected through the use of architecture description (SearchCIO, n.d.). Marley believes that the EA framework mainly guides in three areas for developing enterprise architecture. First, it provides the architecture description. The architecture description intents to transform the enterprise's architecture information into viable models by applying architecture communication methods such as architecture views and viewpoint, diagram notations (IASA, n.d.). EA framework visualizes architects' thinking and divide the architecture

¹⁰ <https://www.webagesolutions.com/wp-content/uploads/2017/11/architecture-assets.png>

¹¹ https://upload.wikimedia.org/wikipedia/commons/1/1e/EA_Transition_Strategy_-_from_Baseline_to_Target.jpg

description into different domains and layers and provides views to let the stakeholders look at different concerns. Matrix, catalogues, and diagrams are common forms for documenting the enterprise (Marley, 2003).

Secondly, EA framework provides methods for designing architecture. It defines a structured process that architects or information managers can follow when developing a specific EA for an organization. EA stakeholders go through different phases and create a list of deliverables with the support of tools and principals that the framework offers. Then the third significant function of the EAF is organizing the architect team and providing architecture governance. EA framework gives guidance for the architect team of the organization so that people in the group can understand what skills and capability requires to build EA and how to train the employees to support the building of architecture (Marley, 2003).

3.2.2 Comparison Of Enterprise Architecture Framework

Frameworks

Criteria	Ratings			
	Zachman	TOGAF	FEA	Gartner
Taxonomy completeness	4	2	2	1
Process completeness	1	4	2	3
Business focus	1	2	1	4
Governance guidance	1	2	3	3
Partitioning guidance	1	2	4	3
Vendor neutrality	2	4	3	1
Information availability	2	4	2	1
Time to value	1	3	1	4
Readiness assessment	1	4	2	3
Business process standardization	1	1	1	1
Average rating	1.5	2.8	2.1	2.4

Table 2. A Comparison between Zachman, TOGAF, FEA and Gartner ¹²

Nowadays, enterprises can have many options when choosing an EA framework. Roger Session in 2007 has attempted to make a comparison between the top leading EAF (Enterprise Architecture Framework) which concludes framework like Zachman, TOGAF, FEA and Garner for companies to choose (Sessions, 2007). He sets ten criteria to compare the performance of those four frameworks and ranked them with number 1-4. (1: does a very poor job, 2: does an inadequate job, 3: does an acceptable job, 4: does a very good job). In the end, the result indicates that none of those approaches is complete, and all have pros and cons. In other words, those frameworks have different concerns and advantages (Sessions, 2007). However, in the last row, we can find that the average rating has shown that TOGAF ranked number one with relatively strong comprehensive strength.

A new comparison of the most popular frameworks in recent years was made in 2018 by AltexSoft, a technology and solution consulting company. In the comparison table below, it identified the general description of five popular methods to build EA, the critical functions of EA frameworks, and when to use that framework.

¹² <https://slideplayer.com/slide/9317290/28/images/61/Comparing+EA+Approaches.jpg>

Enterprise Architecture Frameworks Comparison

Framework	Description	What it does	When to use
TOGAF	Leading EA development tool for step-by-step architecture implementation	Creates an outline for rapid and iterative architecture development	As a guide for clear-cut architecture implementation and governance
Zachman	Set of management rules presented in a form of a 36-cell table	Defines relationships between different perspectives and rules	To describe independent elements without losing the holistic view of a system
SABSA	Risk-driven methodology for enterprise information security	Delivers security infrastructure solutions	To coordinate your IT security with business goals
4+1	Model addressing five software architecture roles and their concerns	Describes the system from viewpoints of different stakeholders	To appeal to all types of stakeholders using a common language
Custom framework using UML	Using diagrams and models from Unified Modeling Language to create a custom architecture development method	Provides flexibility and standardized workflows to combine the best of all worlds	When all represented frameworks fail to reach your specific goals and to ensure the largest benefits

Table 3. EA framework comparison¹³

Based on the table, we can find that SABSA put more concern on the aspect of security architecture, which would be more useful for a specific type of organizations. Both studies about EAF comparison tend to believe that instead of an EA framework, Zachman is more like a taxonomy (Sessions, 2007), a template or tool that describes different conceptual relationships and abstract ideas from a group of perspectives. The advantages of Zachman is that it is easy to work for projects. However, the weakness is apparent too; it puts more focus on stakeholder's communication and lack of guidance for technical aspects (AltexSoft, 2018).

4+1 is a similar framework to Zachman but simpler and smaller. It is not really like an EA framework but a general tool or model that help the use of EA framework. Another way to build EA is using UML to create a customized EAF, which can be flexible since the enterprise can design their framework with standardized workflows. However, UML is not a simple tool, which needs to train employees first. Moreover, customizing a new framework without systematic guidance can cause panic for the team at the beginning (AltexSoft, 2018).

¹³ <https://content.altexsoft.com/media/2018/01/ea-frameworks-1.png>

The final framework is TOGAF. TOGAF was first developed by The Open Group in 1995 based on DoD's TAFIM, a reference model for enterprise architecture for the defence department in the US. Now TOGAF is the leading EA framework. 80% of global 50 enterprises and 60% of fortune 500 companies uses it to organize their enterprise architecture (White, 2018).

TOGAF is a general EA framework and can suit all type of organizations with all level of architecture because it has strong adaptability and can be tailored to fit different firms. Meanwhile, TOGAF can be used simultaneously with other methods and frameworks in the organization (Josey et al., 2018). Therefore, based on all comparison above, the final proposed framework in this study will be aligned with TOGAF.

3.2.3 TOGAF Architecture Development Method

ADM (Architecture Development Method) is a step by step iterative approach that helps the organization to establish and governate EA by going through nine phases. (Kvaes, 2012)

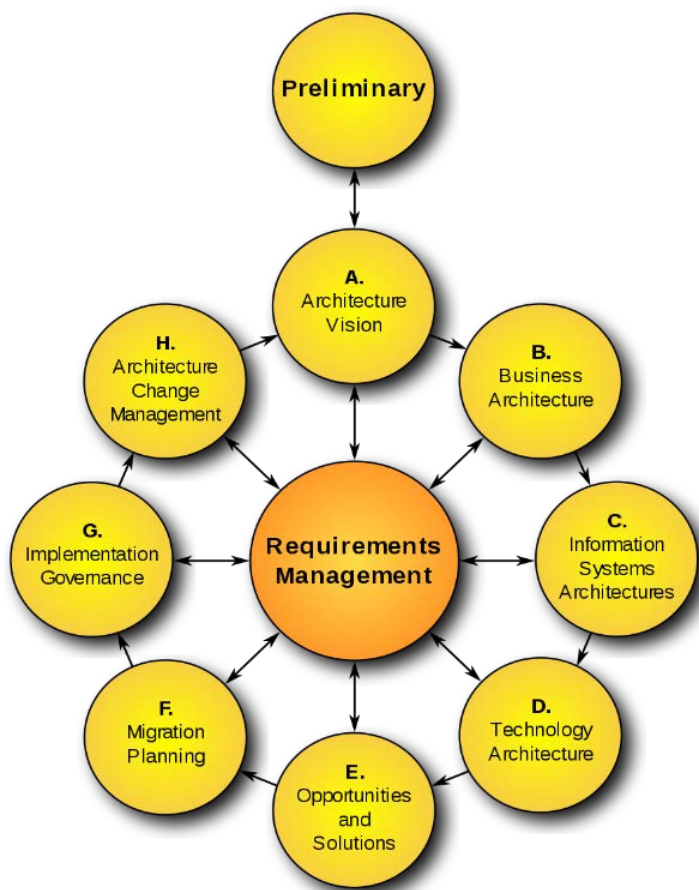


Figure 6. Architecture Development Cycle (ADM)¹⁴

¹⁴ <https://pubs.opengroup.org/architecture/togaf8-doc/arch/Figures/adm.gif>

In each phase, there are guidances for input and output and steps that organizations could follow when adopting EA. A highlight of objective for every phase is listed in the table below.¹⁵

ADM Phase	Objective
Preliminary Phase: Framework & Principles	Prepares the organization for a successful architecture project
Requirements Management	Every stage of the project should base on and validate business requirements.
Phase A: Architecture Vision	Sets the scope, constraints and expectations for the project. Validate the business context and create the statement of architecture work
Phase B: Business Architecture Phase C: Information Systems Architectures Phase D: Technology Architecture	Develop business architecture Develop data and application architecture Develop technology architecture Analyse gaps and develop the baseline ("as is") and target ("to be") architecture.
Phase E: Opportunities & Solutions	Identify major implementation projects
Phase F: Migration Planning	Analyse the costs, benefits and risks. Produce an implementation roadmap.
Phase G: Implementation Governance	Ensure that the implementation projects conform to the architecture
Phase H: Architecture Change Management	Ensure that the architecture responds to the needs of the enterprise as changes arise

Table 4. ADM phases and objective

3.3 Enterprise Architecture Artefacts

TOGAF architecture content framework provides a structured content meta model to enable the deliverable to be defined, structured and illustrated consistently. It defines the most critical components for building EA.¹⁶

¹⁵ https://pubs.opengroup.org/architecture/togaf8-doc/arch/chap03.html#tagfcih_2

¹⁶ <https://pubs.opengroup.org/architecture/togaf91-doc/arch/chap33.html>

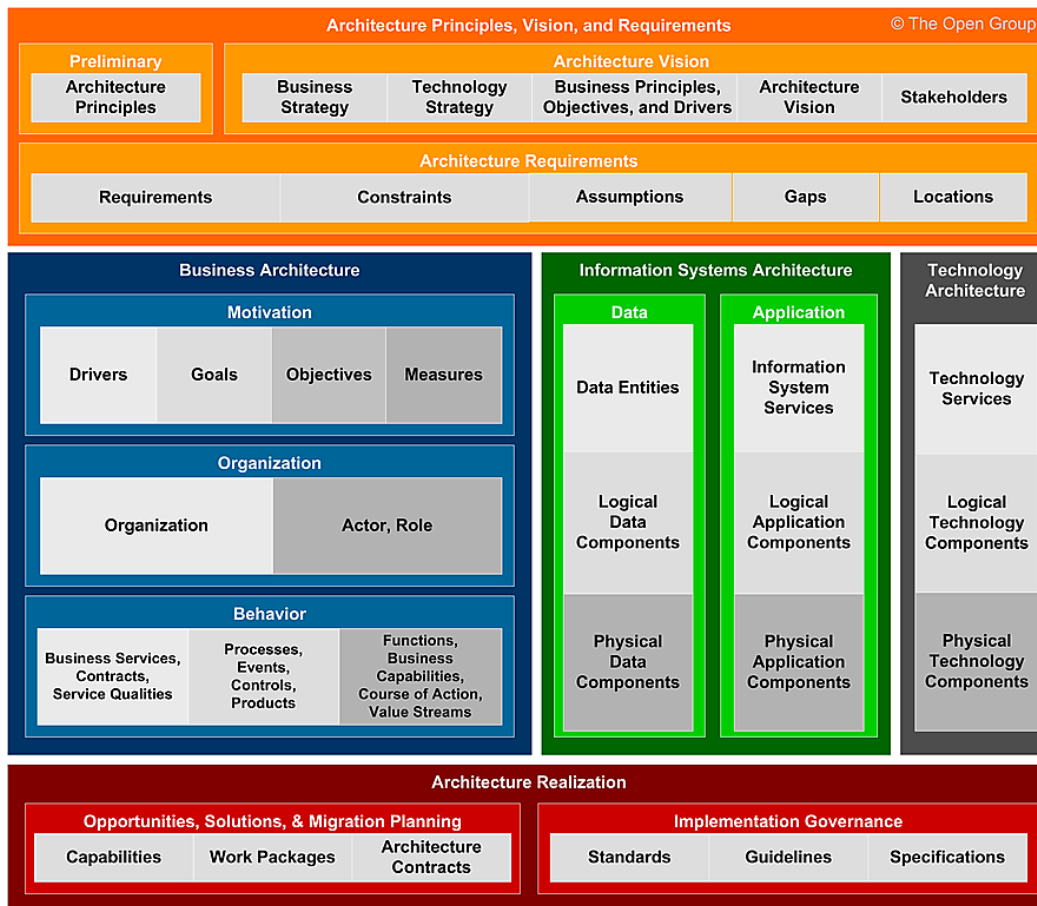


Figure 7. Detailed Representation of the Content Metamodel¹⁷

3.3.1. Important EA Artefacts

In this session, a set of very significant artefacts when doing EA will be explained.

- **Principal catalogue**

A list of business and architecture principles that describe a 'good' solution or a way of how a 'good' architecture should look like. It helps to manage changes in architectural governance. Principal catalogue can also measure the outcome for architecture-related decisions (The Open Group, n.d.).

- **Architecture term catalogue**

A list of architecture terms regarding a concise and consistent definition for architectural elements. This catalogue provides a common language for people who are doing architecture together and let them avoid misunderstandings caused by interpretations (Mauersberger, n.d.).

- **Requirement catalogue**

¹⁷ https://pubs.opengroup.org/architecture/togaf9-doc/arch/figures/34_contentfwk5.png

A list of quantitative statements that indicate what the organization needs to do to achieve its objectives when building EA. Requirements are often implemented when change initiatives and scope are identified. This catalogue is also a tool to ensure the future architecture to meets its purpose (The Open Group, n.d.).

- **Architecture, vision goals, objectives Scope description**

A resource that documents the best practice from the past. The project team can rely on a good reference architecture to avoid making some mistakes, saving time and enhancing IT efficiency. It often concludes reference for things such as hardware, software, processes etc. The reference architecture should be updated based on the specific needs of the enterprise.

- **Process flow diagram**

A diagram that shows the sequential flow between activities under the control of the organization. Process flow diagram is used to represent the interpretation of processes. It can also display a process in detail, including the trigger events, the product that is generated by a specific process, the process flow diagram describes what steps or activities employees take for a particular function.

- **Stakeholder map matrix**

A matrix that is used to identify key stakeholders for the architecture project, their influence level and involvement on the project. Understanding stakeholders' key concerns can help the organization to make efforts on the right place and ensure the project gets enough support.

Reference Architecture: reference of solutions that can be used to guide organizations in practice. The reference architecture documents things such as system processes, specifications, logical components and interrelationships (Rouse, 2012).

- **Business landscape**

A high-level diagram that describes an organization's primary business function and processes.

Organization actor catalogue

A definitive list of all participants that interact with information technology, including users and owners of systems.

- **Data lifecycle diagram**

The diagram represents changes in the status of data entities and triggers that cause change. It helps to manage business data throughout its life circle from completion to disposal. The separation of data also helps to identify the common data requirement, which increases the efficiency of resource sharing.

- **Application landscape**

Application landscape is a high-level diagram. It represents the essential applications in the organization and the communication between them. It also shows how systems support the preliminary business function of the group. Schools often chose this way to present their application architecture while TOGAF separates it into two more specialized models. One is the application

communication diagram, which depicts all applications and communication. The other is the process application realization diagram that illustrates the sequence of events when several systems are involved in implementing one business process (Dragon1, n.d.).

- **Application/Role matrix**

The matrix aims to represent the relationship between applications and business roles that interact with it in the organization (The Open Group, n.d.).

- **Infrastructure model**

Infrastructure model is a graph that shows the entire technical communication infrastructure of the organization. It represents how IT systems and associated hardware systems are networked through different devices (Aris Community, n.d.).

- **Roadmap**

A strategic blueprint that represents how the organization will use ordered IT plans to make the transition from baseline architecture to the target architecture (Wikidot, n.d.).

- **Architecture contract**

A joint agreement that addresses the deliverable, quality, and feasibility of the architecture between development parties and sponsors (The Open Group, n.d.).

- **Project plan**

A formal document that is used to guide the ennoblement and control of a project. It includes estimation and plans for the project budget, timing, priority, resources etc (Techopedia, no date).

- **Project start architecture (PSA)**

PSA is a transition or subsides architecture, often used for big projects. The main goal of PSA is to provide the project with a well-defined and a practical scope to ensure the project fits into the big picture of the enterprise (Berg, 2009).

- **Complaints assessment**

Compliance assessment is an important governance mechanism. It often offers the organization a checklist to assess whether the implementation of the project is compliant with the defined architecture (SPRAX, n.d.).

- **Governance model and guidelines**

Governance model and guidelines provide organization methods, process, and tools to ensure that the EA project is well managed. It supervises deliverables and ensures the plan fits the actual demand and goal of the organization (Gopala, n.d.).

- **Project context diagram**

The project contacts diagram is often used for project portfolio management and project mobilization. It represents the scope of the work package in the execution of a broader transformation roadmap. It links a work package to the organization, application, functions, services, processes data and technology that can be influenced by the project (The Open Group, n.d.).

- **Conceptual information model**

A high-level diagram that describes the most critical information/data entities in organization or system and their relationship to each other. It's a useful way to communicate ideas to a great variety of business and technical stakeholders (SPRAX, n.d.).

- **Application/ technology matrix**

The matrix records the mapping of applications to technology perform (The Open Group, n.d.).

- **Technology portfolio catalogue**

A list of all technologies that are used in the organization for achieving its business goal, such as hardware, application software, infrastructure software etc (The Open Group, n.d.).

3.3.2 Reference Architecture In The Netherlands

To be precise, reference architecture is not an artefact while selecting a suitable reference architecture for enterprise is genuinely an essential step when developing EA.

Reference architecture aims to offer a template solution of architecture or a specific domain to the organization. Those templates are the conclusion of project experience from the past (DovelTechnoogies, n.d.). Documents such as software, hardware processes, logical components and their relationship are often recorded in the reference architecture (Rouse, 2012).

Not using reference architecture does not mean the project will fail, but it may cause panic in the initial period and indeed, the organization will waste more time and cost because they spend extra energy on researching something that is already available (Paul, 2002). On the other hand, by reusing a practical solution, the organization can avoid making more mistakes. Furthermore, it enhances internal communication inside of the organization and allows the stakeholder to modify it flexibly based on organization and project's characteristics (Clements et al., 2010). Thereby, the reference architecture is a handy and practical reference tool for enterprises, especially in the initial phrases of EA construction. In the mid and late stages, it can also exert its function to provide organizations with a basic methodology to help them achieve the goal (DovelTechnoogies, n.d.).

The following three reference architectures are well-known and the commonly used ones in the educational field in the Netherlands. And in the multiple cases study in chapter four, we will know the situation of the current use of MBO institutions, as well as school experts' preference in terms of reference architecture selection.

- **Triple-A**

Triple-A is a reference architecture designed for MBO institutions. A network of ROCs and AOCs institutions worked together and transferred the joint vision of educational innovation to process

model based on the standard processes at schools. In the encyclopedia of Triple-A, there is the reference of vision, architecture and functional designs (TripleA, 2012).

- **HORA**

HORA is a reference architecture for Dutch higher education. In recent years, the scale of higher education institutions is getting bigger and more institutions seek for cross-organization corporation and digitization, which further urged the demand for EA. HORA helps organizations to manage their structure and information, guide them to transfer the general template to the architectures that suit to their organizations. HORA launched in 2013 and keeps regularly updating in line with user feedback. This reference architecture is mainly used by an enterprise or information architect and other personnel who are responsible for information provision such as information manager, solution architect (HORA, 2019).

- **NORA**

NORA is a reference architecture for the Dutch government. It offers a description of principles for the establishing a systematic government's information management. Many specific reference architectures are developed based on NORA such as GEMMA, DERA, etc. (NORA, n.d.).

3.3.3 Modelling Tools

To make the communication easier and reduce IT complexity, the enterprise architect, business manager or application engineer tend to visualize the structure of the organization and systems using the form of models. Models then provide stakeholders with different views and help them to manage group information, identify all components of the organization and interrelationships (The Open Group, n.d.).

Since models are very significant artefacts when developing EA, in this paragraph, I will put a focus on the commonly used modelling tools. And in chapter four, the school's choice of modelling tools will be analysed.

- **Archi**

ArchiMate is an open and independent modelling language for EA and is also a technical standard (The Open Group, n.d.). It helps the organization to describe, analyse and visualize their architecture in each domain and shows the interlink between them. Compared to other enterprise modelling tools such as UML or BPMN, ArchiMate sets up its own rules and principles.

Archi is a modelling tool that is specially designed for creating ArchiMate standard models (Archi, n.d.). By using this common language on Archi, enterprise architects or modellers can easily visualize things like business processes, organizational structure, information flow, IT systems, and technical infrastructure. Furthermore, unlike other modelling tools, Archi is entirely free and aligned well with TOGAF and other EAF (Archi, n.d.).

- **Visio**

Visio is a diagramming application that belongs to the Microsoft Office product. It provides two versions to the user: standard and professional. In the professional version, more advanced diagrams, layouts and a variety of features are offered to the user (Mirosoft, 2016).

- **PowerPoint**

PowerPoint might be the most well-known presentation program for the public (Britannica, n.d.). Although PowerPoint is not a professional modelling tool, it has a very user-friendly interface, and the basic patterns it offers allows the user to make simple models quickly. Users do not need to learn anything beforehand and can create, share and discuss models easily to the other group members.

- **BlueDolphin**

BlueDolphin is mainly an enterprise architecture but also offers many modelling techniques for enterprises. BlueDolphin attempts to make the modelling process simple, intuitive and professional. It works well with a variety of platforms and supports ArchiMate standard (ValueBlue, n.d.).

Below I compared the pros and cons for different modelling tools:

	Pro	Con
Archi	<ul style="list-style-type: none"> ✓ professional ✓ provide common language elements and metamodels ✓ update regularly ✓ free and open source ✓ a wide range of architectural users ✓ display models in a clear and logical way ✓ user-friendly and straightforward interface 	<ul style="list-style-type: none"> × complicated for non-IT users × the file needs specific software to open × inconvenient to communicate and corporate with others × needs to acquire ArchiMate related knowledge before making models × no clouds service <p>(Archi, n.d.)</p>
Visio	<ul style="list-style-type: none"> ✓ market leader of diagramming software ✓ provide various diagramming shape and allows to create more precise models, e.g. network diagrams, process diagrams, flow plans ✓ three versions with different pricing and features ✓ the most advanced version support cloud service ✓ can be used together with excel ✓ most experts are familiar with Visio ✓ relatively user-friendly interface, create process diagram flexibly 	<ul style="list-style-type: none"> × poor customer support × only match with the Window system × no update for years × do not support collaboration editing if using assistant software × big file size, can slow down the user's computer × long learning curves, difficult for new users × not easy to share models × not easy to print or present models × sometimes it can be difficult to use when moving objectives (Eliza, 2015)
PowerPoint	<ul style="list-style-type: none"> ✓ no extra charge ✓ no need to learn new things before drawing ✓ easy to use 	<ul style="list-style-type: none"> × does not suit to draw detailed process

	<ul style="list-style-type: none"> ✓ can draw simple diagrams quickly. e.g. basic process flow diagram, roadmap ✓ easy to share, edit, cooperate, present 	× no common modelling legend language
BlueDolphin	<ul style="list-style-type: none"> ✓ convenient to cooperate easily to share and edit models ✓ web-based ✓ users can access devices in different locations at any time easily ✓ update regularly ✓ supportive customer service ✓ integrate with all kind of input sources automatically ✓ can create different views easily ✓ friendly to both IT and non-IT employees ✓ support ArchiMate standard ✓ support cloud backup 	× expensive (Eliza, 2015)

Table 5. Enterprise architecture tool comparison: Archi, Visio, PowerPoint, BlueDolphin

3.3.4 EA Repository

There are a significant number of inputs and outputs when the organization is doing architecture and architecture repository is the specific tool to reserve architecture products.

TOGAF offers a structured repository framework for organizations. This framework helps them to classify and reuse architecture components. The overview of the architecture repository of TOGAF includes six types of architecture information: architecture meta-model, architecture capability, architectural landscape, standards information base, reference library and governance log (The Open Group, n.d.).

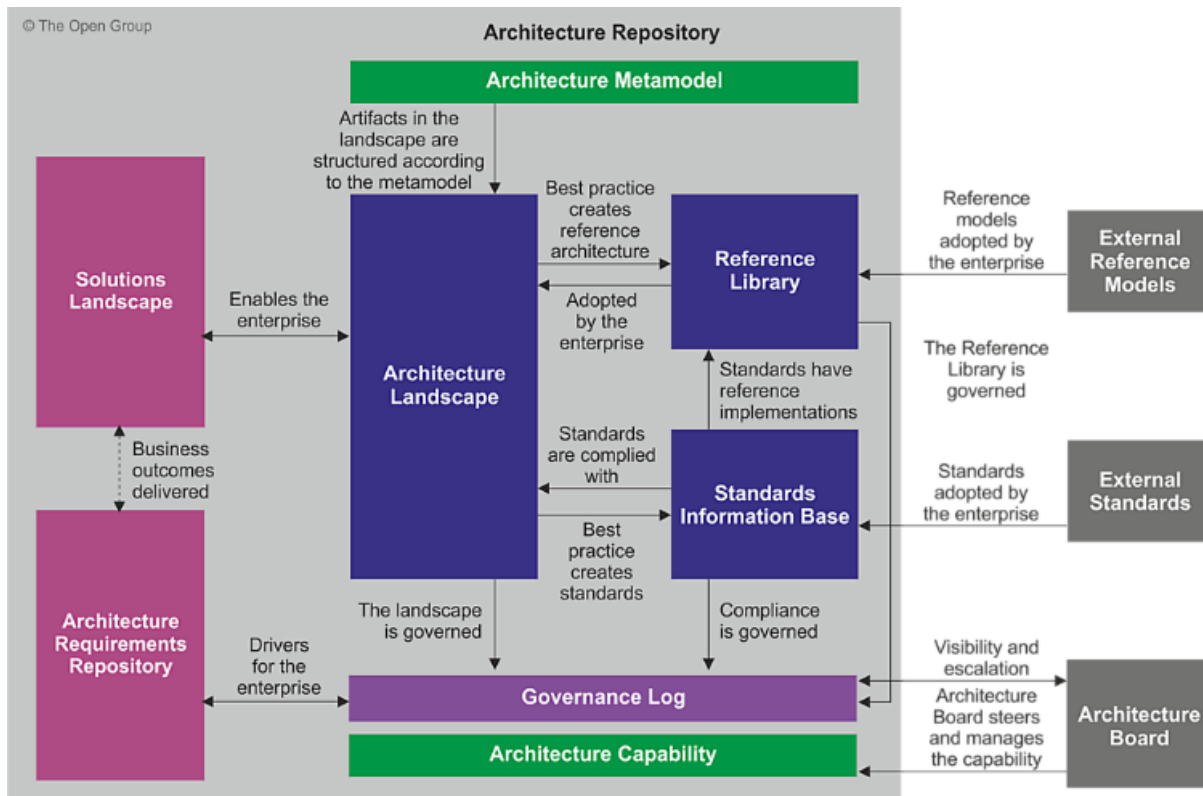


Figure 8. Structure of the TOGAF architecture repository¹⁸

When choosing an architecture repository, organizations can have various preferences. Some organizations may store their architecture products in San, and others may use web-based cloud service.

Based on the statistic of cases, I found that one of the most commonly used architecture repositories that MBO organizations use is SharePoint. This web-based corporation platform is developed by Microsoft and used primarily as a file management and storage system. SharePoint is highly configurable (Oleson, 2007). From the same supplier, 'Microsoft Teams' provide another product that can be set as the repository. One of the most significant advantages of 'Teams' is it can also offer a unified platform for communication and collaboration meanwhile provide functions for storing documents.

When using Microsoft Teams, the group members can work together in different places through workplace chat audio, real-time data sharing and other communication means (Rebekah, 2019). Furthermore, TOPdesk and Agile Cloud can also be used for reserving architecture components. Through cloud computing, information can be reached and stored easily and seamlessly (TOPdesk, n.d.) (AgileCloud, n.d.). Besides that, enterprise architecture development tools such as BlueDolphin and Enterprise Architect also offer functions to store and manage EA artefacts (ValueBlue, n.d.) (SPARX, n.d.)

Although every tool of architecture repository has different pros and cons, some basic demands when selecting a repository should be concerned (Philippe & Gilbert, 2014).

- enable to store content and metadata easily
- provide essential features such as searching, access, control put etc.
- safe and sustainable

¹⁸ https://pubs.opengroup.org/architecture/togaf91-doc/arch/Figures/41_archrepos.png

- have good customer support (Heery *et al.*, 2005)

CHAPTER 4 DATA ANALYSIS AND RESULTS

4.1 Elaboration Of Data Collecting And Processing

EA documents were collected from eight MBO schools to find answers for the research question. The case schools were chosen through the strategy described in chapter 2.4. All cases are public secondary vocational institutions with similar size and business process. Each major district of the Netherlands has one or a few schools to participate in this study. Three institutions are in the southern area, two are in the east, and the rest is in the central and northern parts. Among all participated schools, six of them have shared their EA documents before the interview through email, two schools have shown their EA files on-site during the interview. Since the architecture of most of the schools mentioned is under construction, all participated schools and interviewees are anonymous and named with code in this research. The table below shows the background information for each case.

Cases	Industry	Organizational nature	Type of education	Location	Employee number	Student number	Interviewee role	Interview length
A	Education	Non-profit organization	Middle-level applied education	Southern Netherlands	1,700	15,000	Enterprise architect	1.5 hour
C	Education	Non-profit organization	Middle-level applied education	Southern Netherlands	1,000	9,000	Information manager	1.5 hour
H	Education	Non-profit organization	Middle-level applied education	Southern Netherlands	1,000	10,000	IT advisor	1.5 hour
B	Education	Non-profit organization	Middle-level applied education	Central Netherlands	1,000	11,000	Information architect	1.5 hour
D	Education	Non-profit organization	Middle-level applied education	Eastern Netherlands	1,400	12,000	Enterprise architect	2 hours
E	Education	Non-profit organization	Middle-level applied education	Eastern Netherlands	900	10,000	Information manager	1.5 hour
G	Education	Non-profit organization	Middle-level applied education	Northern Netherlands	1,000	11,000	Information manager	1 hour
F	Education	Non-profit organization	Middle-level applied education	Northeastern Netherlands	1,100	13,000	Information manager	1 hour

Table 6. Case background information

Except for providing relevant documents, all schools have participated in the interview session. The interview format is a one-on-one structured interview. By using this format, the data can be compared easily and lead to a durable result.

During the around one and a half-hour-long interview, candidates were asked the same question, but the order of the question was not always the same, which depends on the answer the interviewee gives. Except for one telephone interview, all the other interviews are face to face interviews conducted at case schools.

A pilot interview was conducted prior to the first interviews at the case school to formulate the right questions. In the pilot interview, the interviewees were two experts who know the school's situation very well and have good knowledge of EA. After this, the interview process and timing were tested, and the questions were refined. The final design of interview questions was divided into four parts which related to the research question to ensure needed data can be collected.

In the first three parts of the interview, I attempt to gather data of schools' EA maturity level and their demands for EA. And in the fourth part, it is about how schools are doing EA in the daily working

environment. This part is especially valuable for readers who want to know how schools are doing EA in practice and the data there can also be served as an essential input for designing a simple EA framework from a practical perspective.

The tables below show the research questions that were asked during the interview and how they correspond with the sub research questions and lead to the answer for the main research question.

I. Importance of EA

Sub question 1	Related interview question
Do MBO schools need enterprise architecture?	<ul style="list-style-type: none"> Do you think enterprise architecture is needed for your school?

II. Current use of EA in MBO schools

Sub question 2	Related interview question
How is the current use of enterprise architecture in MBO schools?	<ul style="list-style-type: none"> Does your school use enterprise architecture framework? Why?
	<ul style="list-style-type: none"> Do you think your school have a matured EA?

Demands for EA

Sub question 3	Related interview question
Why do MBO schools need enterprise architecture?	<ul style="list-style-type: none"> What do you expect to achieve through enterprise architecture?
	<ul style="list-style-type: none"> What problems does your school want to solve through EA?

III. EA in practice

Sub question 4	Related interview question
How do MBO schools build enterprise architecture in practice?	<ul style="list-style-type: none"> Can you help me to review the most critical artefacts that your school sent me? / Can you show me the EA artefacts your school has?
	<ul style="list-style-type: none"> Where does your school store EA artefacts/ where is your school's EA repository?
	<ul style="list-style-type: none"> What kind of modelling tools do you use?
	<ul style="list-style-type: none"> Where do you start with EA and can you share some of your opinions to get started with EA?

Table 7. Interview question associated with the research question

The technique used for data processing in this multiple case study is framework analysis. This is a theme and a case-based approach (Moerman, 2016). It suits for analysing data that has pre-existing research questions, and the researcher is looking to prove this through analysing the data set. Since the interview is designed with a structured list of questions described above. All recorded data in the interview was analysis using this approach and following six steps below:

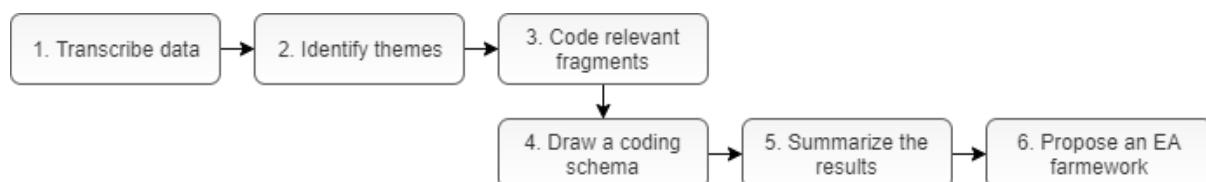


Figure 9. Data processing flowchart

Step 1: Recorded data was transcribed into text and had been read several times.

Step 2: The key themes and sub-themes were identified based on the clear structure of the interview and the research questions.

Step 3: Interesting, important or relevant fragments were selected and highlighted where the contents are related to the themes or sub-themes.

Step 4: A coding schema was drawn to presents key themes, sub-themes, and how they connected together.

Step 5: Summaries are given, which includes the analysing result of interview questions and relevant literature review. The summaries are also the answer to the research questions. The detailed result can be found in chapter 4.2-4.5.

Step 6: Through combing the result from literature and case studies, an EA framework is proposed with strategies that concern the needs mentioned in the interviews and is served as the guide for MBO schools. The framework is also the answer to the main research question.

After the completion of the first three steps, a coding schema is presented in the graph below. In the later parts of this chapter, the result of each interview questions will be described in a more detailed way. Also, a conclusion will be given by combining the result from the analysis of literature, organization documents and interviews before proposing the EA framework.

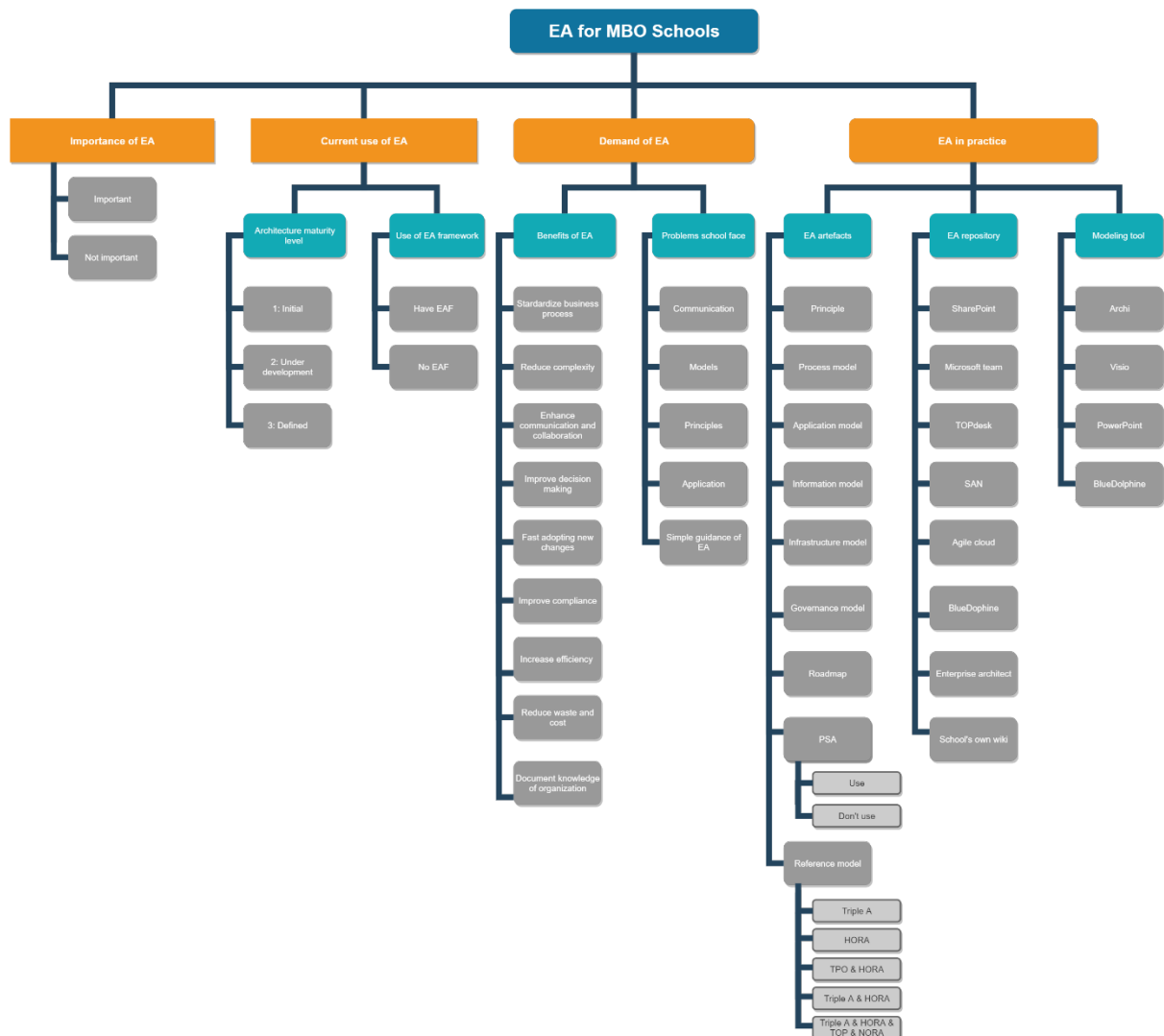


Figure 10. Coding schema

4.2 Importance Of EA

Results from literature

With the continuous innovation of IT, adopting EA to align business with technology is the key to survival for the enterprise (Nageshwar, 2019). Organization can expect a systematic, broad and profound change through the use of EA. At the same time, Paras (2017) believes that institutions should not over-reliance on EA-related individual tools such as supercomputer, and understand that the intangible, long-term value of EA can bring to the organization needs time to appear (George, 2017).

Results from interviews

INTERVIEW QUESTION:

Do you think enterprise architecture is needed for your school?

For this question, all interviewees agreed that enterprise architecture is essential for schools, they further gave reasons to elaborate this statement in the next question.

Conclusion

All size and type of organization benefit from adopting EA. Experts from mid-sized MBO schools all admitted the significance of EA for their institutions.

4.3 Current Use Of EA In MBO Schools

Results from literature

No reference for the status of EA adoption in a secondary vocational education institution has been done so far, only for higher education institutions. The maturity of higher education institutions is often in level 3, a defined level (Syynimaa & Maltusch, 2016).

Results from document review and interviews

In order to gather a general insight of case school's architecture maturity level, I analysed the schools' EA documents and applied the architecture capability maturity model (ACMM) that is introduced in paragraph 3.1.2 to measure the current architecture maturity level of case schools.

The figure below shows that no school participated in the study have very matured enterprise architecture. Seven out of eight schools are all at level 1 or 2 in this aspect, which manifests their EA construction is still in the initial and underdeveloped phase, a very early stage. Only one school is ahead of others with the defined enterprise architecture process at level 3.

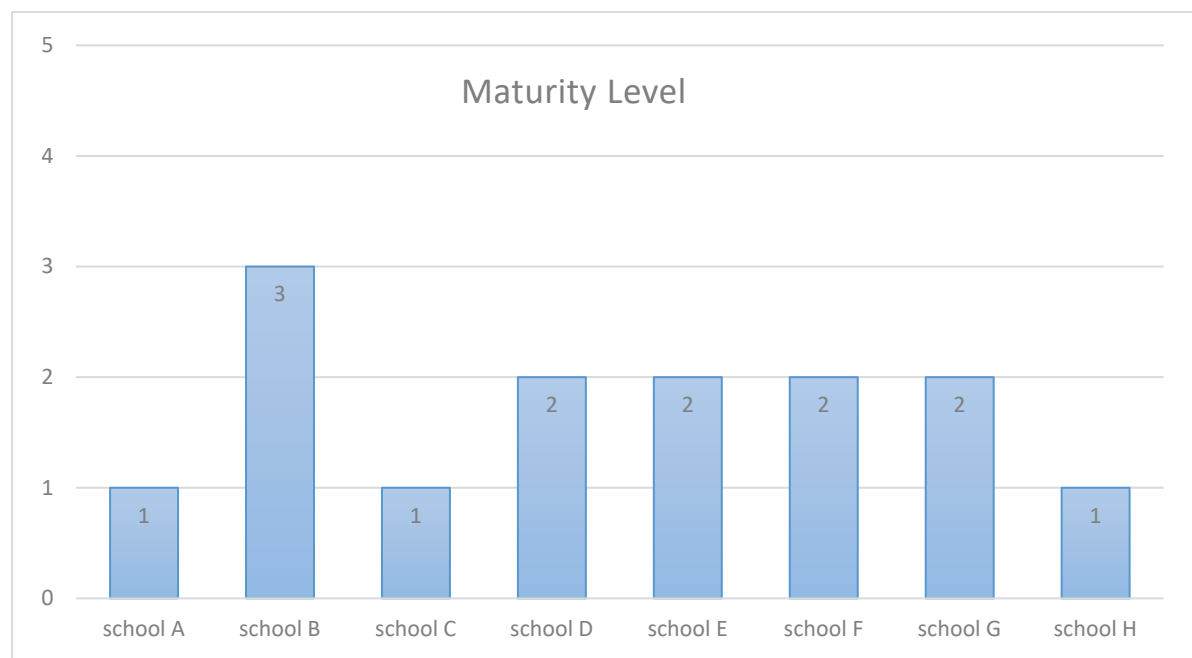


Figure 11. The condition of EA maturity in schools

The architecture process in most of the schools is localized or informal with limited awareness within the organization. They often do not have explicit governance of architecture standards but have established some essential artefacts such as vision, principles, landscape, roadmap.

“Lack of manpower and budget” made most of the schools do not have real architecture teams. It is common for a school to let only one information manager, application engineer or enterprise architect hired from outside to do all the architecture work.

The fast growth of the organization and increasingly complex IT environment are the two most significant reasons to change school leaders’ mind toward adopting EA. A quoting from a chief information manager at school F, where the interviewees said: *“I did not believe enterprise architecture, but I changed my mind these two years when I saw how complex our environment became and how difficult it was to show so many applications on our old small landscape”*.

INTERVIEW QUESTION:

Does your school use an enterprise architecture framework? Why?

Among all eight interviewed schools, only one school uses an enterprise architecture framework. Most interviewees believe EA frameworks in the current market are often too complicated for them and not practical enough so they use their own knowledge, although that can confuse other employees. *“Lack of budget, manpower and support from management”* are three main obstacles regarding the use of EA framework. Interviewees mentioned that they might consider using an EA framework if there is a simple and easy understanding one or smart tool in the future market.

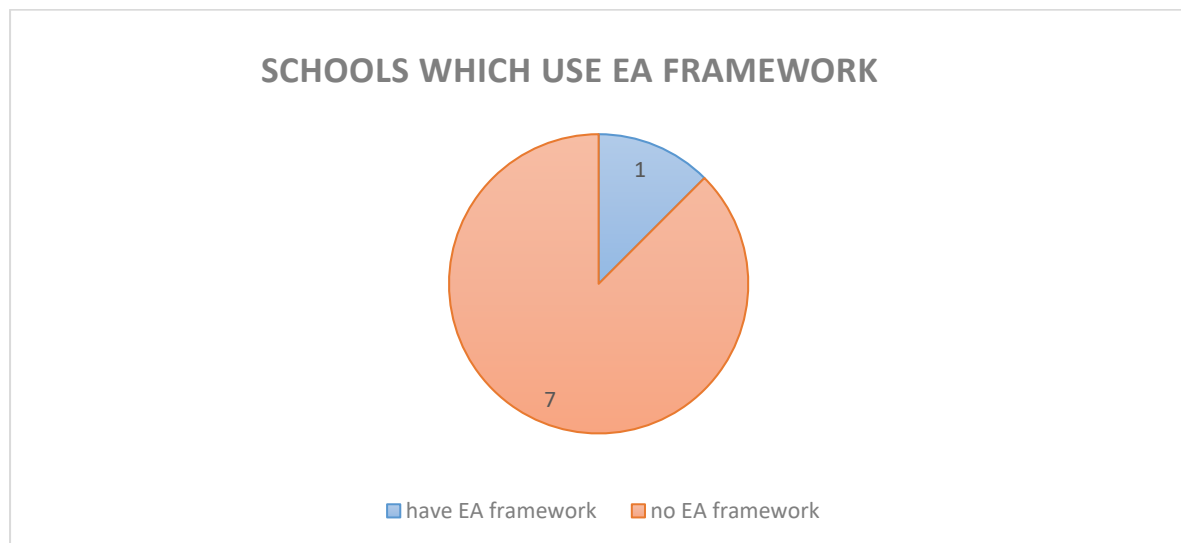


Figure 12. The condition of the use of EAF in schools

Conclusion

According to the survey, I can estimate that most of the Dutch MBO schools realized the importance to adopt EA for their organizations because of the expansion of the school and the complexity of the IT environment. Furthermore, currently, the majority of schools do not have a mature architecture due to employees' poor awareness of EA due to lack of workforce, cost and support from top management. The maturity of the school's architecture construction is often in an initial or underdeveloped phase; only very few schools develop EA faster than their peers.

4.4 Demands For EA

Results from literature

The benefits of EA mainly appear in 6 areas:

1. adding more IT values
2. standardizing organization's business process
3. enhancing efficiency for collaboration and communication inside of the organization
4. identifying requirements
5. contributing decision making
6. designing and refining the structure of the organization

Results from interviews

INTERVIEW QUESTION:

What do you expect to achieve through enterprise architecture?

The figure below shows the most commonly mentioned benefits of EA during the interview.

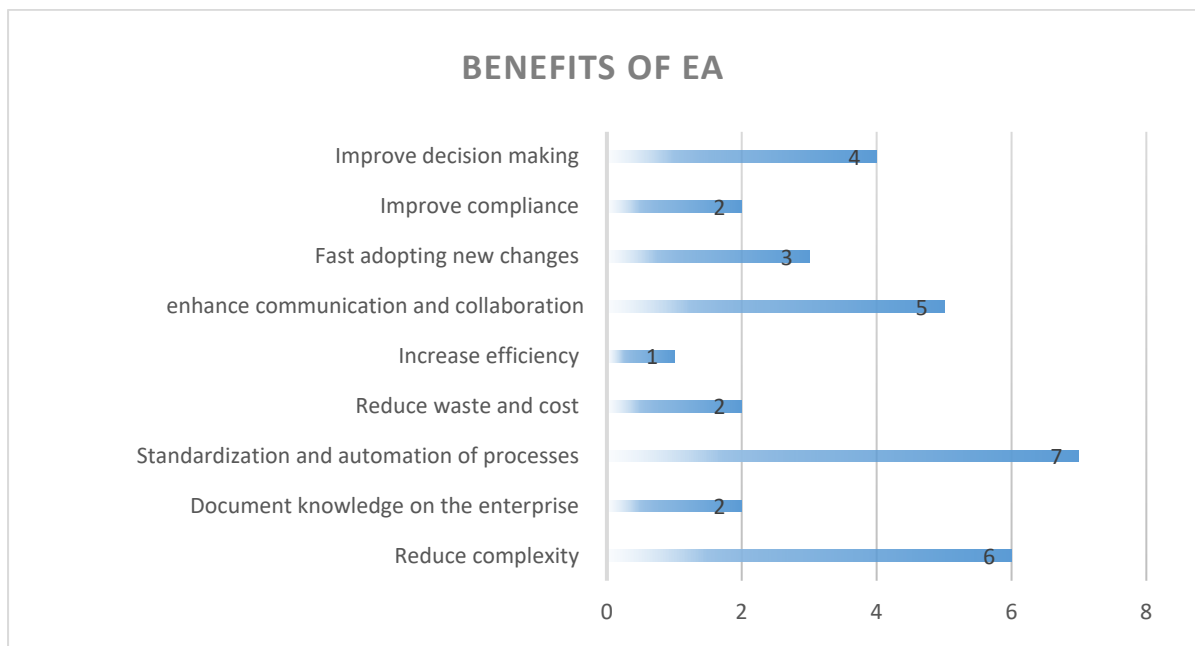


Figure 13. School's opinion about EA benefits

The five most significant benefits of EA that interviewees believe are:

- Standardizing and automating the business process
- 7 schools expect to standardize and automate their business processes through EA.
- Reduce complexity

Simplify complicated IT environments is the second concern of schools. 6 schools indicate that with the help of enterprise architecture, they may expect to manage IT resources easily and gather a whole picture through building landscape and roadmap.

- Enhance communication and collaboration

5 schools believe that enterprise architecture can enhance the efficiency of organization's internal communication and collaboration.

- Improve decision making

Half of the interviewees mentioned that they expect to make a better decision through EA.

- Fast adopting new changes

Three interviewees also believe that enterprise architecture should help the school to adopt transitions in this fast-changing environment.

INTERVIEW QUESTION:

What problems does your school want to solve through EA?

Regarding answers from the interviewees, schools mainly face problems from five aspects: communication, model, application, principle and a need for a simple guide of EA.

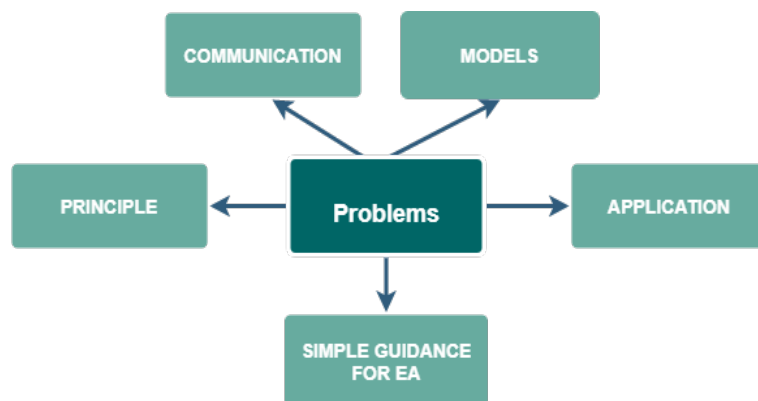


Figure 14. The problem school want to solve with enterprise architecture

Communication

- poor communication in the organization.
- every unit has its ways of work. The school staff lack the whole picture and are only aware of their part of the work.
- duties have not been assigned properly, it is not easy to find people to take responsibility when the problem occurs

Principle

- some principles in the organization are expired
- too many principles
- the description of principles is too complicated to read and understand

-staff do not pay much attention to principles, and there is not enough discussion for principles within the organization

Application

**-the application landscape loses effect very fast
-overlap of applications
-some applications are not connected right to each other
-vendors often integrated data into the single software which requires to lose coupling**

Models

-top management and people from the educational field cannot understand models very well

Simple guidance for EA

-lack of a brief guide to doing architecture work

Conclusion

According to the result of literature review and case studies, I found that EA can bring many long-term benefits to the organization and among all mentioned benefits in the interviews. Standardize business process, reduce complicity of IT environment, enhance internal communication and collaboration, as well as make a better decision are the aspects that schools concern most. Meanwhile, all participated experts from schools indicate that they hope to use EA to solve problems in five areas: modelling, application, communication, principle and get a simple guide of doing architecture.

4.5 EA In Practice

Results from literature

There is no literature for EA practice in MBO schools, but the theoretical foundation of proposed EAF in the next chapter will be based on TOGAF.

Result from document review and interviews

INTERVIEW QUESTION:

Can you help me to review the most critical artefacts that your school sent me? / Can you show me the EA artefacts your school has?

This question is addressing the essential EA products that schools have. The result is collected from document review and interviews in the table below.

Schools	Principle	Process model	Application model	Information model	Infrastructure model	Governance model and guidelines	PSA	Roadmap	Reference architecture
A	×				×				
B	×	×	×		×		×	×	×
C	×	×						×	×
D	×	×	×	×	×		×		X

E	×	×	×		×		×		×
F	×	×	×		×				×
G	×	×	×	×	×	×	×	×	×
H	×	×	×	×	×	×	×	×	×

Table 8. Result from document review: school's artefacts

Based on the document review and interview result, I found ten important artefacts that most schools have.

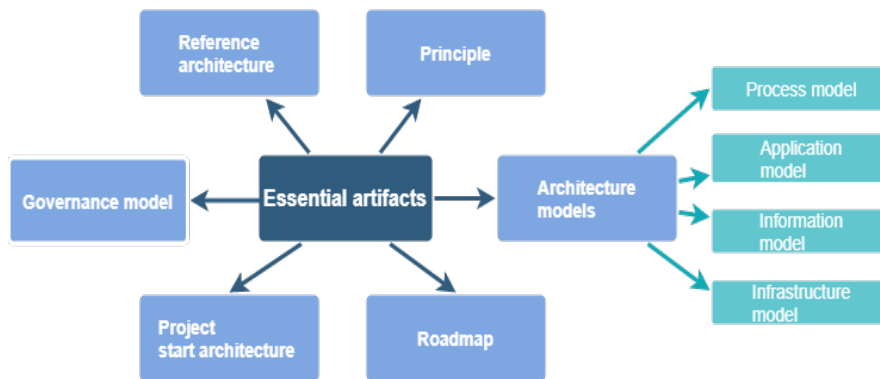


Figure 15. 10 important EA artefacts in schools

Principle:

Principle is one of the most important artefacts with top priority when doing an EA project. All the interviewees have mentioned it during the interview.

Project start architecture:

Project start architecture is a controversial artefact. One-third of schools do not use it, and the majority uses it sometimes. Most experts believe PSA could be helpful, but people need to use it carefully. *“Whether to use PSA highly depends on the size and scale of the project; otherwise, it is a waste of money and time.”* Said by an enterprise architect from the case school.

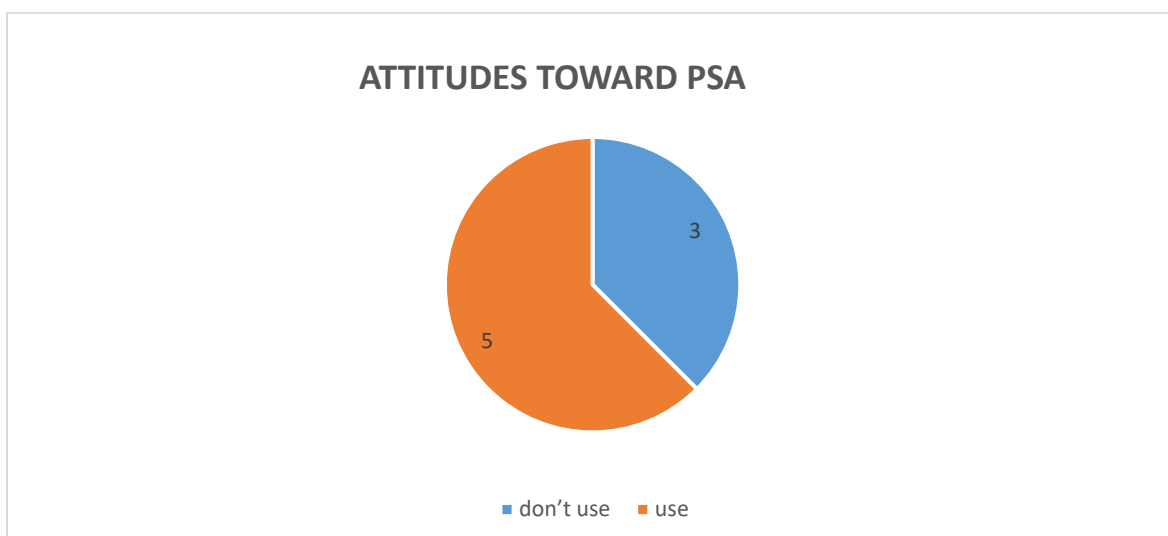


Figure 16. The attitude toward PSA in schools

Reference architecture:

The reference architecture is another focus for many schools. Most schools say that they use HORA and Triple-A that is introduced in paragraph 3.3.2. As we can see on the graph below, 7 schools use Triple-A as reference architecture and among them, half of the school uses it mixed with other reference architectures such as HORA, TPO or Nora. Only 2 schools reply only on personal knowledge; the rest believes that combining the advantages of different reference architecture would be better and prefer to use Triple-A and HORA.

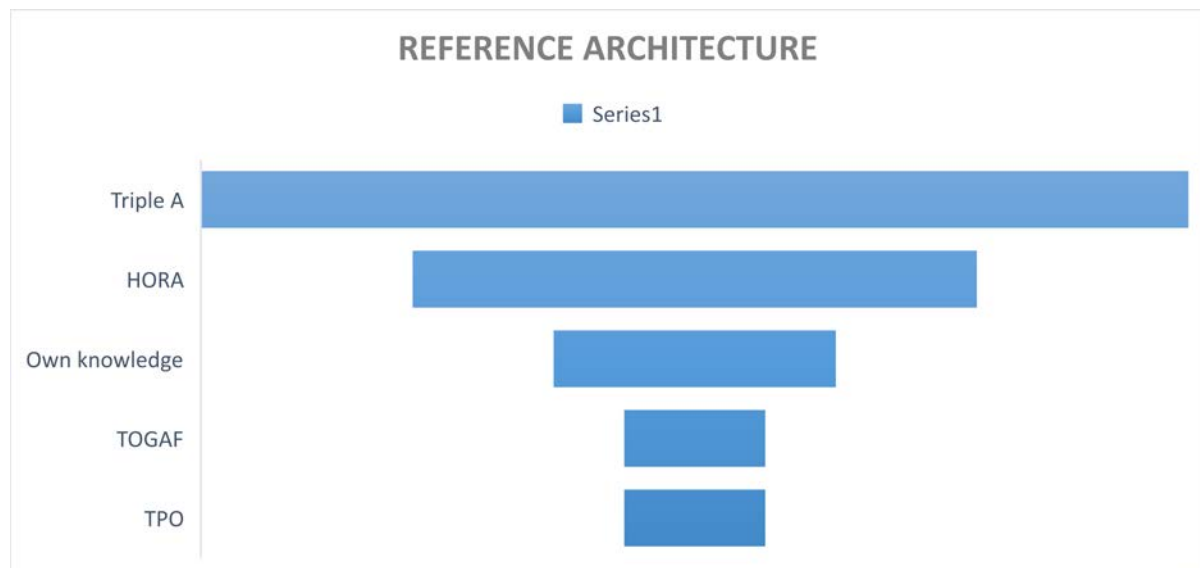


Figure 17. The use of reference architecture in schools

Government model and guidance:

Only one or two schools currently have an architecture governance model and guidance, but few interviewees have mentioned the importance of it.

Roadmap:

Most experts agreed that roadmap is quite essential and useful to have for schools. A roadmap helps schools to identify requirement quickly, guide directions and make detailed implementation plans later.

Architecture models:

Most of the participated experts validated that they often have high-level models for four key architecture layers (business, data, application and technology architecture). Experts suggested that *“When starting from zero, it is better to first create high-level models to describe the foundation and then many problems and more questions will come out automatically, then the next step is to have lower-level models for different purposes.”*

- **Process model:** Business process model is a significant focus for schools. Schools often use a landscape to standardize primary business function and processes and show how they connect to each other.

- Application model: An application landscape is often drawn and presents school's critical systems and interlink between them.
- Information model: Only a few schools have an information model, which are often abstract diagrams that describe the primary data included in the entity and the relationship between them.
- Infrastructure model: The infrastructure model that the schools showed is at a very high level. It described how major technology supports the application layer. Schools often set right their technological architecture a long time ago based on years' practice. Some interviewees said that network communication diagram and server diagram are quite useful for technicians.

INTERVIEW QUESTION:

What kind of modelling tools do you use?

Since schools have paid much attention to modelling, this question addresses their needs for a suitable tool to do the modelling. Through conducting interview and review documents, we can understand there are mainly four types of tools that schools often use to draw models; they are Archi, Visio, PowerPoint and BlueDolphin. Most schools use two or even three tools together to make different views for a different audience.

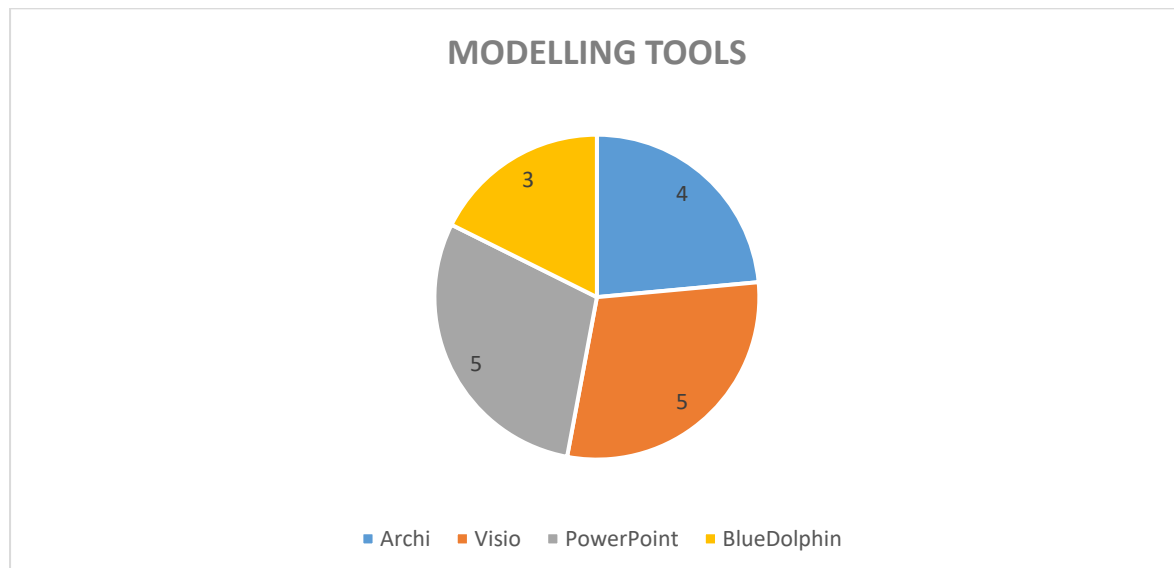


Figure 18. School's opinion toward modelling tools

Currently, Visio and PowerPoint are the most popular tools. Half of the schools chose them because they are easy to use and can be opened easily by everyone in the organization. 4 of the interviewed schools use Archi because it is a free and professional, while the disadvantage of having an ArchiMate standard model is also apparent. Two complaints from interviewees are "hard to understand for many audiences" "not easy to share because many cannot even open this type of file."

On the other hand, currently, 3 schools use BlueDolphin to do modellings. Still, more than half of the interviewed schools believe Blue Dolphin is an ideal tool for them to do modelling and can fulfil their needs in this aspect. Thereby, in total, 5 interviewees said they expect to do modelling with BlueDolphin while the high price of BlueDolphin might be an issue.

INTERVIEW QUESTION:

Where does your school store EA artefacts/ where is your school's EA repository?

Regarding EA repository, different schools have a different preference, but the majority choose to store their artefact on clouds. The graph below shows the schools' current storage place for architecture components. Among all storage sites of EA documents, the most popular tools are BlueDolphin (4) and SharePoint (3) and then Microsoft Teams, TOPdesk, central hard disk for 2 schools each, followed by the others used individually.

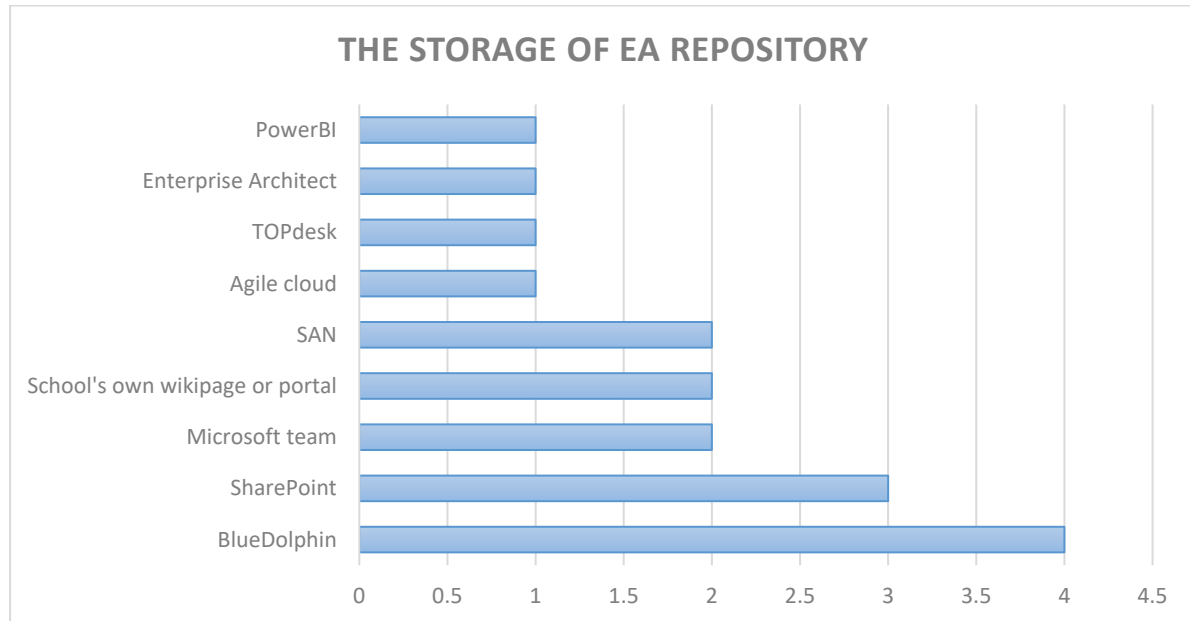


Figure 19. The place where schools store artefacts

On the other hand, BlueDolphin is a tool that we should pay more attention to. More than half of the experts have mentioned it offers good architecture repository; the price of it might be the only disadvantage of this tool. Thus, I can assume that SharePoint and BlueDolphin can be the main tools for schools to place EA knowledge in the future.

Besides, I also found that half of the interviewees store their EA products only in one place while the rest uses two sites to store their files. One of the interviewees mentioned that their EA documents are stored in more than three different systems, which is a big headache. He expects to use only two places as a repository in the future.

INTERVIEW QUESTION:

Where do you start with EA and can you share some of your opinions to get started with EA?

From the result of this question, I expect to know how school doing enterprise architecture in real life using an expert's knowledge and experience. This can be helpful to make a simple framework for other schools who want to start up an enterprise architecture project.

During every interview, the interviewees are given a paper with a graph that shows the architecture development cycle from TOGAF and pointed out what they do or plans to do about enterprise architecture for their schools. Most of the interviewee admitted that the sequence of the ADM framework is logical to follow, but TOGAF is too large and complex to implement. *"Since schools have to move fast, it is very common that people don't think about architecture or framework but immediately go to solve the small parts such as changes, projects. That is not good, so we try to build an EA in a more logical way."* A quoting from an interviewee.

When doing enterprise architecture, most of the interviewees said that they put more concern on *"business and application layer"* because problems often happen there and then *"the migration and*

implementation layer” in which more people will get involved in the project and portfolio management. Before doing EA, there are many existing detailed lower-level documents for technology architecture to ensure the regular implementation of the organization, so that is a part they consider less. “*High level first now*” , mentioned by an expert.

4.6 Proposed Framework And Strategies

In previous chapters, the first three research questions have been answered through analysis data from both a theoretical and practical perspective. From paragraph 4.5 on, the concern moved to the most critical problem of how to develop EA in practice. In the last section, I have found what efforts the case schools made for building EA. The table below recorded the data related to the research of sub-question four, gathered from interviews.

Case	Architecutre maturity level	Modeling tool	Architecture repository	Reference architecture
A	1: Initial	Archi Visio PowerPoint (BlueDolphin)	Microsoft team SharePoint Own portal	None
C	3: Defined	BlueDolphin	BlueDolphin PowerPoint	Triple A
H	1: Initial	Archi	SAN	Triple A HORA
B	2:Under development	PowerPoint Visio	Own wikipedia	Triple A
D	2:Under development	PowerPoint Visio	Agile cloud	Triple A HORA TOGAF Own knowledge
E	2:Under development	Visio PowerPoint BlueDolphin	SharePoint BlueDolphin	Triple A HORA TPO
G	2:Under development	PowerPoint Archi	Microsoft team BlueDolphin	Triple A
F	1: Initial	Archi Visio	BlueDolphin Enterprise architect TOPdesk SAN PowerBI	Triple A HORA

Table 9. Data of document review

And in this section, all related data will be used as input to create a simple EA framework for schools as a guide to help them get started with EA adoption.

The proposed framework is based on TOGAF (the open group framework), and the process is aligned with TOGAF ADM (architecture development method). Since many schools complained the expression of TOGAF guidebook is too complicated. I will interpret this lightweight framework using an easier way to make it more accessible for readers from both IT and non-IT field.

The framework mainly consists of two parts; one is a logical process that helps the organization to build enterprise architecture, then is a content metamodel that presents the most significant artefacts. This framework is designed for schools or mid-sized institutions to gather a quick insight into EA adoption so that they can get started with EA more easily. However, to make the best use of EA, people in the organization need to have a better awareness of EA in the early phase. The top management in particular needs to have enough interest and make the group ready for EA construction. Therefore, educating leaders from the business side for EA knowledge and letting them

know their goals and expectations for initiating EA project is a wise thing to do. Then the employees 's awareness of EA also needs to be increased.

The figure below is the proposed EA developing process model. Furthermore, the table under the process model shows how the four main phases of the development are connected to the phases in the ADM cycle.

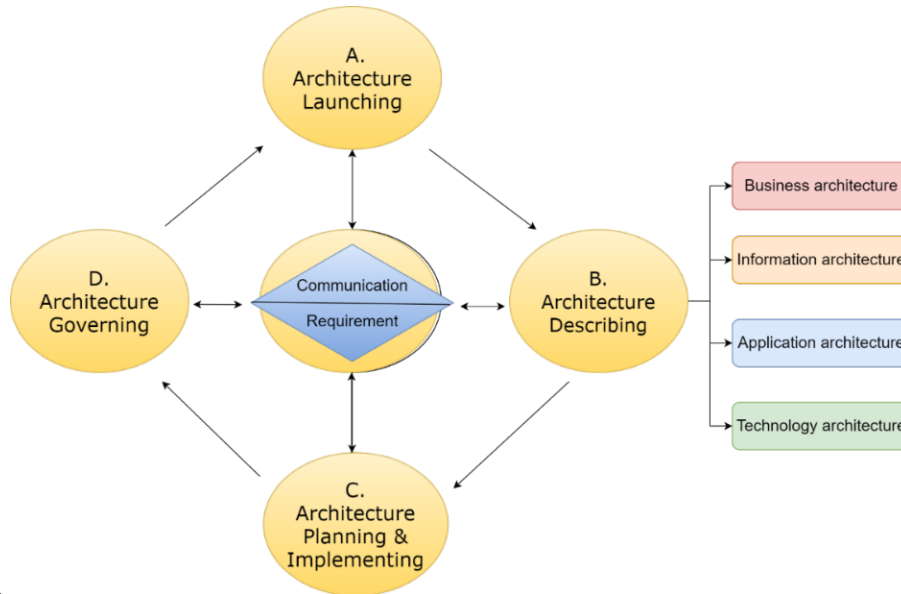


Figure 20. Proposed EA framework

Proposed Framework Phases	TOGAF ADM Phases
Phase A: Architecture Launching	Preliminary Phase Phase A: Architecture Vision
Phase B: Architecture Describing	Phase B: Business Architecture Phase C: Information Systems Architecture Phase D: Technology Architecture
Phase C: Architecture Planning & Implementing	Phase E: Opportunities and Solutions Phase F: Migration Planning Phase G: Implementation Governance
Phase D: Architecture Governing	Phase G: Implementation Governance Phase H: Architecture Change Management

Table 10. The link between phases of proposed process model and ADM cycle

The framework consists of four phases. From phase A to D, namely, architecture launching, architecture describing, architecture planning & implementing and architecture governing. In the middle are communication and requirement, they are essential aspects that need attention in every phase. Since the developing of enterprise architecture will never end entirely as long as the firms are still ongoing, the process of EA establishing will be iterative, while for the institution that started EA from zero, it is suggested first to take the most significant steps listed below.

Phase A: Architecture Launching
<p>The objective of phase A is to initiate the enterprise architecture project. In this phase, we need to define the needs of EA and make the organization ready to conduct the following stages.</p>
<p><u>Key steps:</u></p> <ul style="list-style-type: none"> -establish rules, disciplines and architecture principles -make a high-level formal statement of architecture requirement, vision, scope, the current and future status of architecture -define EA stakeholders and create a communication plan -select a reference architecture -make a simple catalogue of EA related terms to ensure people speak the same language when doing an EA project together
Phase B: Architecture Describing
<p>The primary purpose of phase B is to make a clear and understandable description for the baseline and target architecture in four architecture domains, as we described in chapter 3.2.3. In this phase, we present the structure of the organization, and this can be done through visualization or different forms of description.</p>
<p><u>Key steps:</u></p> <ul style="list-style-type: none"> -establish a high-level baseline and a target business architecture -create a high-level baseline and a target information architecture -create a high-level baseline and a target application architecture -create a high-level baseline and a target technology architecture -conduct gap analysis for the established AS-IS and TO-BE architectures

Suggestion:

- the target architecture can be built based on baseline architecture using one landscape with different colours
- make different views for different users
- modelling tools suggested: Archi, Visio, PowerPoint, BlueDolphin

Phase C: Architecture Planning and Implementing

The objective of phase C is to identify implementing projects, do the portfolio management and take actions for achieving the target architecture.

Key steps:

- make a high-level migration plan, a roadmap that shows how we can get to the target status of architecture
- if the project is too large, we can make a project start architecture
- make project plans to estimate needed resource and cost requirement, set realistic project timing, availability, prioritize tasks and identify the risk
- make an architecture contract to monitor the implementation work to conformance
- implement the task based on the plan

Phase D: Architecture Governing

Governing of enterprise architecture is a critical part of EA deployment. In this phase, the primary purpose is to oversee the implementation and provide a continuous monitoring process for possible future changes. When the requirement appears, a new cycle of this process will start from phase A again. Some relevant existing artefacts will be modified and updated for the new architecture request. With proper architecture governance, the organization would response changes more rapidly in both technology and business environment.

Key steps:

- perform post-implementing review

-make a governance model and guidelines for governing and managing the architecture and new changes

Table 11. Objective and steps in each phase of the proposed EAF

Based on the result of document review in paragraph 4.5, and the TOGAF content metamodel in section 3.1, a core artefact metamodel is designed below. This model belongs to the proposed EA framework and presented the essential artefacts or outputs in different phases to help with the establishing of EA.

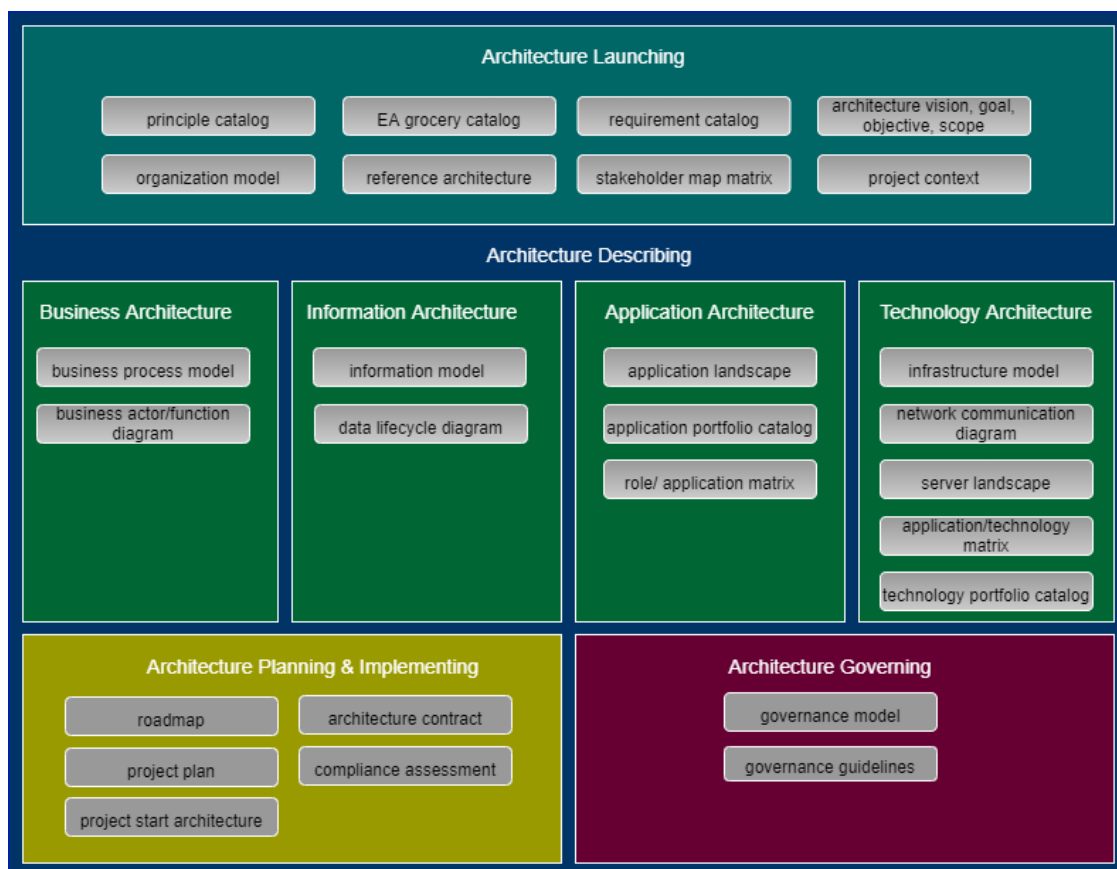


Figure 21. Proposed core artefact metamodel

According to an expert's advice, with limited time and budget, it is always wise to first make a high-level model and descriptions and further make lower-level products step by step.

Finally, based on the result of EA demands in paragraph 4.4, there are some strategies for solving problems on four aspects that concern the schools quite often.

- **Strategy for communication problems:**

-enhance communication by getting more stakeholders involved in the construction of enterprise architecture.

-take regular meetings and write things down to clarify employee' roles and responsibilities

- educate employees to strengthen their awareness toward enterprise architecture and understand the links between them and others.

- build a better communication environment with automatic tools such as BlueDolphin.

- **Strategies for principles problems:**

- simplify principles

- make the description understandable, using the language and terms that general audience can understand

- have more discussions about principles in the organization, review and update them once or twice a year

- ensure employees to read and remember critical principles by heart

- **Strategy for application problems:**

- build a good application landscape to understand the connection between systems

- build a roadmap to see the requirement and change on the application layer

- create artefacts for system management to make records in a more detailed level

- use smarter tool to manage the application such as BlueDolphin

- **Strategy for modelling problems:**

- choose appropriate modelling tools

- choose good reference models

- make different views for a different audience

4.7 Data Validation

For validating the result of data analysis, experts who have participated in the interviews were invited to fill in a questionnaire in which the most critical questions for answering the research question are included. Seven out of the eight interviewees have sent back the feedback for data validation. The design of the questionnaire can be found in appendix E, and the result of each question will be presented below.

- **Benefits**

Q1. Do you agree on the most commonly mentioned benefits of EA found in the interviews?

7 responses

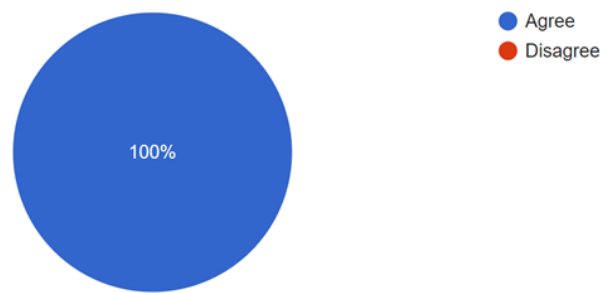


Figure 22. Data validation result regarding EA benefits

All the experts agreed that the list of benefits is the most significant thing that they want to achieve through EA.

One expert also emphasized the importance of communication and collaboration with EA. *“The architectural documents are very important in discussion with managers, teacher and other employees to show the dependencies and possibilities when making choices currently IT solutions.”*

Moreover, another added, *“It is useful for allocating ownership on EA components like a process or an application.”*

- **EA framework**

Q2. Do you find the phases and keys logical and helpful to follow for schools?

7 responses

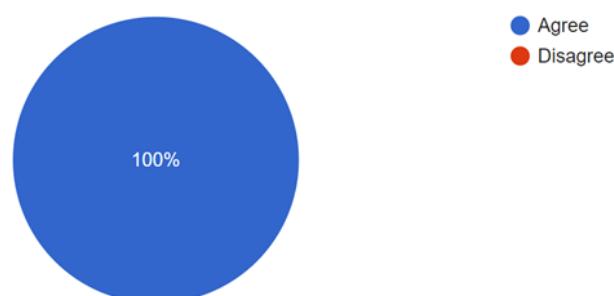


Figure 23. Data validation result for the proposed EA framework

All experts agreed on the proposed EAF and found the process helpful. Some experts have also shared their opinions:

“In our institution, there are smaller areas where there is a need for change (smaller targeted). Documenting our EA helps in this. (clarifying all aspects involved, communicating, ownership discussions etc.)”

“To make it simpler: at phase B information and application architecture can be combined.”

“It will take several years where our digital EA knowledge base grows (in detail) and (last but not least) company-wide EA knowledge will grow. So not just by the IT department but also by the business analyst, process owners (or the process experts), project leaders, system owners, application specialists, information managers, some department heads etc. there is not enough stakeholders with enough IT-maturity to understand the need for building, maintaining and using enterprise architecture.”

“To- be situation is always moving. There will be a constant need for adjustments.”

“It is a really good scheme, but to me, it is a bit theoretical. Take a practical problem and work that out with the stakeholders. In this way, your architectural governance will be built based on a real-life situation, and it will immediately show the value to the stakeholders.”

- **Artefacts**

The essential artefacts proposed in the literature and document review are listed below, please mark the priority and importance level for them. (1: the least urgent and important, 5: the most urgent and important).

After the data validation session, all essential artefacts are validated and can be classified for these groups based on the importance and priority level that the experts have set. A more detailed graphic statistic of the collected result can be found in Appendix G.

1. The most important artefacts

More than five experts have marked them with grade 4 or 5.

Business Landscape	Principal Catalog	Projects Start Architecture	Roadmap
Application Landscape	Process Flow Diagram	Architectural Vision, Goals, Objectives, Scope Description	

Table 12. The most important artefacts validated by the experts

2. Very important artefacts

Around half of experts have marked them with grade 4.

Reference Architecture	Organization/Actor Catalog	Governance Model & Guidelines
Compliance Assessment	Application/Role Matrix	Project Plan

Table 13. Very important artefacts validated by the experts

3. Important but not urgent artefacts

Three to four experts have marked them with grade 3.

Architecture Term Catalog	Requirement Catalog	Stakeholder Matrix	Technology Portfolio Catalogue
Conceptual Information Model	Data Lifecycle Diagram	Infrastructure Mode	Project Context Diagram

Table 14. Important artefacts validated by the experts

Among all validated artefacts, application/technology matrix and architecture contract are not seen as essential artefacts. Experts have quite various opinions on them, but only two to three interviewed

experts think they are important, and the majority gave very low grade on them, so these two artefacts are wiped out from the previous artefacts list.

Regarding identified the key artefacts, some experts also added:

“Catalogues of (open) Standards for exchange of information between systems and set of Information Security & Privacy requirements and guidelines” are also important artefacts.

Based on new feedback gathered from data validation, the proposed artefacts metamodel in paragraph 4.6 has been improved as below.

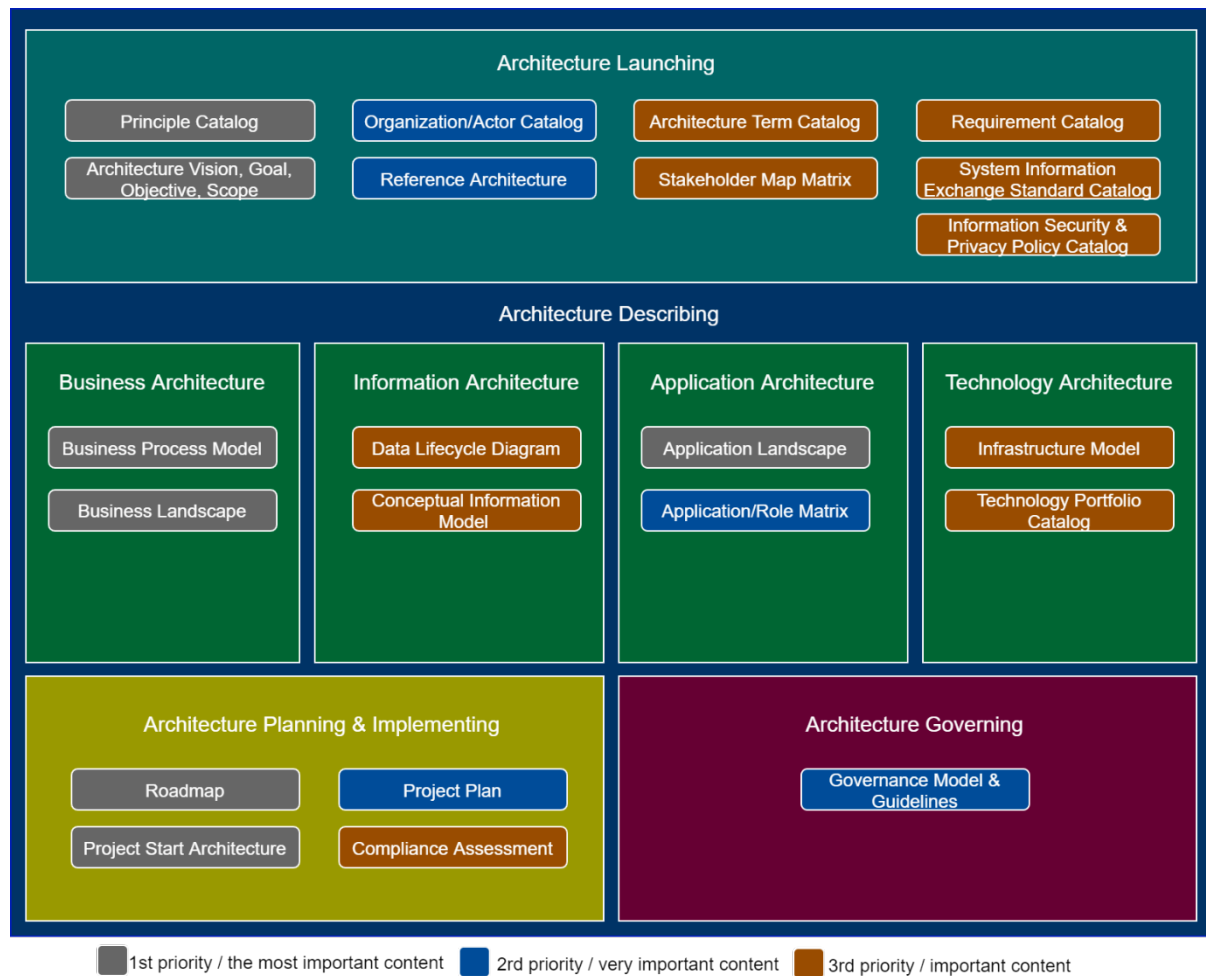


Figure 24.Updated core artefact metamodel

- **Strategy**

Q4. Below are strategies/tips when deploying EA, please choose how helpful they are.

Experts have reviewed the strategies with the proposed EA framework and further voted their practical level. (Whether the tip is very helpful/ can be helpful / or not so helpful). The overview bar chart below has shown the result of statistics regarding thirteen proposed strategies, and the graph of the individual charts can be found in Appendix G.

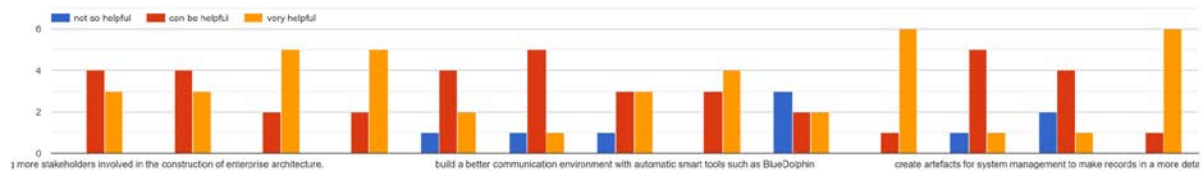


Figure 25. Overview of strategies' practical level

To conclude, most of the experts believe the strategies that can help the organization most on building EA are:

simplify principles
make different views for a different audience
have good reference model and make use of it
build a good application landscape to understand the connection between systems
make principle and other documents description understandable, using the language and terms that the general audience can understand

Table 15. The most helpful strategies when doing EA

The rest of the strategies are seen helpful but not the most helpful ones.

enhance communication by getting more stakeholders involved in the construction of enterprise architecture.
take regular meetings and write things down to clarify employee' roles and responsibilities
have more discussion about principles within the organization, review and update them once or twice a year
educate employee to strengthen their awareness toward enterprise architecture and understand the links between them and others.
build a better communication environment with automatic smart tools such as BlueDolphin
build a road map to see the requirement and change on the application layer
create artefacts for system management to make records in a more detailed level

Table 16. The strategies that can be helpful when doing EA

The only strategy that is marked as not helpful is to ensure employees to read and remember critical principles by heart. Experts believed it would not help the organization to improve EA.

CHAPTER 5 DISCUSSION

A critical discussion of this research will be given in this section. I will explain where this research contributes particularly, the most interesting findings, and some thoughts of mine regarding applying the result of this research. In paragraph 5.1, the main research problem and the four sub-questions will be put forward again and given to answers. Then, some limitations of this study, possible methods that help with them, and suggestions for the future work will be discussed in paragraph 5.2 and 5.3.

First, I would like to start with the discussion of the contribution this research can bring to the beneficial owners.

This study can theoretically and practically contribute to the EA application of mid-sized and educational organizations. In terms of theory, it makes up the research gap in the area of EA adoption for mid-sized companies, especially mid-sized secondary vocational education institutions. As I mentioned in the previous chapter, currently, only a few research concerns questions regarding the use of EA for SMEs. The research that related to EA development for mid-sized education institutions are quite blank. Hence, this research is original in some respects and can provide theoretical reference for the future study.

In addition, from a practical perspective, mid-sized educational organizations that do not have many resources and hope to get started with EA would get benefits from this research. Through reading data analysis and result, they would understand the current use of EA for secondary vocational education institutions in the Netherlands quickly by referring to peers practice when doing their EA.

Moreover, the EAF proposed in this study has shown the most significant architecture development process, key artefacts, and helpful strategies when doing EA, which can provide mid-sized companies with a practical guide to build their architecture.

Then, I will share some thought I had after I have visited all the MBO schools that participated in this study and talked with many experts. The most interesting finding I had is that the increasing enormous demands the mid-sized schools have for enterprise architecture. At the same time, the challenges they are facing and trying to conquer when school leaders gradually realized the significance of using EA for a better business-IT alignment in their organizations. Apparently, more studies should focus on this area, not only because of the knowledge gap but also the fact that mid-sized firms are as important as the large corporations for our society.

During the interview, I also found that since the mid-sized educational institutions often lack cost, labour and awareness to do enterprise architecture, experts tend to use their personal experience and knowledge to organize IT resource of their institutions. However, I believe this can be risky and should not be a long-term solution.

Besides, a good thing to see is almost all the MBO schools in the Netherlands are getting started to do their architectures work for a better development of their organization. Therefore, we can expect that schools will have more matured architecture in the future by continuous exploring and implementing.

About the EA framework that I proposed in this study, I do not think MBO schools in the Netherlands will use it directly because currently, many of them are using their ways and they are

under a lead of an official group to guide them in architecture related work. However, for mid-sized schools in other countries in Europe, if they have not started yet, it is feasible for them to implement the advice I give and using the framework, especially referring to the essential artefacts and strategies when doing EA, that can be very helpful.

5.1 Answering The Research Questions

In the last paragraph, I will restate the main research question, sub-questions and give answers and explanation for them.

Main RQ: What are the essential process steps and core artefacts to build an enterprise architecture for secondary vocational education institutions?

- RQ 1: *Do MBO schools need enterprise architecture?*
- RQ 2: *How is the current use of enterpriser architecture in MBO schools?*
- RQ 3: *Why do MBO schools need enterprise architecture?*
- RQ 4: *How do MBO schools build enterprise architecture in practice?*

To find an answer to the research question, I have conducted multiple case study. The findings below were all gathered by strictly applying suitable research methods. The result is based on the data collected from eight MBO schools located in different areas in the Netherlands. These data include dozens of internal architectural documents from the organisation practised in this study, about 62 hours recorded interview materials from experts, as well as the reference of the TOGAF guidebook, and many other EA related reference.

- **RQ 1: Do MBO schools need enterprise architecture?**

Nageshwar believes that EA is the key for enterprises development. The organization can expect a systematic broad and proud transition through adopting EA (Nageshwar, 2019). By conducting interviews with experts, I have confirmed this point of view. I found that school leaders hope to make a good business-IT alignment for their organization with EA. (Detailed analysis and result regarding this part can be found in chapter 4.2.)

- **RQ 2: How is the current use of enterpriser architecture in MBO schools?**

Based on the document review and measuring method provided by ACMM, I found that the architecture maturity level of most of MBO institutions are not mature. According to ACMM (architecture capability maturity model), schools are usually at level 1 (initial phase), or level 2 (underdeveloped phase). Only very few schools have a more matured architecture, at level 3 (defined phase). All experts in the interview mentioned that the architecture work of their organization is under construction. (Detailed analysis and result regarding this part can be found in chapter 4.3. ACMM measuring method is attached in the appendix H.)

- **RQ 3: Why do MBO schools need enterprise architecture?**

Based on the result of the literature review, the benefits of EA for MBO institutions primarily appear on these aspects:

- adding more IT values
- standardizing organization's business processes
- enhancing efficiency for collaboration and communication inside of the organization
- identifying requirements

- contributing decision making
- designing and refining organization structure

From in-depth interviews, I found that the primary motivations for MBO schools to develop EA are:

- standardizing and automating the business process
- reduce complexity
- enhance communication and collaboration
- improve decision making
- fast adopting new changes

Another interesting finding is that schools expect to use EA to solve some problems. This finding also indicates the needs of EA. Experts in the interview were asked to express their opinions regarding this question. The research result has shown that the needs of EA mainly on the aspects of communication, principle, model, application, and a template to build EA.

• **RQ 4: How do MBO schools build enterprise architecture in practice?**

To find an answer to this question, I collected data and made a comparison from the following perspectives:

(1) The most important artefacts

Though conducting document review, I found the essential artefact MBO schools often develop. They are principle, project start architecture, reference architecture, government model and guidance, roadmap, and architecture models. These artefacts are listed in the core artefact metamodel in paragraph 4.6 and 4.7.

Furthermore, to find out how schools build EA in practice, I have studied the question and the selection of PSA, reference architecture, modelling tools and architecture repository. Interviewees from different schools gave answers to this question; a detailed result can be seen in chapter 4.5.

• **Main RQ: What are the essential process steps and core artefacts to build an enterprise architecture for secondary vocational education institutions?**

Based on the investigation of the questions above, and the literature study conducted beforehand, I have proposed an EAF presenting the essential process steps and core artefacts for secondary vocational education institutions. Also, I offered a series of effective strategies to help them to build EA.

➤ Essential process steps:

Phase A Architecture Launching: to initiate the enterprise architecture project and make the organization ready

Key steps:

- establish rules, disciplines and architecture principles
- make a high-level formal statement of architecture requirement, vision, scope, the current and future status of architecture
- define EA stakeholders and create a communication plan
- select a reference architecture
- make a simple catalogue of EA related terms to ensure people speak the same language when doing an EA project together

Phase B Architecture Describing: to make a clear and understandable description for the baseline and target architecture in four architecture domains

Key steps:

- establish a high-level baseline and a target business architecture
- create a high-level baseline and a target information architecture
- create a high-level baseline and a target application architecture
- create a high-level baseline and a target technology architecture
- conduct gap analysis for the established AS-IS and TO-BE architectures

Phase C Architecture Planning and Implementing: to identify implementing projects, do the portfolio management and take actions for achieving the target architecture.

Key steps:

- make a high-level migration plan, a roadmap that shows how we can get to the target status of architecture
- if the project is too large; we can make a project start architecture
- make project plans to estimate needed resource and cost requirement, set realistic project timing, availability, prioritize tasks and identify the risk
- make an architecture contract to monitor the implementation work to conformance
- implement the task based on the plan

Phase D Architecture Governing: to oversee the implementation and provide a continuous monitoring process for possible future changes.

Key steps:

- perform post-implementing review
- make a governance model and guidelines for governing and managing the architecture and new changes

➤ Core artefacts:

The finding about critical artefact is based on the study of document of case schools and refer to the content metamodel of TOGAF. The core artefacts list is validated by experts in paragraph 4.7.

Phase A:

principal catalogue, organization/ actor catalogue, architecture term catalogue, requirement catalogue, architecture vision, goal, objective, scope, reference architecture, stakeholder map matrix, system information exchange standard catalogue, privacy policy catalogue

Phase B:

Business process model, business landscape, data lifecycle diagram, conceptual information model, application landscape, application/role matrix, infrastructure model, technology portfolio catalogue

Phase C:

Roadmap, project plan, project start architecture, compliance assessment

Phase D:

Governance model and guidelines

Finally, the most helpful strategies that EA can contribute for organizations:

- simplify principles
- make different views for a different audience
- have good reference model and make use of it
- build a good application landscape to understand the connection between systems
- make principle and other documents description understandable, using the language and terms that the general audience can understand

➤ Some other helpful strategies:

- enhance communication by getting more stakeholders involved in the construction of enterprise architecture.
- take regular meetings and write things down to clarify employee' roles and responsibilities
- have more discussion about principles within the organization, review and update them once or twice a year
- educate employee to strengthen their awareness toward enterprise architecture and understand the links between them and others.
- build a better communication environment with automatic smart tools such as BlueDolphin
- build a road map to see the requirement and change on the application layer
- create artefacts for system management to make records in a more detailed level

5.2 Limitations

In this section, I will elaborate on some limitations of this research, meanwhile discussing how to solve them.

First, eight experts from MBO institutions participated in this research, although they have the same or similar positions at school and all know about EA to a certain extent, the level of their knowledge on EA can be different. That could lead to inaccuracy of the research result. Since the data collected from qualitative interview mainly comes from personal experience and knowledge, the accuracy of the research result might be influenced if one expert tends to think about things from his or her position unconsciously instead of considering the organizational benefit. But two methods can still be adopted to make the research as relevant as possible.

The first method is to increase the number of cases and simultaneously ensure that the scope of their official duty includes business-IT alignment in the organization, and they have a basic knowledge of EA. The second improvement is to remind the interviewees to not think about things from their own position but try to be the representatives of the interest of the enterprise before the interview get started.

Another limitation is that the research results are maybe relatively generalizable. Regarding this, I suggest that future research can validate and expand the EAF proposed in this study. It is recommended to conduct research by continually observing and comparing several MBO institutions from time to time; this would help us to see the changes that EA could bring to the enterprises easily and clearly.

5.3 Future Work

In this section, I will point out possible directions for the future research.

It is recommended for future researchers to study other aspects regarding the developing and application of EA framework because this study only focuses on the essential architecture development process and artefacts. Therefore, future studies can investigate fields such as EA governance, architecture development techniques and expand the framework.

Furthermore, this study has found some areas that schools concern most and hope to solve with EA; this part can be explored at a deeper level. Questions would be meaningful to study in the future, for example how to use EA to deal with the problem related to communication or principle in the organization? What problems schools have when using reference architecture? And how to increase non-IT employees and leader's awareness of EA and enhance the internal communication efficiency using EA.

CHAPTER 6 CONCLUSION

Previous studies believe that EA can bring companies many benefits, and it is the key for enterprise survival (Nageshwar, 2019). Through conducting a literature study, I found that the majority of current research only focus on EA's application for large organizations, although very few have mentioned the significance of EA for small and medium-sized enterprises. This research conducted multiple case studies to investigate the adoption of EA for mid-sized enterprises, specifically secondary vocational education institutions to fill in the research gap.

The main research problem of this paper is to find what are the essential process steps and artefacts to build an EA for MBO institutions. Four sub-questions are formed and studied to find this answer.

The research result has first shown the urgent needs of MBO schools on EA and the current use of EA in an actual working environment. Based on these findings, a lightweight EAF is further put forward to help the development of EA for MBO institutions.

The proposed EA framework aims to provide a guide for mid-sized education institutions that have limited resources and budget to get started with EA. The framework includes (1) An architecture development model with primary phases and process steps (2) An artefact model with core architecture documents.

At the same time, through conducting literature study and gathering opinions from experts, I have also provided a set of practical strategies to solve problems that schools often face.

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APPENDIX A: LIST OF REVIEWED DOCUMENTS

Architecture slides

20180511 ICT_Architectuur_IST_Definitief_v1.0

Applicatiemodel kleur incl. Ontbrekende V1.1 29-06-2018 (1)

Procesmodel

Architectuur 1.3 - concept 20180914

Applicatielaag huidig

Bedrijfsfunctiemodel

Core-Netwerk 2019v003

Servers 2019v001

Management learning environments at Healthcare

Abstract architecture frameworks

Presentation IT method

Start architecture learning management system (LMS)-PSA

The state of affairs in the IMI sector

Dragon1-processen HC_v4 (1)

Presentatie IT werkwijze-Presentation IT method

De stand van zaken in de sector IMI

Startarchitectuur leermanagementsysteem

2019-01-28 - Applicatielandschap (2019)

Applicatielandschap 2017 naar 2020

Applicatielandschap 2017-application landscape

Applicaties en eigenaren-Applications and owners

Application landscape

DEF Drieluik deel 1 Informatiebeleidsplan

DEF Drieluik deel 2 Thema Aansluiten op het werkveld-DEF Triptych

DEF Drieluik deel 3 Thema Onderwijslogistiek-DEF Triptych

DEF Drieluik deel 4 Thema Besturen en beheren-DEF Triptych

DEF Drieluik deel 5 Thema ICT in het onderwijs-DEF Triptych

DEF Drieluik deel 6 Thema Studieloopbaan-DEF Triptych part 6

APPENDIX B: INTERVIEW QUESTIONS

Organization:

Interviewee:

E-mail address:

Job title:

INTERVIEW QUESTIONS

1. Do you think enterprise architecture is needed for your school?
2. Does your school use enterprise architecture framework? Why?
3. What do you expect to achieve through enterprise architecture?
4. What problems does your school want to solve through EA?
5. Can you help me to review the most critical artefacts that your school sent me? / Can you show me the EA artefacts your school has?
6. Where does your school store EA artefacts/ where is your school's EA repository?
7. What kind of modelling tools do you use?
8. Where do you start with EA and can you share some of your opinions to get start with EA?

APPENDIX C: E-MAILS SENT TO INTERVIEWEES

Hello xxx

My name is Ellie. I am delighted and honest to get in touch with you through my teacher's referral. As he mentioned, I am currently doing a research project on enterprise architecture.

I began to be interested in this topic in his class and later read more things about EA framework, especially TOGAF. It is said that TOGAF is one of the leading frameworks and is applied by 60% of fortune 500 companies, a so-called best practice of EA framework.

However, I found in reality, TOGAF seems not practical enough and often only used by some large firms. For instance, all MBO institutions have their own ways to build EA. Therefore, my research purpose is to make a more practical, lightweight EA framework that can save the organizations time and energy while developing EA, giving them the key process and points.

I plan to achieve that through comparing documents from some MBO schools, collecting experience and wisdom from experts like you, as well as combining with some previous reference in the end.

Therefore, before interviewing with you, I sincerely hope that you can share me with some relevant EA documents of your school. Files are like slides, docs, excel sheets that show EA process, reference model, roadmap, principals etc. so that I can know what methods your school has while doing EA.

I can guarantee that all the documents you shared with me will be only used for in-house analysis. Without your approval, they will not be published in any place or seen by others. I believe by comparing documents with a different school; we can also learn things from each other and try to deliver a better solution.

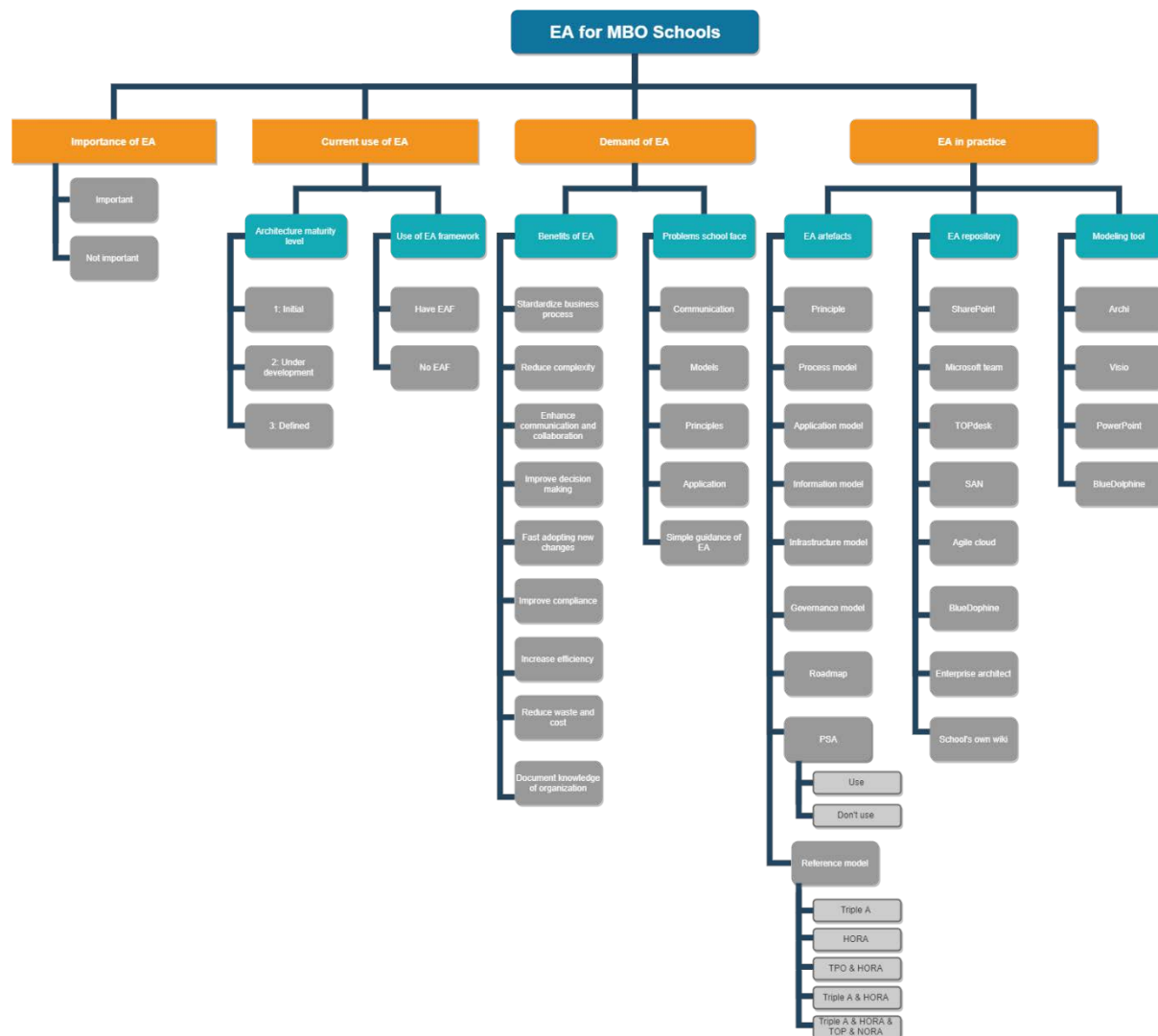
I am looking forward to hearing from you and hope you have a great day!

With appreciation,

Ellie

9/10/2019

APPENDIX D: CODING SCHEME



APPENDIX E: QUESTIONNAIRE OF DATA VALIDATION

Data Validation Survey

This survey is regarding validation of collected data from participated MBO schools and a proposed framework. There is no right or wrong answer; all different opinions are welcome.

*Required

1. School Name *

2. Below are the most commonly mentioned benefits of enterprise architecture during interviews. Do you agree with them or have something else in mind? *

- Improve decision making
- Improve compliance
- Fast adopting new changes
- Improve communication and collaboration
- Increase efficiency
- Reduce waste and cost
- Standardization and automation of the business process
- Document knowledge on the enterprise
- Reduce complexity

*Mark only one oval.

☐ Agree

☐ Disagree

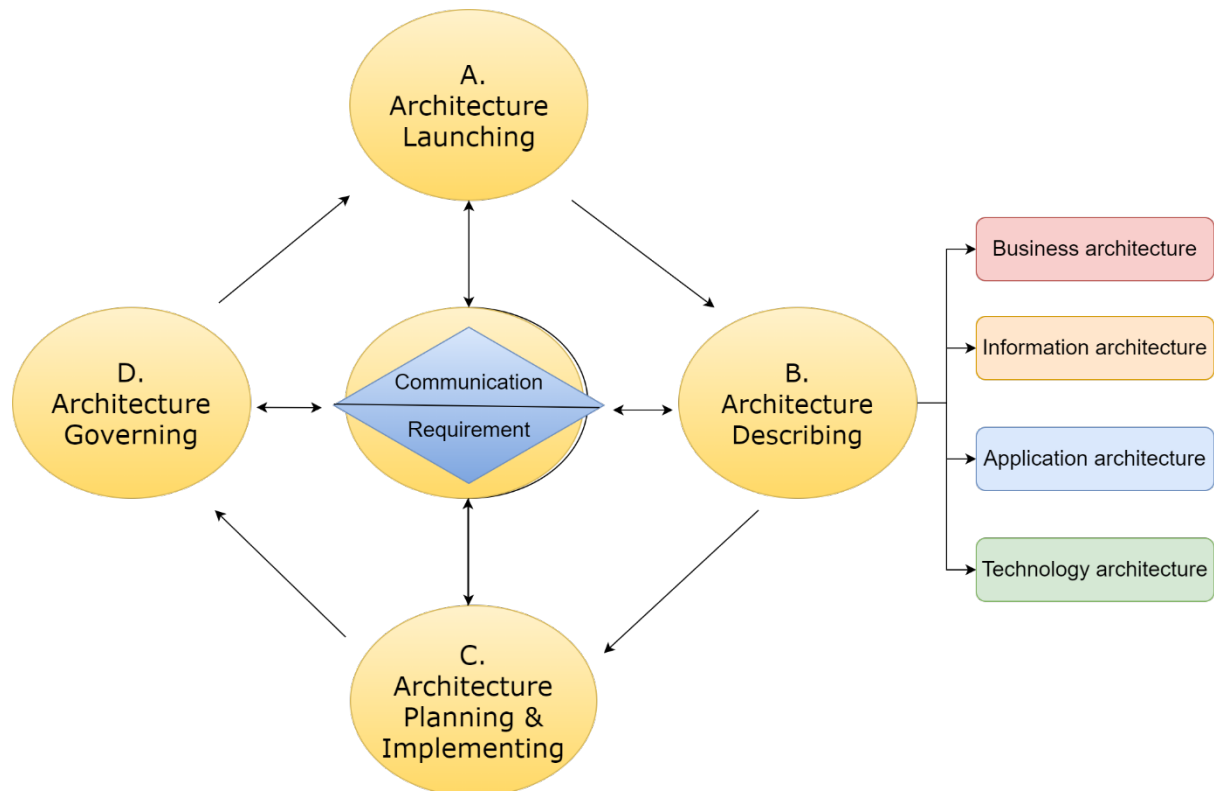
3. Please add here if there are things lack that you want to achieve

EA framework

Based on the research, nearly all institutions have realized the importance of enterprise architecture. However, schools often confused about where to start and when to stop the architecture work. Very often, they will receive help from enterprise architects, while not all school have this kind of resources. So, to avoid the initial panic, a lightweight EA framework as a starting point is proposed below and hope to help schools grasp the whole picture quickly and easily.

The framework is created through combining theory with practice. By talking with experts and reviewing the school's architecture documents, the most critical processes and key concerns are clearer. Then these findings are aligned with a professional framework such as TOGAF and come up with a simple guide. (Please notice that TOGAF is considered not suitable to apply for small and mid-sized schools in this study but is seen as a good resource to check as a reference because it's comprehensive and based best years best practice).

A lightweight EAF and key processes:



Phase A: Architecture Launching

The objective of phase A is to initiate the enterprise architecture project. In this phase, we need to define the needs of EA and make the organization ready to conduct the following stages.

Key steps:

- establish rules, disciplines and architecture principles
- make a high-level formal statement of architecture requirement, vision, scope, the current and future status of architecture
- define EA stakeholders and create a communication plan
- select a reference architecture
- make a simple grocery of EA terms to ensure people speak the same language when doing an EA project together

Phase B: Architecture Describing

The primary purpose of phase B is to make a clear and understandable description for the baseline and target architecture in four architecture domains, as we described in chapter 3.2.3. In this phase, we present the structure of the organization, and this can be done through visualization or different forms of description.

Key steps:

- establish a high-level baseline and a target business architecture
- create a high-level baseline and a target information architecture
- create a high-level baseline and a target application architecture
- create a high-level baseline and a target technology architecture
- conduct gap analysis for the established AS-IS and TO-BE architectures

Suggestion:

- the target architecture can be built based on baseline architecture using one landscape with different colours
- make different views for different users
- modelling tools suggested: Archi, Visio, PowerPoint, BlueDolphin

Phase C: Architecture Planning and Implementing

The objective of phase C is to identify implementing projects, do the portfolio management and take actions for achieving the target architecture.

Key steps:

- make a high-level migration plan, a roadmap that shows how we can get to the target status of architecture
- if the project is large enough, we can make a project start architecture
- make project plans to estimate needed resource and cost requirement, set realistic project timing, availability, prioritize tasks and identify the risk
- make an architecture contract to monitor the implementation work to conformance
- implement the task based on the plan

Phase D: Architecture Governing

Governing of enterprise architecture is a critical part of EA deployment. In this phase, the primary purpose is to oversight of the implementation and provide continuous monitoring process for possible future changes. When the requirement appears, a new cycle of this process will start from phase A again. Some relevant existing artefacts will be modified and updated for the new architecture request. With proper architecture governance, the organization would response changes more rapidly in both technology and business environment.

Key steps:

- perform post-implementing review

-make a governance model and guidelines for governing and managing the architecture and new changes

4. Do you find the phases and key steps logical and helpful to follow for schools?

*Mark only one oval.

☐ Yes

☐ No

5. Please share your suggestions and opinions to improve the framework

Artefacts

Different artefacts are created to describe systems, solutions or state of the enterprise when doing architecture work. For sure we do not make documents only for documenting but helping the schools to organize, visualize and simplify their work. Please mark the priority and important level for the core artefacts mentioned in interview and authority literature (1 is the least important and urgent, 5 is the top priority deliverable)

6. Principal Catalog: general rules and guidelines that inform and support the way that organization fulfil its mission *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

7. Architecture Term Catalog: a list of terminology that is used to communicate and describe the architecture work. *

Mark only one oval.

12. Business Landscape: a high-level diagram that describes an organization's main business function and processes *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

13. Process Flow Diagram: a diagram that shows the sequence flow of control between activities, it also allows the specialist to describe how the job is done for a particular function *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

14. Organization/Actor Catalog: a definitive list of all participants that interact with it, including users and owners of IT system *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

15. Conceptual Information Model: a high-level diagram describing critical information in an enterprise or a system *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

16. Data Lifecycle Diagram: a diagram that represents the changes in status and triggers that causes changes through its lifecycle from conception until disposal within the constraint of the business *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

17. Application Landscape: a high-level diagram that shows all essential applications and how they support the primary business function *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

18. Application/ Role Matrix: a list of all applications in the Enterprise and the responsible person and the business roles that use them within the Enterprise *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

19. Infrastructure Model: a diagram shows the entire technical communication infrastructure, where application components are deployed, how the components are networked *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

20. Technology Portfolio Catalogue: a list of all technology in use across the enterprise including hardware, infrastructure software, applications software *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

21. Application/Technology Matrix: documents the mapping of applications to technology perform *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

22. Roadmap: a strategic blueprint that represents what changes the organization required to make in order to transform the baseline architecture to future architecture *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

23. Architecture Contract: joined agreement between development parties and sponsors on the deliverable, quality and fitness for the purpose of architecture *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

24. Project Plan: a formal document design to Guide the control and execution of a project. It includes plans for estimated budget, time, resource and personal *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

25. Projects Start Architecture: a subset architecture as a starting point for a big project. It is used to initiate a project, provide it with a well-defined relevant and practical scope *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

26. Compliance Assessment: a series of checklist that aims to ensure an implementation project is proceeding in compliance with the defined architecture *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

27. Governance Model and Guidelines: a diagram with a description that indicates the methods and guidance that are applied to govern the Enterprise *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

28. Project Context Diagram: a diagram that shows the scope of a work package to be implemented as a part of a broader transformation roadmap. It links a work package to different aspects that will be influenced by the project such as functions, services, applications etc. *

Mark only one oval.

	1	2	3	4	5	
not important	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	very important

29. Please indicate if there are other significant artefacts

Strategies

30. Below are some strategies/ tips when deploying EA, please choose how helpful they are *

Mark only one oval per row.

	not so helpful	can be helpful	very helpful
enhance communication by getting more stakeholders involved in the construction of enterprise architecture.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
take regular meetings and write things down to clarify employee' roles and responsibilities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
simplify principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
make principle and other documents description understandable, using the language and terms that the general audience can understand	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
have more discussion about principles within the organization, review and update them once or twice a year	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
educate employee to strengthen their awareness toward enterprise architecture and understand the links between them and others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
build a better communication environment with automatic smart tools such as BlueDolphin	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
have good reference model and make use of	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ensure employees to read and remember critical principles by heart	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
build a good application landscape to understand the connection between systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
build a roadmap to see the requirement and change on the application layer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
create artefacts for system management to make records in a more detailed level	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
make different views for a different audience	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Thank you very much for your time and participation!

APPENDIX F: RESULT OF DATA VALIDATION

Text filed questions:

Case school	Do you agree on the benefits mentioned below	Please add here if any other thing you want to achieve	Do you find the phases and key steps logical and helpful to follow for schools?	Please share your suggestions and opinions to improve the framework	Please indicate if there are other significant artefacts
G	Agree	I want to emphasize the importance of the communication and collaboration part. For me, the architectural documents are very important in discussion with managers, teachers and other employees to show the dependencies and possibilities when making choices concerning IT-solutions.	Yes	It is a really good scheme, but to me, it is a bit theoretical. In order to give architecture an important role in the IT-governance of a school, it has to be practical, take a practical problem and work that out with the stakeholders. In this way, your architectural governance will be built based on a real-life situation and it will immediately show the value to the stakeholders.	This is a really complete longlist. Hard to make choices, they are all important.
H	Agree		Yes		
D	Agree		Yes		I scored a number relatively low because I do not see them as artefacts but as knowledge of your own organization.
F	Agree	It is useful for allocating ownership on EA components like a process or an application.	Yes	In our institution, there are smaller areas where there is a need for change (smaller targets) Documenting our EA helps in this. (clarifying all aspects involved, communicating, ownership discussions etc. it will take several	In every change in the IT landscape, it is essential to know the involved business function, the

				years where our digital EA knowledge base grows (in detail) and (last but not least) company-wide EA knowledge will grow. So not just by the IT department but also by the business analyst, process owners (or there process experts), project leaders, system owners, application specialists, information managers, some department heads etc. In other words, it looks like we have not had enough IT-disasters and thereby not enough stakeholders with enough IT-maturity to understand the need for building, maintaining and using enterprise architecture. On the other hand, I even think it is an illusion that building on a companywide to-be situation will ever work. That to- be situation is always moving. There will be a constant need for adjustments.	stakeholders (owners, specialists, users), the involved applications and the information flows (!) especially the way two or more applications exchange information (in Dutch we say koppelingen).
B	Agree		Yes		
C	Agree		Yes	To make it simpler: at phase B information and application architecture can be combined. At phase B you suggest several tools for modelling architectures, but these tools are too different. For example, blueDolphin is an architecture tool based on ArchiMate. But PowerPoint is just for presenting tge information. Aren't there other comparable tools?	
A	Agree		Yes	Relationship Architecture and Information Management will be better governed when using Functional Domains instead of Business/Information/Application/Technology-decomposition	Further to the requirements documents create catalogues for: - (open) Standards for exchange of information between systems

												- Set of Information Security & Privacy requirements and - Guidelines
--	--	--	--	--	--	--	--	--	--	--	--	---

Artefacts related questions:

Case school	Principal Catalog	Architecture Term Catalog	Requirement Catalog	Architectural Vision, Goals, Objectives, Scope Description	Reference Architecture	Stakeholder Matrix	Business Landscape	Process Flow Diagram	Organization/Actor Catalog	Conceptual Information Model	Data Lifecycle Diagram
H	5	3	3	4	3	4	4	4	4	3	3
D	5	3	3	2	4	1	1	4	1	3	3
G	5	4	3	5	4	3	5	5	4	5	2
F	3	3	4	3	3	3	5	3	3	2	2
B	5	4	4	4	4	5	5	4	4	4	5
C	5	3	3	4	3	3	5	5	4	4	3
A	4	4	5	4	4	4	4	4	3	5	3

Artefacts related questions:

Case school	Application Landscape	Application/ Role Matrix	Infrastructure Mode	Technology Portfolio Catalogue	Application/Technology Matrix	Roadmap	Architecture Contract	Project Plan	Projects Start Architecture	Compliance Assessment	Governance Model and Guidelines	Project Context Diagram
H	3	4	4	4	4	4	3	3	4	3	4	4
D	4	2	1	3	1	3	1	4	4	1	3	1
G	5	4	3	2	2	5	5	4	5	3	4	3
F	5	2	1	1	1	4	1	2	2	2	5	4
B	5	4	4	4	4	4	3	4	4	4	4	3

C	5	5	5	5	5	5	2	2	3	3	4	3
A	3	3	3	3	3	4	4	5	5	5	3	2

Strategy related questions:

Case school	enhance communication by getting more stakeholders involved in the construction of enterprise architecture	take regular meetings and write things down to clarify employee' roles and responsibilities	simplify principles	make principle and other documents description understandable, using the language and terms that the general audience can understand	have more discussion about principles within the organization, review and update them once or twice a year	educate employee to strengthen their awareness toward enterprise architecture and understand the links between them and others	build a better communication environment with automatic smart tools such as BlueDolphin
H	very helpful	can be helpful	very helpful	very helpful	very helpful	can be helpful	can be helpful
D	can be helpful	very helpful	very helpful	can be helpful	can be helpful	not so helpful	not so helpful
G	very helpful	can be helpful	very helpful	very helpful	can be helpful	can be helpful	can be helpful
F	very helpful	can be helpful	can be helpful	very helpful	can be helpful	very helpful	very helpful
B	can be helpful	can be helpful	very helpful	very helpful	not so helpful	can be helpful	can be helpful
C	can be helpful	very helpful	very helpful	can be helpful	can be helpful	can be helpful	very helpful
A	can be helpful	very helpful	can be helpful	very helpful	very helpful	can be helpful	very helpful

Strategy related questions:

Case school	have good reference model and make use of it	ensure employees to read and remember critical principles by heart	build a good application landscape to understand the connection between systems	build a roadmap to see the requirement and change on the application layer	create artefacts for system management to make records in a more detailed level	make different views for a different audience
H	can be helpful	very helpful	very helpful	can be helpful	can be helpful	can be helpful
D	very helpful	not so helpful	very helpful	not so helpful	can be helpful	very helpful
G	very helpful	not so helpful	very helpful	can be helpful	not so helpful	very helpful

F	can be helpful	can be helpful	very helpful	can be helpful	can be helpful	very helpful
B	very helpful	can be helpful	very helpful	can be helpful	very helpful	very helpful
C	can be helpful	very helpful	very helpful	very helpful	can be helpful	very helpful
A	very helpful	not so helpful	can be helpful	can be helpful	not so helpful	very helpful

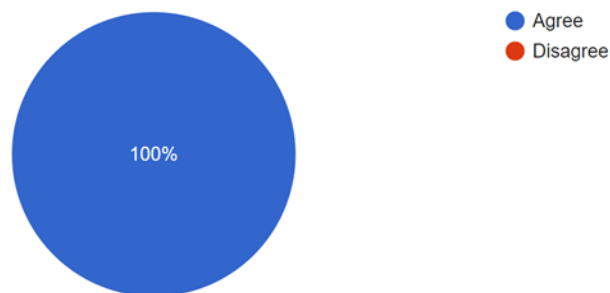
APPENDIX G: STATISTICS OF DATA VALIDATION

School Participated:

H, D, G, F, B, C, A.

Below are the most commonly mentioned benefits of enterprise architecture during interviews. Do you agree with them or have something else in mind?

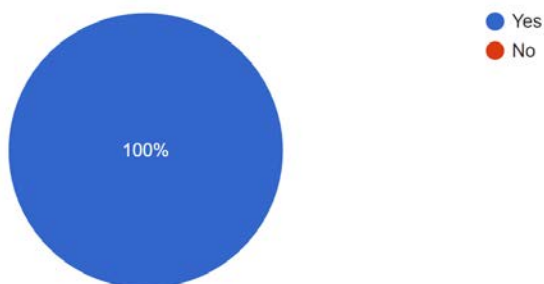
7 responses



EA Framework

Do you find the phases and key steps logical and helpful to follow for schools?

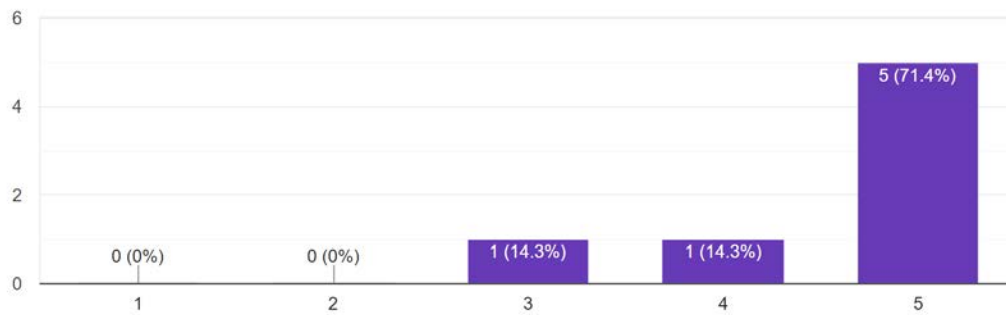
7 responses



Artefacts

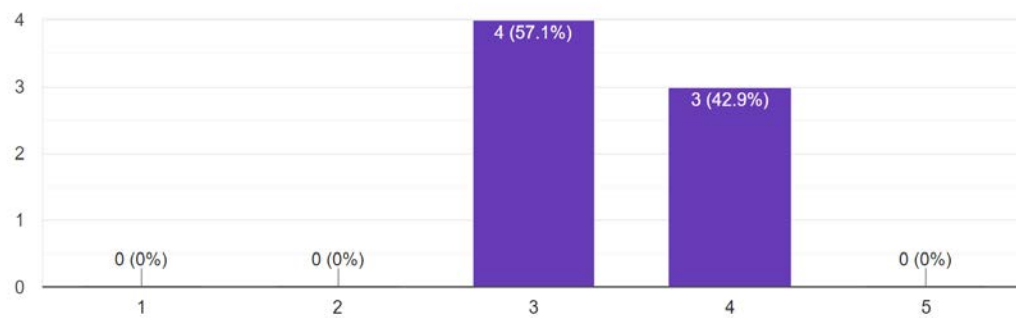
Principal Catalog: general rules and guidelines that inform and support the way that organization fulfil its mission

7 responses



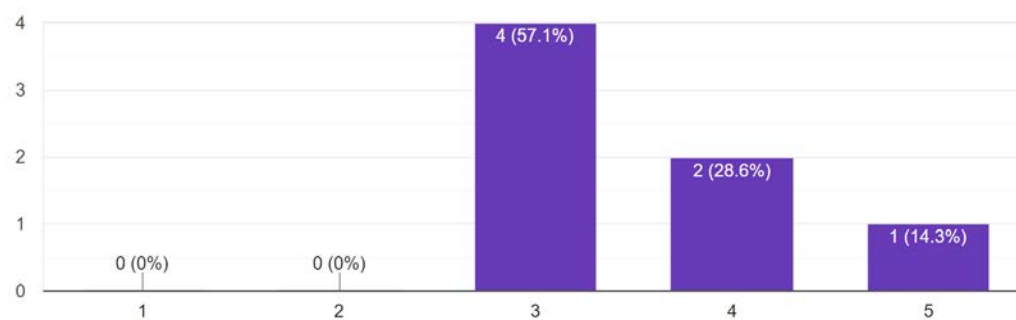
Architecture Term Catalog: a list of terminology that is used to communicate and describe the architecture work.

7 responses



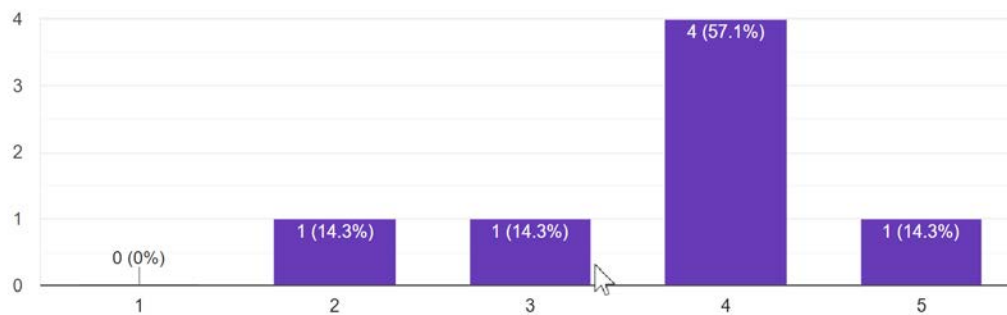
Requirement Catalog: a list of the qualitative statement of business needs that must be met by a particular architecture or work package

7 responses



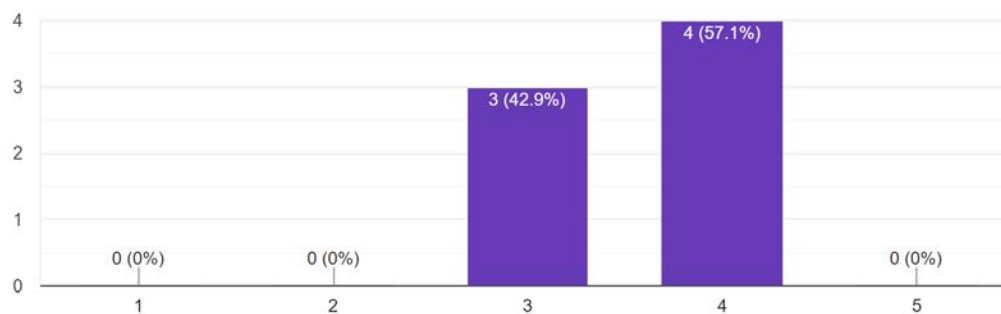
Architectural Vision, Goals, Objectives, Scope Description: a set of formal statement that describes a high-level aspirational view of the future architecture, the goals, the objectives, and scope of the work

7 responses



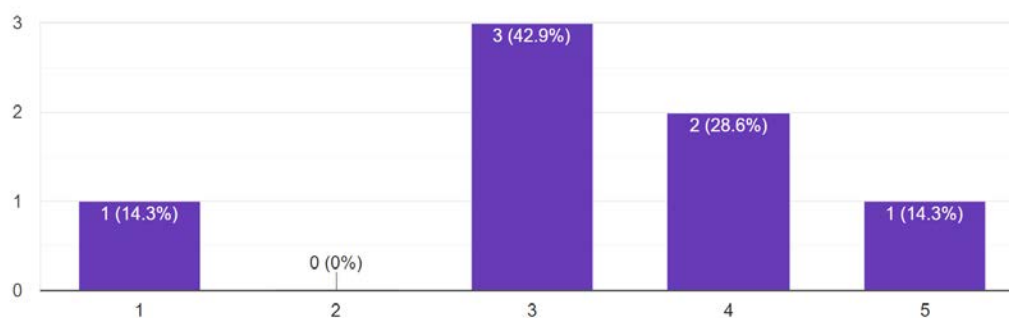
Reference Architecture: a document or set of documents that interested parties can refer to for the best practice. The reference will document things such as system processes, specifications, logical components and interrelationships

7 responses



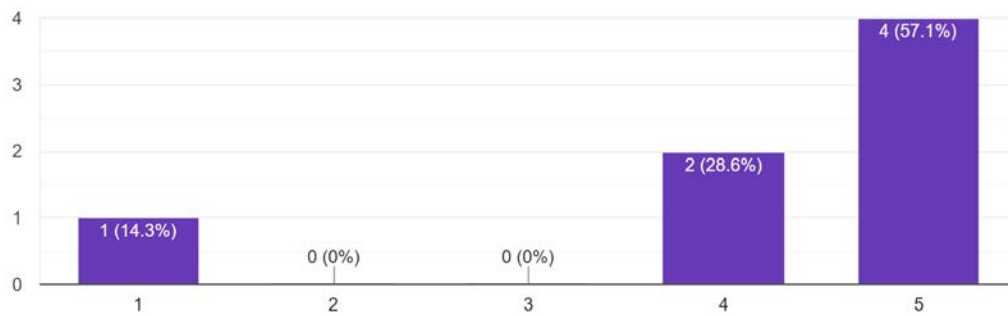
Stakeholder Matrix: a matrix that helps to identify and understand stakeholder's engagement and requirement they need to be addressed, by the architecture framework

7 responses



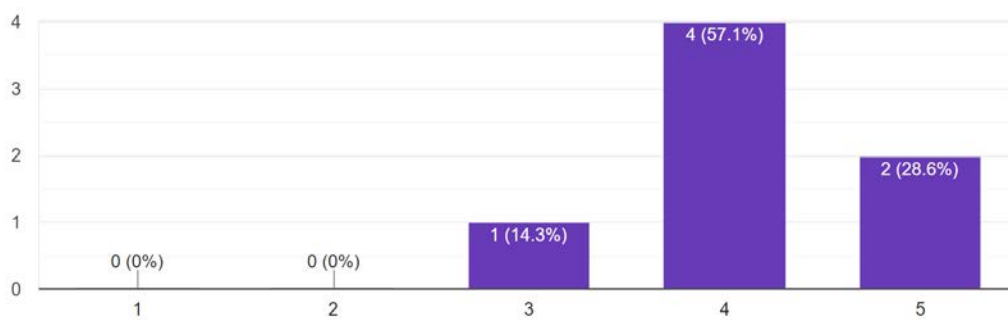
Business Landscape: a high-level diagram that describes an organization's main business function and processes

7 responses



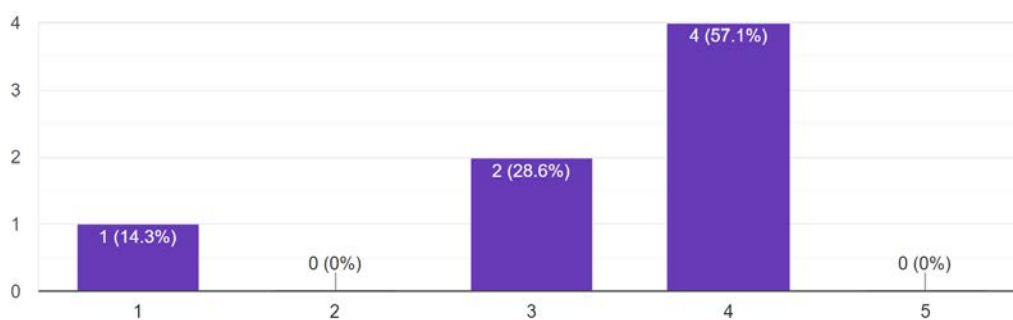
Process Flow Diagram: a diagram that shows the sequence flow of control between activities, it also allows the specialist to describe how the job is done for a particular function

7 responses



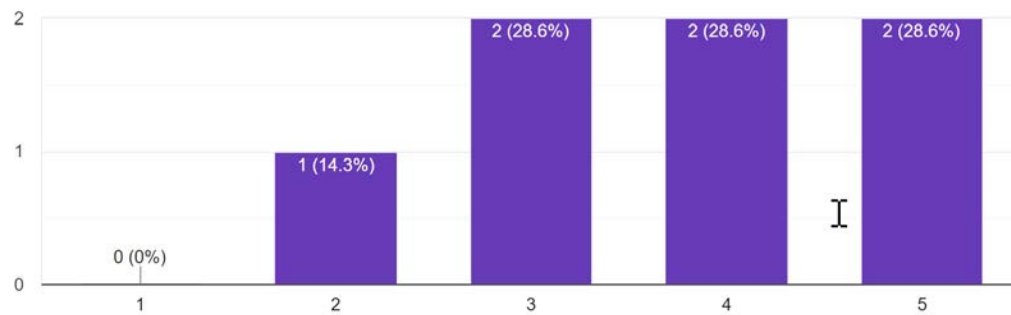
Organization/Actor Catalog: a definitive list of all participants that interact with it, including users and owners of IT system

7 responses



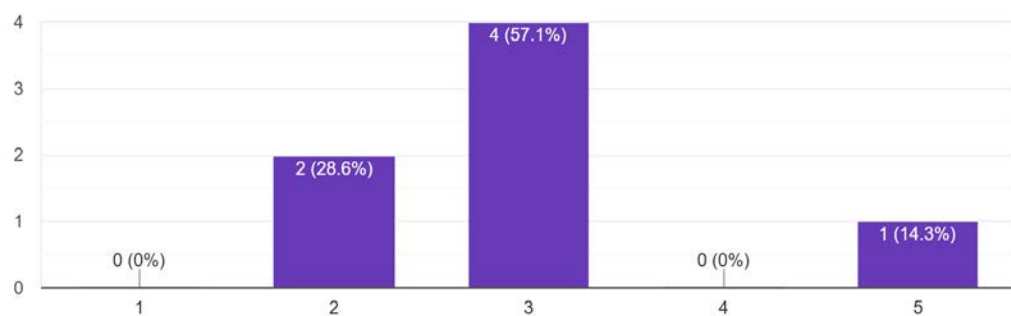
Conceptual Information Model: a high-level diagram describing critical information in an enterprise or a system

7 responses



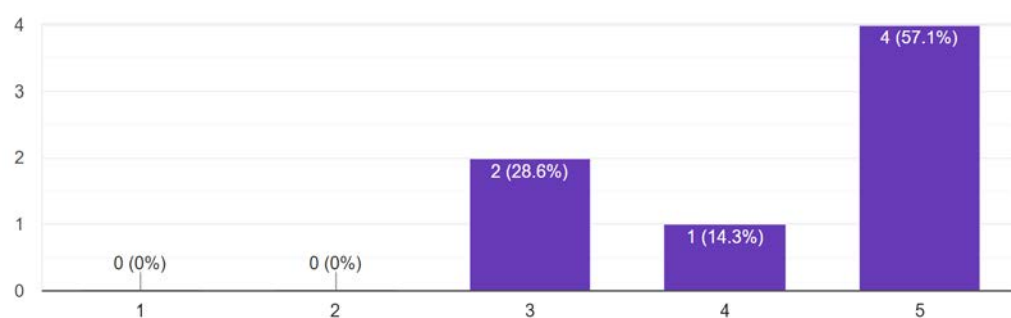
Data Lifecycle Diagram: a diagram that represents the changes in status and triggers that causes changes through its lifecycle from conception until disposal within the constraint of the business

7 responses



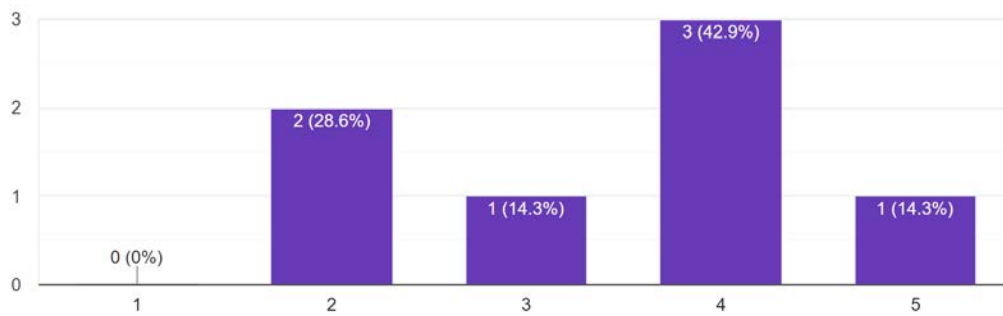
Application Landscape: a high-level diagram that shows all essential applications and how they support the primary business function

7 responses



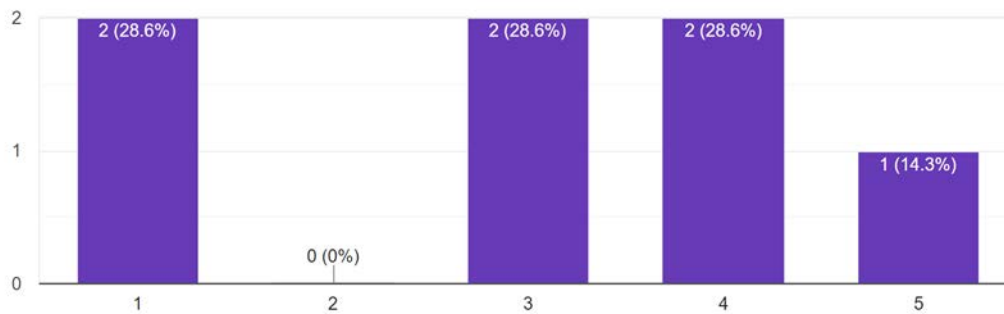
Application/ Role Matrix: a list of all applications in the enterprise and the responsible person and the business roles that use them within the Enterprise

7 responses



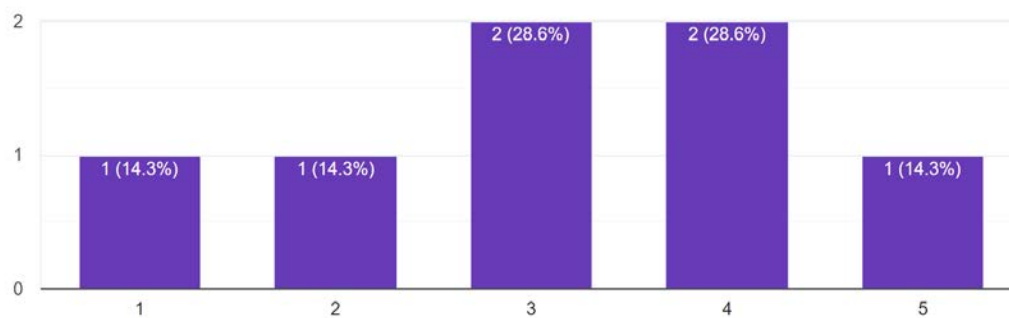
Infrastructure Model: a diagram shows the entire technical communication infrastructure, where application components are deployed, how the components are networked

7 responses



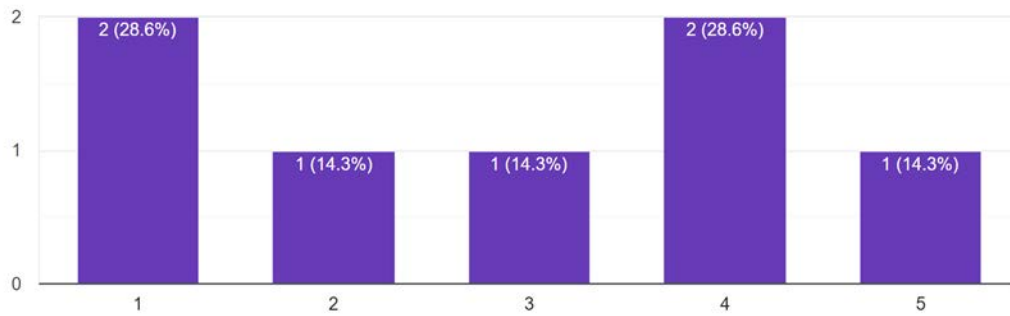
Technology Portfolio Catalogue: a list of all technology in use across the enterprise including hardware, infrastructure software, applications software

7 responses



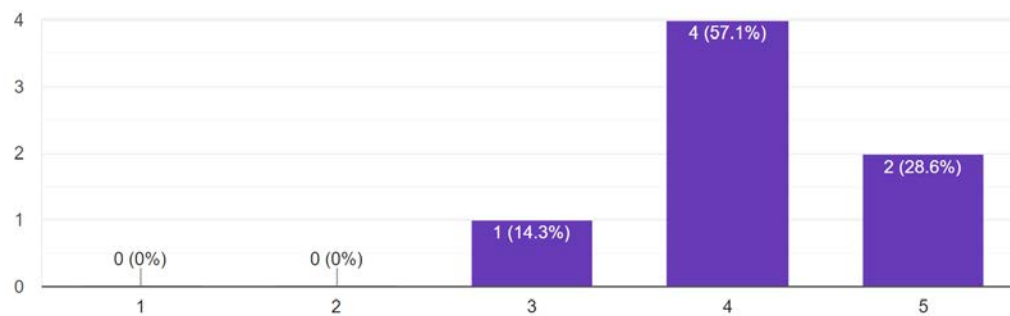
Application/Technology Matrix: documents the mapping of applications to technology perform

7 responses



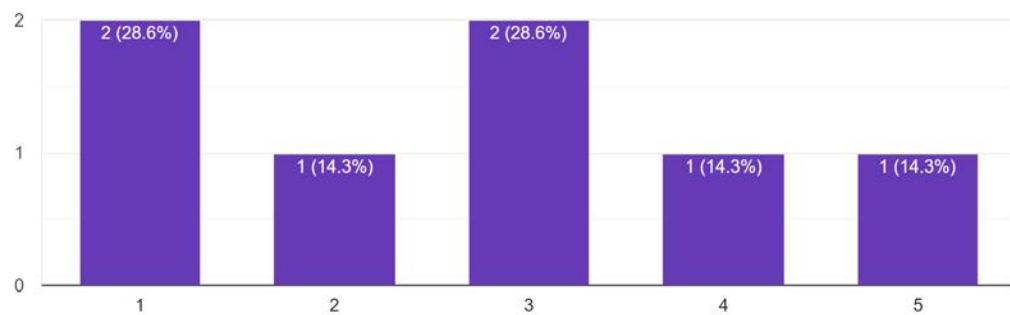
Roadmap: a strategic blueprint that represents what changes the organization required to make in order to transform the baseline architecture to future architecture

7 responses



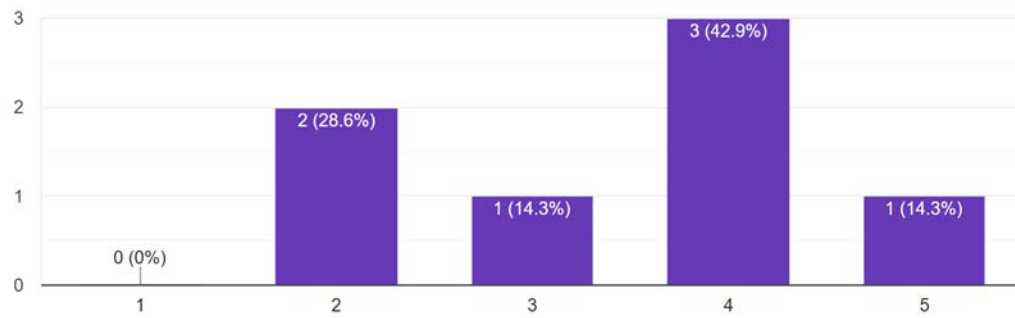
Architecture Contract: joined agreement between development parties and sponsors on the deliverable, quality and fitness for the purpose of architecture

7 responses



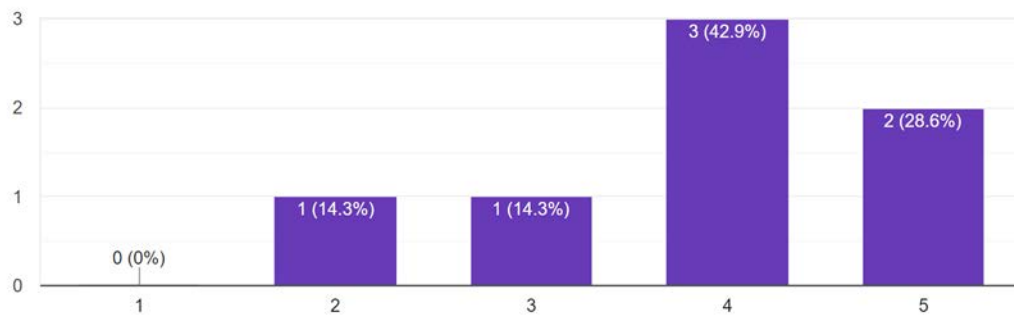
Project Plan: a formal document design to Guide the control and execution of a project. It includes plans for estimated budget, time, resource and personal

7 responses



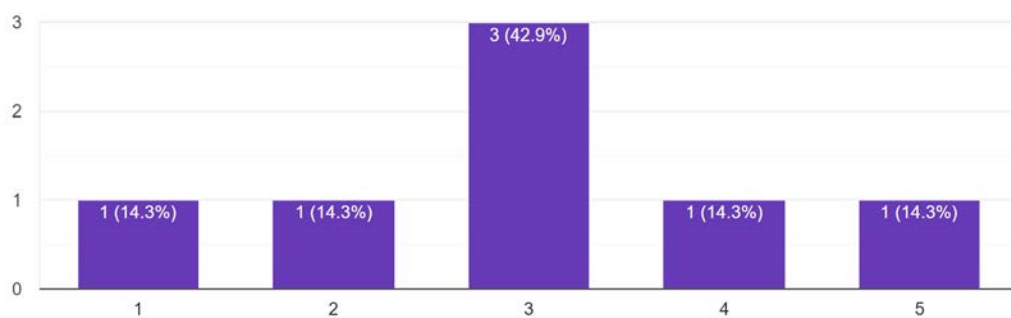
Projects Start Architecture: a subset architecture as a starting point for a big project. It is used to initiate a project, provide it with a well-defined relevant and practical scope

7 responses



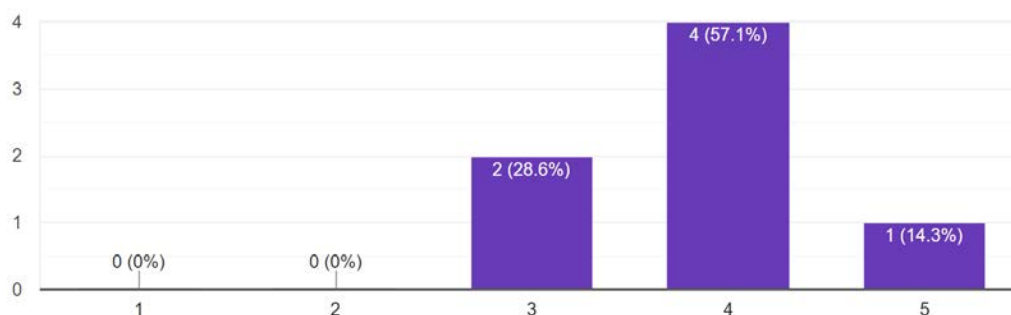
Compliance Assessment: a series of checklist that aims to ensure an implementation project is proceeding in compliance with the defined architecture

7 responses



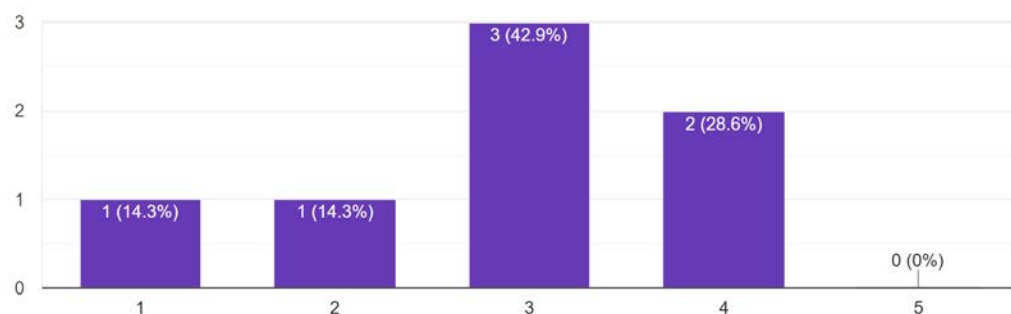
Governance Model and Guidelines: a diagram with a description that indicates the methods and guidance that are applied to govern the Enterprise

7 responses



Project Context Diagram: a diagram that shows the scope of a work package to be implemented as a part of a broader transformation roadmap. It links a work package to different aspects that will be influenced by the project such as functions, services, applications etc.

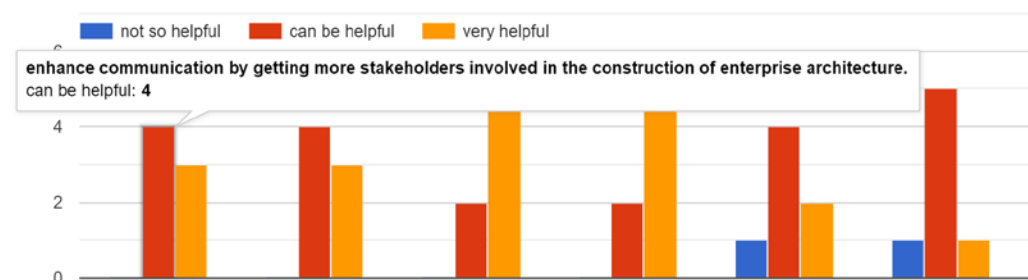
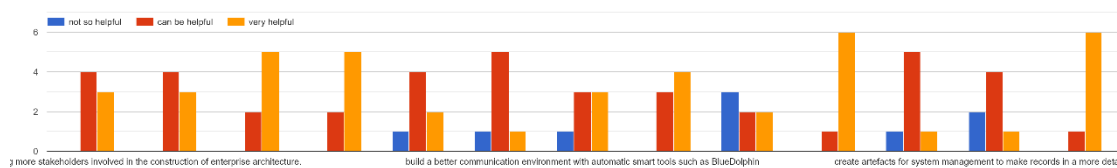
7 responses



Strategies

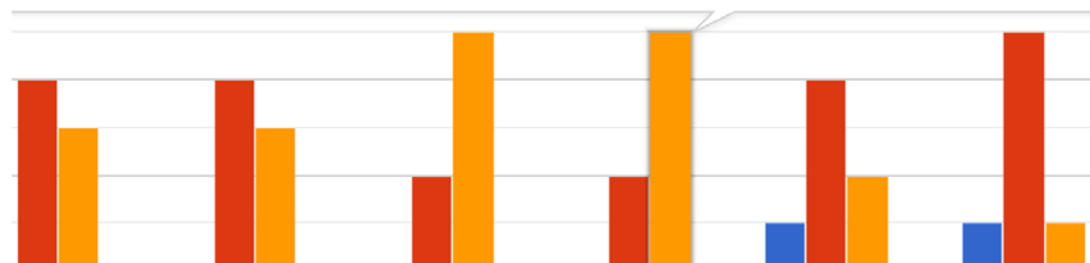
Below are some strategies/ tips when deploying EA, please choose how helpful they are.

Below are some strategies/ tips when deploying EA, please choose how helpful they are

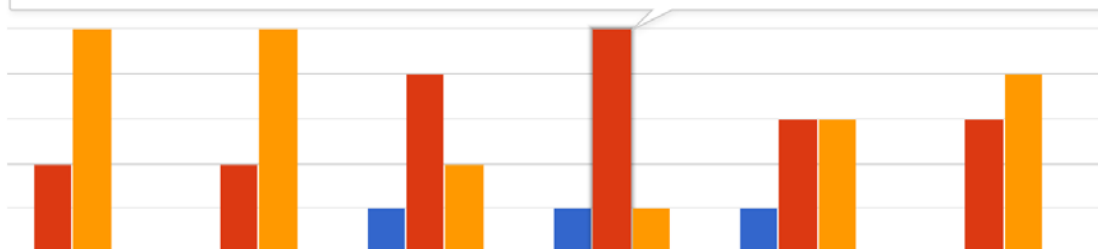




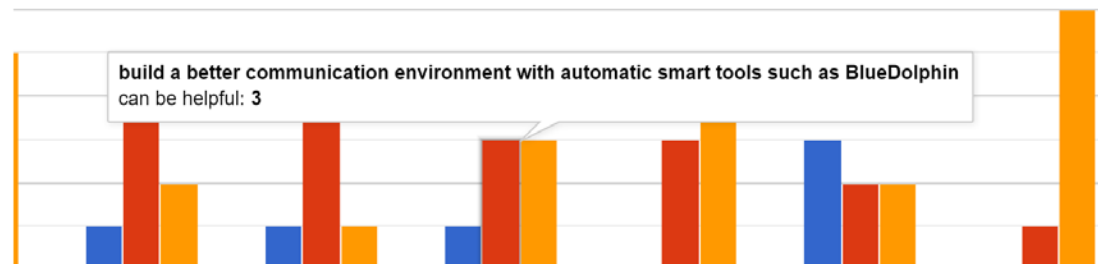
make principle and other documents description understandable, using the language and terms that the general public can understand
very helpful: 5



educate employee to strengthen their awareness toward enterprise architecture and understand the links between can be helpful: 5



build a better communication environment with automatic smart tools such as BlueDolphin can be helpful: 3

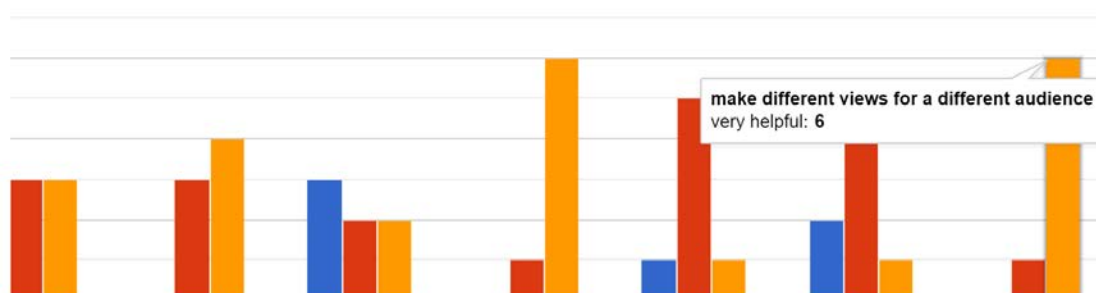
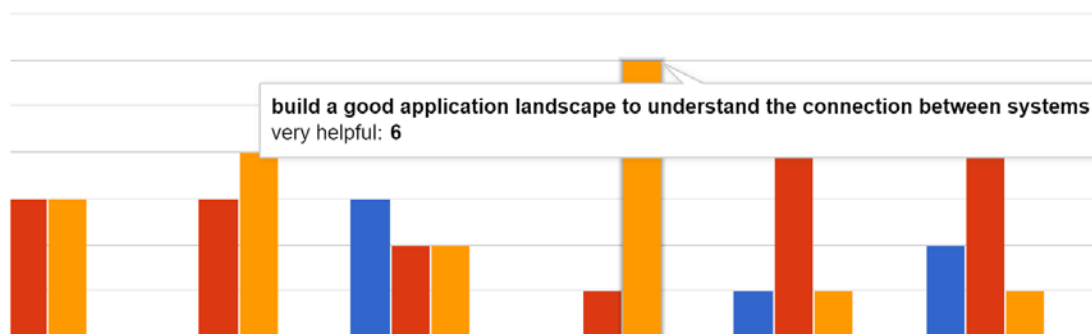


have good reference model and make use of it very helpful: 4



ensure employees to read and remember critical principles by heart not so helpful: 3





APPENDIX H: ELEMENTS OF THE ACMM AND MEASURING METHOD¹⁹

The DoC ACMM consists of six levels and nine architecture characteristics. The six levels are:

- 0 None
- 1 Initial
- 2 Under development
- Defined
- Managed
- Measured

The nine IT architecture characteristics are:

- IT architecture process
- IT architecture development
- Business linkage
- Senior management involvement
- Operating unit participation
- Architecture communication
- IT security
- Architecture governance
- IT investment and acquisition strategy

Two complementary methods are used in the ACMM to calculate a maturity rating. The first method obtains a weighted mean IT architecture maturity level. The second method shows the percent achieved at each maturity level for the nine architecture characteristics.

Example: IT Architecture Process Maturity Levels

The following example shows the detail of the IT architecture maturity levels as applied to the first of the nine characteristics, IT architecture process.

➤ Level 0: None

No IT architecture program. No IT architecture to speak of.

➤ Level 1: Initial

Informal IT architecture process underway.

Processes are ad hoc and localized. Some IT architecture processes are defined. There is no unified architecture process across technologies or business processes. Success depends on individual efforts.

IT architecture processes, documentation, and standards are established by a variety of ad hoc means and are localized or informal.

Minimal, or implicit linkage to business strategies or business drivers.

Limited management team awareness or involvement in the architecture process.

¹⁹ <https://pubs.opengroup.org/architecture/togaf8-doc/arch/chap27.html>

Limited operating unit acceptance of the IT architecture process.

The latest version of the operating unit's IT architecture documentation is on the web. Little communication exists about the IT architecture process and possible process improvements.

IT security considerations are ad hoc and localized.

No explicit governance of architectural standards.

Little or no involvement of strategic planning and acquisition personnel in the enterprise architecture process. Little or no adherence to existing standards.

➤ Level 2: Under Development

IT architecture process is under development.

Basic IT architecture process is documented based on OMB Circular A-130 and Department of Commerce IT Architecture Guidance. The architecture process has developed clear roles and responsibilities.

IT vision, principles, business linkages, baseline, and Target Architecture are identified. Architecture standards exist, but not necessarily linked to Target Architecture. Technical Reference Model (TRM) and Standards Profile framework established.

Explicit linkage to business strategies.

Management awareness of architecture effort.

Responsibilities are assigned and work is underway.

The DoC and operating unit IT architecture web pages are updated periodically and are used to document architecture deliverables.

IT security architecture has defined clear roles and responsibilities.

Governance of a few architectural standards and some adherence to existing Standards Profile.

Little or no formal governance of IT investment and acquisition strategy. Operating unit demonstrates some adherence to existing Standards Profile.

➤ Level 3: Defined

Defined IT architecture including detailed written procedures and TRM.

The architecture is well defined and communicated to IT staff and business management with operating unit IT responsibilities. The process is largely followed.

Gap analysis and migration plan are completed. Fully developed TRM and Standards Profile. IT goals and methods are identified.

IT architecture is integrated with capital planning and investment control.

Senior management team aware of and supportive of the enterprise-wide architecture process. Management actively supports architectural standards.

Most elements of operating unit show acceptance of or are actively participating in the IT architecture process.

Architecture documents updated regularly on DoC IT architecture web page.

IT security architecture Standards Profile is fully developed and is integrated with IT architecture.

Explicit documented governance of majority of IT investments.

IT acquisition strategy exists and includes compliance measures to IT enterprise architecture. Cost benefits are considered in identifying projects.

➤ Level 4: Managed

Managed and measured IT architecture process.

IT architecture process is part of the culture. Quality metrics associated with the architecture process are captured.

IT architecture documentation is updated on a regular cycle to reflect the updated IT architecture. Business, Data, Applications, and Technology Architectures defined by appropriate de jure and de facto standards.

Capital planning and investment control are adjusted based on the feedback received and lessons learned from updated IT architecture. Periodic re-examination of business drivers.

Senior management team directly involved in the architecture review process.

The entire operating unit accepts and actively participates in the IT architecture process.

Architecture documents are updated regularly, and frequently reviewed for latest architecture developments/standards.

Performance metrics associated with IT security architecture are captured.

Explicit governance of all IT investments. Formal processes for managing variances feed back into IT architecture.

All planned IT acquisitions and purchases are guided and governed by the IT architecture.

➤ Level 5: Optimizing

Continuous improvement of IT architecture process.

Concerted efforts to optimize and continuously improve architecture process.

A standards and waivers process is used to improve architecture development process.

Architecture process metrics are used to optimize and drive business linkages. Business involved in the continuous process improvements of IT architecture.

Senior management involvement in optimizing process improvements in architecture development and governance.

Feedback on architecture process from all operating unit elements is used to drive architecture process improvements.

Architecture documents are used by every decision-maker in the organization for every IT-related business decision.

Feedback from IT security architecture metrics are used to drive architecture process improvements.

Explicit governance of all IT investments. A standards and waivers process is used to make governance-process improvements.

No unplanned IT investment or acquisition activity.

build a better communication environment with automatic smart tools such as BlueDolphin

build a road map to see the requirement and change on the application layer

create artefacts for system management to make records in a more detailed level