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The Enterprise Architecture Competence Framework

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Abstract: Enterprise architecture (EA) is essential for both public and private organizations as it provides a holistic approach to align information technology with business objectives. EA implementation is a multidisciplinary, complicated, and endless process. Therefore, successful EA implementation calls for highly-skilled personnel possessing diverse competencies. During the last years a few attempts have been made to identify these competencies. Current works however, provide heterogeneous and fragmented views of the domain, do not distinguish between private and public sector employees and are not interoperable with other generic competence frameworks. This paper aims at proposing an EA Competence Framework (EA-CF) that provides a holistic view of EA competencies and overcomes existing limitations. We anticipate that EA-CF will assist in obtaining an in depth understanding of EA competencies, will assist in the efficient training of future enterprise architects, and will facilitate the incorporation of EA competencies in more generic competence frameworks.

1. Introduction

Enterprise architecture (EA) underpins the alignment of an enterprise's data, information systems and infrastructure with its business visions, goals and services. EA is today widely spread among organizations in both private and public sector throughout the world (Janssen and Hjort-Madsen, 2007). Its importance is indicated by the "Clinger-Cohen Act of 1996" which enforces all public authorities in the United States to implement an EA.

However, successful implementation of EA is not a straightforward process and requires appropriate competencies to be obtained by the relevant group of employees i.e. enterprise architects (Strano and Remani, 2007). An enterprise

architect addresses significant daily challenges and undertakes tasks that require an in depth understanding of the strategic business processes as well as the acquisition of domain – specific competencies for a sustainable competitive advantage (Minoli, 2008).

Despite EA importance and challenges a few only attempts have been made for describing the relevant required competencies (EA competencies onwards). This includes work by academia (Boster, Liu and Rob, 2000; Steghuis and Proper, 2008; Strano and Rehmani, 2007), consulting companies of the private sector (Bredemeyer and Malan, 2004; The Open Group, 2009; Walker, 2007; Bean, 2006) and public administration (The Federal CIO Council, 2004). However, such attempts differ in both their description of the concepts that fully describe an EA competence (Clarke and Winch, 2006) and in the EA competence instances they focus on (Steghuis and Proper). Moreover, the definition of EA in the public sector is different than that of the private (Tarabanis, Peristeras and Frigidis, 2001). Thus, there is significant indication that EA competencies should be differentiated across these sectors. Lastly, the above frameworks do not support interoperability with other generic Information and Communication Technologies (ICT) or business competence frameworks, reducing their significant value to the ICT domain. All of the above call for further investigation towards a complete and homogenous description of the domain.

The aim of this paper is to propose an EA Competence Framework (EA-CF) that provides a holistic view of EA competencies, enables interoperability with other generic competence frameworks and differentiates between three sectors (namely public sector, private sector and academia).

EA-CF comprises a conceptual model that describes EA competencies as well as data that populates the model. To ensure interoperability with existing competency frameworks, the proposed conceptual model adopts as its core the European eCompetence Framework (e-CF) (CEN, 2008). The proposed EA-CF model extends e-CF with concepts that specifically characterize EA competencies according to the relevant literature. It is further augmented with instances from e-CF, the EA literature as well as data retrieved from a questionnaire that was adopted by e-CF and was answered by EA experts of the three sectors. We anticipate that EA-CF will not only be able to interoperate with other established ICT competence frameworks but will foremost provide a complete and in depth

overview of EA competencies, thus fostering and guiding the training and education of current and future enterprise architects (Stoof, Martens and Merrienboer, 2006) .

The rest of the paper is organized as follows: Section 2 presents the methodology that was followed. Section 3 presents the proposed EA-CF conceptual model while section 4 proceeds with indicatively populating EA-CF model. Section 5 discusses EA-CF's facilitating role in EA training, whereas the final section presents the main results and draws conclusions from our findings.

2. Methodology

Several methods have been proposed in the literature for defining and developing competencies. The methods that focus on achieving consensus on competencies include activities such as literature review, surveys, focus groups and expert interviews (OECD, 2005; Klein et al., 2004). Our work was based on these activities since we aspire to consolidate the fragmented views that are available in the literature regarding EA competencies with the development of EA-CF. More specifically, the methodology for creating EA-CF comprises two phases as follows:

Phase 1: Creation of EA-CF conceptual model

This phase contains two steps.

Step 1.1: Adoption of a generic competence framework as a baseline for EA-CF

As already mentioned, it was a decision of this research at the outset to adopt e-CF as the baseline model for EA-CF to ensure interoperability with existing competency frameworks. e-CF is proposed by the European Committee for Standardization (CEN) as European standard reference for communicating ICT competence requirements in a transnational environment (CEN, 2008).

Step 1.2: Enriching e-CF with EA-specific concepts to develop EA-CF

e-CF has been proposed for general ICT competence requirements and therefore needs customization to be applicable to the EA domain. In this step, we conducted a literature review on EA competencies in order to identify EA-specific concepts that could extend e-CF. During this review we searched scientific sources of relevance to software engineering and computer science as well as works

published on the Web by various organizations and institutions. We also adopted the suggestions of Webster and Watson (2002) to go backward by reviewing the citations of the articles identified during the previous process as well as to go forward and identify articles citing those articles.

Phase 2: Population of EA-CF

This phase contains two steps.

Step 2.1: Population of EC-CF with appropriate e-CF instances

In this step we commenced by considering all instances documented in e-CF. Currently, there are 32 generic competencies in e-CF that needed to be further evaluated for relevance to EA domain. Due to the differentiated approach the public and private sectors follow regarding the description of EA and on the competencies they focus on, we deemed necessary to organize focus groups that represent the three main sectors, public, private and academia and determine whether indeed there are differences in which EA competencies are considered important for each sector. For this purpose, we developed a questionnaire that includes 32 Likert questions with values from 1 to 5 indicating the level of importance, where each question refers to one of the 32 e-CF competencies and includes a short corresponding description. Moreover, the respondents were required to provide specific information regarding each competence's relevance to EA. The questionnaire was completed by employees in both private and public organizations as well as by academics. This resulted in the elicitation of EA-specific competencies and their mapping to each sector along with the respective participants' justification. Before and after the completion of the questionnaire a preparatory discussion in the form of interviews with the respondents of each sector and a post-processing session took place respectively.

Step 2.2: Incorporation of EA-specific instances

Finally, we conducted a literature review in order to (a) identify EA-specific competencies and other instances and (b) incorporate them in the proposed framework. Moreover, we formed relations between these instances to the EA competencies, based on the justifications received with the questionnaires. Through this above-mentioned methodology we aimed to extend and customize e-CF into an EA-oriented competencies framework.

3. EA-CF's Conceptual Model

EA-CF conceptual model is based on e-CF, a framework proposed by the European Committee for Standardization (CEN). According to e-CF, each competence belongs to a competence area derived from the ICT business processes. A competence is related to one or more skills and knowledge and also needs a specific level of proficiency. More formally, e-CF proposes six main concepts defined as follows (CEN, 2008):

- *Competence*: represents a demonstrated ability to apply knowledge, skills and attitudes for achieving observable results.
- *Skill*: ability to carry out managerial or technical tasks.
- *Attitude*: represents the personality characteristics of a person.
- *Knowledge*: represents the "set of know-what" (e.g. programming languages and design tools) and can be described by operational descriptions.
- *Competence area* that derives from the ICT business processes plan, build, run, enable and manage.
- *Proficiency level* of a competence, which is related to autonomy, behaviour and context complexity.

In Figure 1 we present e-CF as a class diagram to enhance comprehensiveness.

The circles in the figure represent concepts, while the arrows represent relationships between concepts.

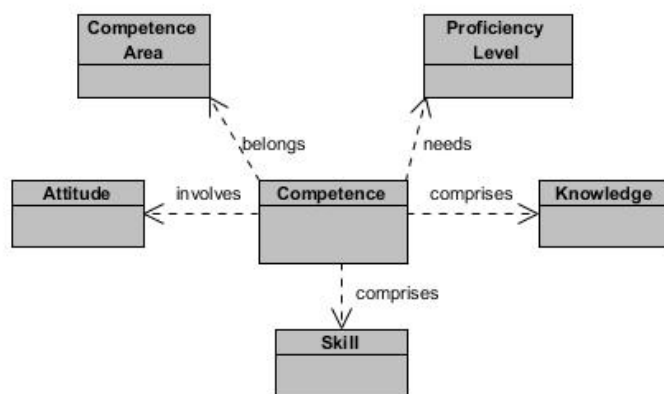


Fig. 1 Class diagram of e-CF

In order to enrich the framework with EA-specific models the relevant literature was reviewed. This revealed eight articles describing the competencies of an enterprise architect. In Table 1 we synthesize and structure the results of the

review in a concept-centric manner as suggested by relevant literature (Webster and Watson, 2002) with regards to the terminology used for describing EA competencies. In the first column the adopted common terminology is presented.

Table 1 Mapping between EA-CF and concepts from literature

	1. Steghuis & Proper, 2008	2. Strano & Rehmani, 2007	3. Boster et al., 2000	4. Bredemeyer & Malan, 2004	5. Open Group, 2009	6. Walker, 2007	7. Bean, 2006	8. The Federal CIO Council, 2004
Competence				Capabilities		Skill	Specialist skill and core capabilities	Competence
Skill	Professional competence	Competence	Technical and business skill	Do	Skill (6 categories)	Skill		
Knowledge	Professional competence	Competence	Technical and business skill	Know		Skill		
Attitude	Personal competence	Competence	Core skill	Be	Generic skill	Non-technical skill		
Proficiency Level				Level of decision scope	Proficiency level			
Competence Area	Area			Area				Competence area
EA Process Step	Architecture process		EA process step					
Role	Role	Role			TOGAF role	EAs role		
Responsibility	Responsibility			Responsibility				

The mapping between this terminology and the terminology used in each identified work is also depicted. For example, the concept *Attitude* is described in the literature as *personal competence*, *competence*, *core skill*, *be*, *generic skill* and *non-technological skill*.

The additional concepts that were identified from this literature review and incorporated in EA-CF model as classes are as follows:

- *Role*: Enterprise Architects can act different roles (e.g. a communicator, a leader, a manager, a modeller etc) that require the development of different competencies.
- *Responsibility*: Enterprise Architects require specific sets of competencies in order to be successful in all of the responsibilities they have to meet during the EA design and implementation.
- *EA process step*: Enterprise Architects are required to follow a series of EA process steps.

Additionally, the literature review suggested concept *Skill* has three sub-categories, namely *business* (mentioned in papers 2, 3 and 5 in Table 1), *technical* (papers 2, 3 and 5) and *legal* (paper 5). Furthermore, concept *Knowledge* has three sub-categories, namely *business* (papers 2, 3 and 5), *technical* (papers 2, 3 and 5) and *EA specific* (papers 5 and 8).

Finally, the following concepts were added in EA-CF model for the explicit mapping of the competencies in the three sectors:

- *Target Group*
 - *Private*: EA employees in private sector
 - *Public*: EA employees in public sector
 - *Student*: University students enrolled in EA relevant courses

By synthesizing the identified concepts the final conceptual model of the EA-CF is structured, as shown in the class diagram of Figure 2. We differentiate between concepts that were adopted by e-CF, those that emerged from the literature and those added for conceptualizing the difference between the three target groups by using different shading.

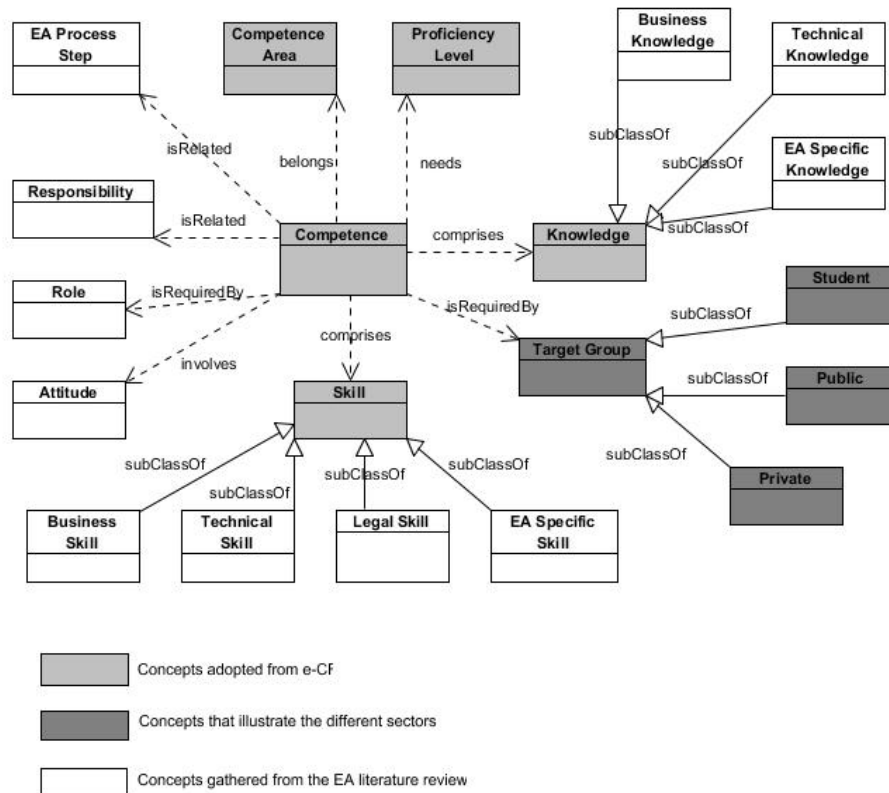


Fig. 2 Class diagram of EA-CF concepts

4. Population of EA-CF

The EA-CF population aims in the framework’s augmentation with EA-specific information. We start by considering the 32 specific competencies e-CF introduces as instances to the *Competence* class. We aim to eliminate the non EA related competencies and determine if indeed the three sectors consider different EA competencies as important. To this end, respondents from the sectors were selected based on their high EA expertise. More specifically, four high-level and eight high and medium level employees from two private organizations located in Austria and Greece identified the competencies that enterprise architects working in the private sector should possess or develop. Furthermore, five persons from all three levels of public administration in Poland identified competencies for enterprise architects working in the public sector. Finally, eleven professors and lecturers from Greek, Italian and German universities identified the competencies to be obtained by students being taught EA related courses at university-level education.

The results from the questionnaires were processed and the mean per competence for each target group was calculated. The results are presented in Appendix A whereas the questionnaire with the competencies as well as representative descriptions for each as they were retrieved by e-CF are available in Appendix B. Based on these results we concluded that the most important competencies for EA in general as well as for each sector are those with a mean greater than or equal to 3.80, since those competencies gathered the majority of answers above the value 3 (neutral position) and closer to the value 4 (positive position) of the Likert scale. In overall, 14 of the 32 e-CF competencies have been considered by the responders of the questionnaire as highly relevant to EA. Therefore, we removed the 18 non EA related instances from the *Competence* class in EA-CF ontology. The 14 competencies are mapped to the target group that indicated their EA relevance in Appendix A.

The final step includes a thorough investigation of the literature on EA competence models for an indicative identification of additional instances to populate EA-CF's classes. Additionally, the literature review as well as the justification provided by the participants in the questionnaires completion process facilitated the creation of links that connect each instance of the classes *Skill*, *Knowledge* and *Attitude* with the corresponding competence instances.

The final EA-CF model contains 10 classes, 13 sub-classes, 127 concepts and 30 relationships. The final model is too complex to present in this paper thus the interested reader can obtain it as an ontology (OWL file) from http://islab.uom.gr/ea_owl.owl. A graphical view of the classes and sub-classes of the ontology was generated by the Protégé Ontology Editor (Noy et al, 2001) and is presented in Figure 2.

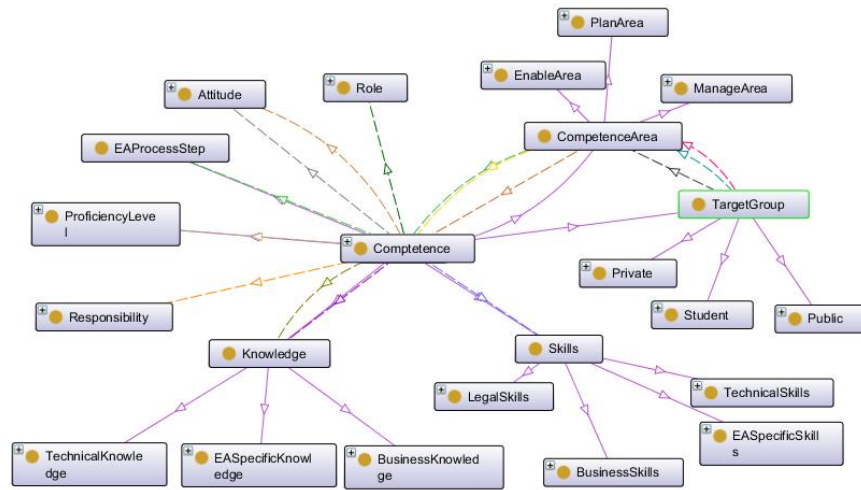


Fig. 2 Graphical view of the ontology with EA-CF's concepts

As an example, we present a small part of the model in Figure 3. This figure was created with Protégé and shows the *Problem Management* competence along with all related concepts.

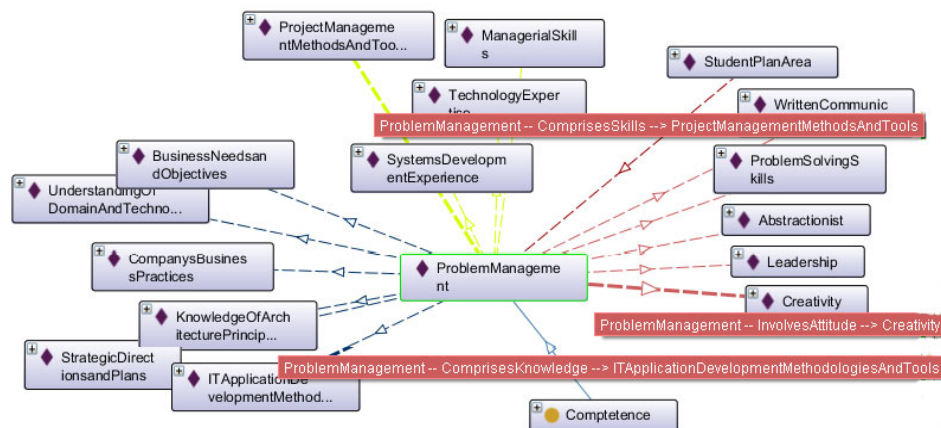


Fig. 3 The *Problem Management* competence in the EA-CF ontology

5. EA-CF as a training facilitation tool

European Commission's Education and Training 2020 policy emphasizes on the need for the "education and training systems to deliver the right mix of skills, including digital and transversal key competencies" (European Commission, 2010). This brings forth the need to develop such competencies in the workplace but also from the early stages of an adult's life. Focusing on the EA domain, this necessity can be addressed with the assistance of EA-CF, since relevant literature shows that, indeed, training strongly influences enterprise architects' achievements (Land et al, 2009; Ross et al., 2006; Bernus et al., 2003).

Furthermore, formal education can successfully prepare future enterprise architects by customizing their teaching programs and designing corresponding competency – based activities.

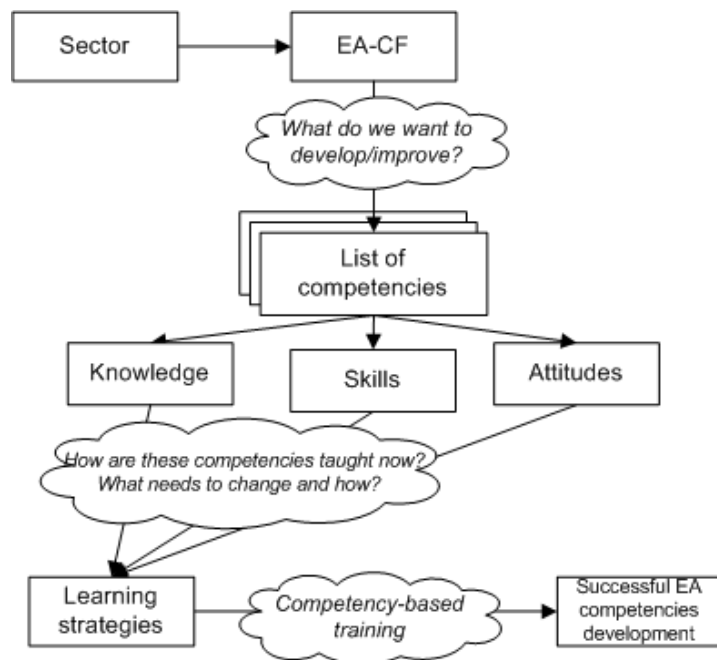


Fig. 4 Identification of knowledge/skills for EA training

Figure 4 graphically depicts how private and public companies, as well as academics can consult EA-CF when the need arises for the development of a specific set of competencies. EA-CF provides analytical information on the knowledge, skills and attitudes that underpin the development of the competencies in question. This way, the framework provides guidelines that will ensure the design of appropriate educational EA-based material and activities by customizing the existing training processes or building new ones.

More specifically, as depicted in Figure 4, when the need arises, stakeholders from a specific sector can access EA-CF. The stakeholders browse through the *Competence* concept’s instances and choose those that answer the “What do we want to develop/improve?” question. Subsequently, EA – CF provides information regarding which instances of the concepts *Knowledge*, *Skill* and *Attitudes* are inter-related to each selected EA competence. This way, the stakeholders are aware of the specific knowledge that will need to be taught as well as the specific skills and attitudes that will need to be fostered so that a specific competence can be successfully obtained.

However, the simple knowledge of who these instances are doesn't guarantee a successful competence development. To this end, existing teaching methodologies must be reviewed on their appropriateness for competency-based learning, and if needed, new methodologies must be adopted and applied. This can be achieved with the incorporation of innovative learning strategies (e.g. Problem Based Learning, Computer Supported Collaborative Learning, On-the-Job-Training etc) that promote active participation through the execution of activities instead of passive knowledge delivery and hence lead to the development of the target competencies.

Apart from the adaptation of existing EA courses or professional training programs, the consultation of EA-CF could lead to the creation of new good practices that would reflect the needs of enterprise architects. This way, EA-CF can support the transformation of training processes into lifelong training mechanisms for EA successful implementation.

6. Conclusions

In this paper we developed the EA-CF, a framework that enables an integrated and complete understanding of the competencies that an enterprise architect should possess or develop. EA-CF comprises a conceptual model that describes EA competencies as well as data (i.e. skills and knowledge) that populate the model.

The competencies identification process that we followed is accordant with the methods suggested by the relevant literature on defining and developing competencies (OECD, 2005; Klein et al, 2004). We performed the activities proposed in these methods, such as literature review, surveys, focus groups, and expert interviews, in order to consolidate the fragmented views on EA competencies. This resulted in the identification of an extensive set of competencies, skills, knowledge and attitudes that are proposed for delivering a successful EA.

There are three important outcomes of this research study that meet our initial objectives. First, the results contribute to the literature by reviewing and synthesizing prior, relevant works and presenting them in a structured manner. According to Webster and Watson (2002), an effective literature review creates a

firm foundation for advancing knowledge. Second, the conceptual model of EA-CF enables interoperability between EA competence models and other generic competence frameworks as well as among EA competence models. To this end, we adopted e-CF, the European standard reference for communicating ICT competencies, and we mapped different concepts from the literature to a common set of relevant concepts.

Third, the proposed framework also differentiates between three sectors, namely employees in both private and public sector and academia. We think this is important because although EA is essential for both private companies and public administration, its implementation differs. In addition, we did not identify in the literature any relevant work describing the differences between enterprise architects in public and private sector. The majority of the works focus on private sector while only two reports were found to address the public sector (Strano and Rehmani, 2007; The Federal CIO Council, 2004).

The proposed list of EA competencies can contribute to the development of new and the improvement of existing EA training and education programs, as it was discussed in the corresponding section, with the adaptation or the creation of new curricula and educational content and the implementation of competency-based learning strategies that foster the development of skills and attitudes. Future work towards this would include the implementation of specific cases in EA courses and training programs where EA-CF will provide information regarding knowledge, skills and attitudes that are needed for the development of EA competencies. The implementation results gathered will serve in the accumulation of concrete data and the corresponding configuration of EA-CF in order to successfully underpin EA education and training. Another useful future approach would address the identification and thus the augmentation of the EA-CF with other competencies that should be taught in the EA domain along with the ones that are already part of the educational process in order to more holistically foster the development of future enterprise architects.

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Appendix A

e- CF No.	Competencies	Mean			Sector relevance		
		Private	Public	Student	Private	Public	Student
1.	Information Systems and Business Strategy Alignment	4.90	4.25	4.63	X	X	X
2.	Service Level Management	3.80	3.50	3.10	X		
3.	Business Plan Development	4.80	4.13	3.87	X	X	X
4.	Specification Creation	4.15	3.90	3.97	X	X	X
5.	Systems Architecture	5.00	4.13	4.29	X	X	X
6.	Application Design	3.30	3.20	3.69			
7.	Technology Watching	4.40	3.40	3.98	X		X
8.	Design and Development	3.00	3.10	3.30			
9.	Systems Integration	3.25	3.30	3.27			
10.	Testing	2.50	2.00	2.98			
11.	Solution Deployment	2.90	2.80	2.82			
12.	Technical Publications Development	2.00	3.60	2.60			
13.	User Support	3.15	2.70	2.33			
14.	Change Support	2.50	3.00	3.04			
15.	Service Delivery	3.20	2.50	3.18			
16.	Problem Management	2.60	3.20	4.02			X
17.	Information Security Strategy Development	3.40	4.40	3.21		X	
18.	ICT Quality Strategy Development	3.95	4.40	3.53	X	X	
19.	Education and Training Provision	2.70	3.50	2.96			
20.	Purchasing	2.30	3.20	2.68			
21.	Sales Proposal Development	2.55	3.10	2.18			
22.	Channel Management	2.55	2.80	2.39			
23.	Sales Management	2.55	3.00	2.08			
24.	Contract Management	2.30	3.20	2.29			
25.	Forecast Development	2.50	3.60	3.21			
26.	Project and Portfolio Management	4.30	3.70	4.39	X		X
27.	Risk Management	2.80	3.60	4.15			X
28.	Relationship Management	1.80	4.70	2.48		X	
29.	Process Improvement	3.15	4.00	4.43		X	X

30.	ICT Quality Management	2.70	3.10	3.06			
31.	Business Change Management	2.55	4.50	4.28		X	X
32.	Information Security Management	2.50	3.50	2.93			

Appendix B

Competences	Importance (1-5)	How is this competence associated with the tasks/responsibilities of an EA? Why?
1. Information Systems and Business Strategy Alignment		
2. Service Level Management		
3. Business Plan Development		
4. Specification Creation		
5. Systems Architecture		
6. Application Design		
7. Technology Watching		
8. Design and Development		
9. Systems Integration		
10. Testing		
11. Solution Deployment		
12. Technical Publications Development		
13. User Support		
14. Change Support		
15. Service Delivery		
16. Problem Management		
17. Information Security Strategy Development		
18. ICT Quality Strategy Development		
19. Education and Training Provision		
20. Purchasing		
21. Sales Proposal Development		
22. Channel Management		
23. Sales Management		
24. Contract Management		
25. Forecast Development		
26. Project and Portfolio Management		
27. Risk Management		
28. Relationship Management		
29. Process Improvement		
30. ICT Quality Management		
31. Business Change Management		
32. Information Security Management		