

Role Clusters and Representative Skill Sets for Designing EAM Teams: A Quantitative Approach

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Abstract

Due to its holistic nature, different units and roles typically co-exist in Enterprise Architecture Management (EAM) teams. Such roles are defined by the organizational leaders based on uncoordinated and vague requirements, which might lead to problems. A solution proposal is focusing on the required competencies of the roles, rather than their naming and definition. When studying the roles, EAM literature rarely revolves around the skills. Albeit its considerable complexity, TOGAF's Architecture Skills Framework aims to close this gap. We argue that it is an intricate undertaking to analyse 790 different values per position when acquiring an EAM team member. Hence, this study presents a quantitative approach that aims to reduce the complexity of Architecture Skills Framework in designing Enterprise Architecture Management teams. The approach consists of i) clustering the EAM roles from TOGAF using ANOVA, ii) reducing the number of skills, and iii) creating a well-defined set of competencies for each group using a survey. Against this background, the initial contributions of this work are the four role clusters that can be used when designing EAM teams, a representative set of skills that the roles require and recommendations for EAM practitioners.

Keywords

Enterprise Architecture Management, ANOVA, Architecture Skills Framework, TOGAF

1. Introduction

Driven by the new technologies, customer needs, regulations, and pressure from market players, organizations are in constant need of transformation. Transformation can be addressed from several perspectives, such as strategy (goals, challenges, opportunities, capabilities), business operations (processes, actors, resources), information (business concepts, products), information technology (requirements, components), etc. However, to develop effective solutions and to ensure their fit in the organization, these perspectives need to be analyzed in an integrated manner. For example, business processes should support goals, manage the information objects, and motivate requirements for supporting information systems. Enterprise Architecture Management (EAM) is one approach which allows organizations to manage their structures, and navigate their way through the complexity by adopting Enterprise Modeling methods. This integrated and multi-perspective way of capturing and analyzing enterprise solutions is at the

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core of EAM. Offering a holistic perspective, EAM links different views of an organization in a meaningful way.

Traditionally EAM consists of various modeling dimensions, such as business, application, technology or data, different organizational units, teams and roles typically co-exist in EAM teams. For example, in a transformation project, a business architect provides knowledge on business requirements, a solution architect provides the details of the to-be application landscape, a data architect ensures adherence to corporate data standards and infrastructure architect plans the underlying technologies and systems.

In practice, such roles are defined by the organizational leaders based on uncoordinated and vague requirements when putting a team together. This rather inconsistent approach might lead to some problems [1]. First, there is a lack of standardization within the organizations, i.e., role definitions are generated arbitrarily. Oftentimes the name of the architectural layer that a team member is responsible for is just used as a prefix to the term "architect", such as "Application Architect". A common challenge in EAM projects is the lack of understanding of EAM benefits, followed by a biased perception on its technical nature [2]. Defining roles arbitrarily might strengthen this perception and enforce the view that EAM is operating in an ivory tower. Furthermore, given the lack of expert knowledge in the market, it is rather unrealistic to aim at filling the open positions in EAM teams with respective architects. What could be more feasible is training the employees of the organization for EAM tasks based on their competencies and interests.

A solution proposal against the above-mentioned problems could be focusing on the required skills of the roles, rather than paying too much attention on the naming of the roles and their definitions. As discussed in Section 2, there is a plethora of roles discussed in the EAM literature, yet the required levels for the skills are missing. One exception is TOGAF Architecture Skills Framework which documents roles in EAM projects and their required proficiency levels [3]. The Architecture Skills Framework includes 10 roles, 79 skills, and four competency levels, totaling in the analysis of 790 different values per position in an EAM team. This is a large number, which should be reduced for a practical application in designing EAM teams. Against this background, this study shows how the Architecture Skills Framework can be compressed both from roles and skills perspectives by adopting quantitative methods. Hence, our research question is "How can the roles and skills of the TOGAF Architecture Skills Framework can be clustered for a practical use in designing EAM teams?".

This work is organised as follows: Section 2 reviews the literature on the EAM roles and introduces three approaches when defining the roles. Section 3 details the research method, data collection and data analysis process. Section 4 documents the results, clusters the EA roles and attributes them a distinct set of skills. The results are discussed in Section 5 in a greater detail. Section 6 summarizes the findings, informs on the limitations of this work and mentions the future studies.

2. Literature Review

2.1. Enterprise Architecture Management

Enterprise Architecture Management is a management discipline that “establishes, maintains and uses a coherent set of guidelines, architecture principles and governance regimes that provide direction and practical help in the design and development of an enterprise’s architecture to achieve its vision and strategy” [4]. [5] defines the implementation of an Enterprise Architecture (EA) as a multidisciplinary process. Alternatively, [6] describes EA as a “structured and aligned collection of plans [to represent the] business and [IT] landscape of the enterprise”. [7] goes one step further by defining it as the description of the enterprise that aligns business with IT as well as their stakeholders. Ultimately, EAM aims to create business-IT alignment in the enterprise with the use of various Enterprise Architecture artifacts [8, 7, 9].

2.2. Approaches for Defining EAM Team Roles

Our literature review shows three approaches for defining the EAM team roles. The first approach determines roles within an enterprise architecture team that are based on the responsibilities and tasks required in an EA endeavor. Here, [10] conducts a survey with more than 350 experts in the EA domain. Arguing for a new perspective of roles in EAM, the study describes the roles, tasks, and skills of enterprise architects in today’s volatile, uncertain, complex, and ambiguous (VUCA) world. The roles are distributed into two categories, the “general roles” (e.g. Change Agents, Communicators, Leaders) and the “domain-specific roles” (e.g. Applied Enterprise Architects, Enterprise Business Architects). Furthermore, 7 skill facets of enterprise architects are presented which are applied to both categories.

In a similar manner, [11] conducts an extensive literature review by analyzing more than 50 EAM frameworks and uses seven of them to compile a comprehensive overview of eleven roles (e.g. Business Architect, Application Architect, Infrastructure Architect) in an EAM team. The study present an overview of the required core skills and competencies for the aforementioned roles.

The second approach is defining the enterprise architect as a multidimensional role. Each dimension of the enterprise architect is responsible for another functional activity within the EAM process, which makes this approach comparable to Mintzberg’s managerial roles [12]. One example is [13], which conducts a thematic analysis of expert interviews and argues that the enterprise architect is a “multifaceted” role with two distinct global themes; the *Manager* and the *Technologist*. The Manager global theme comprises seven subset roles (e.g. Vendor Manager, Standards Enforcer) that are of holistic, organizational nature, while the four roles of the Technologist global theme are rather specialized and execution-focused (e.g. System Architecture Designer, Business Process Modeller). Together both themes comprise a total of eleven subset roles of the enterprise architect that are based on its various responsibilities and functions within the company. Similarly, [14] argue that the enterprise architect is a multidimensional role, divided into five broad categories (e.g. Change Agent, Communicator, Leader). All categories of the enterprise architect require joint competencies (e.g. Analytical and Problem Solving Skills, Modeling Skills).

| Roles | Architecture Board Member | Architecture Sponsor | Enterprise Architecture Manager | Technology Architect | Data Architect | Application Architect | Business Architect | Program/Project Manager | IT Designer | Solution Architect |
|--------------------------------------|---------------------------|----------------------|---------------------------------|----------------------|----------------|-----------------------|--------------------|-------------------------|-------------|--------------------|
| Generic Skills | | | | | | | | | | |
| Leadership | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 1 | 2 |
| Teamwork | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 |
| Inter-personal | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 |
| Oral Communications | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 |
| Written Communications | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 |
| Logical Analysis | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 |
| Stakeholder Management | 4 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2 | 3 |
| Risk Management | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 1 | 3 |
| Business Skills & Methods | | | | | | | | | | |
| Business Case | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 |
| Business Scenario | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 |

Figure 1: Architecture Skill Framework: Role Skill Matrices based on [3]

The third approach groups roles within the enterprise architecture team, based on a hierarchical structure. One example is [15], which proposes a hierarchical design by dividing the company's EA stakeholders into three clusters (Core, Implicit and Applied Enterprise Architects). Similarly, [16] propose hierarchical division of roles and introduce an EA Role structure as a three-level pyramid. The higher a role is located within the pyramid, the more holistic its responsibilities within the organization become. Lower positions within the pyramid entail a rather operational focus on their responsibilities.

The general field of EAM has been abundantly studied in the past, yet the literature shows diverging approaches of defining roles in EAM. While the roles and responsibilities are tied to competencies, proficiency levels for those skills are not sufficiently investigated within the aforementioned approaches. The Open Group Architecture Framework (TOGAF) Version 9.2 attempts to close this gap with the Architecture Skills Framework [3], which is a supportive resource to train and develop EAM staff in an organization. The framework comprises of 10 roles, 79 EA-related skills, and 4 knowledge levels for the skills and roles. For example, a Business Architect (*role*) needs to be an expert (*level*) in Business Process Design (*skill*), whereas an Architecture Sponsor (*role*) needs to have background knowledge (*level*) in this area. The Architecture Skills Framework is quite extensive since the levels ranging from 1 (background knowledge) to 4 (expert knowledge) are attributed to each of the 79 skills of the 10 roles. However, due to this complexity, the framework might be rather difficult to apply in practical scenarios. Motivated by the solution proposal mentioned in Section 1, we suggest that the roles can be clustered into groups of distinct skill requirements. Next sections detail this process.

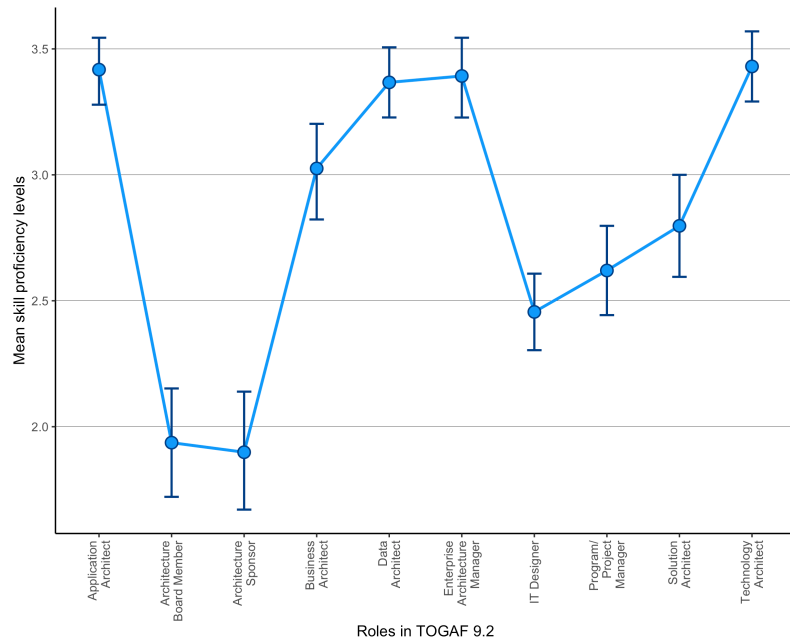


Figure 2: Line chart with error bars of mean proficiency levels per role

3. Research Method

The research method utilised in this study is quantitative and comprises of three phases; organizing the data (Section 3.1), analyzing the data (Section 3.2), and designing a survey (Section 3.3).

3.1. Data Organization

Given its popularity in EAM [17, 18] and extensive focus on skill/ knowledge levels, TOGAF 9.2 Architecture Skills framework has been chosen as a base for further analysis of the roles of enterprise architects and experts in the field. A visual inspection of the skill matrices revealed that some of the roles share the same skill proficiency levels across a selection of skills.

The initial step of the research process was the organization of data from the TOGAF 9.2 Architecture Skills Framework [3]. Its role-skill matrices were gathered in a spreadsheet (see Figure 1), compiled via a union join, and subsequently transposed into the long format for further analysis. Further cleansing of the data was not necessary, as it contained no missing values and was sufficiently structured. The resulting table was imported into an R environment. After this, line chart with error bars of the roles' mean values with a 95% confidence interval was created to visually inspect the differences between the mean values, as depicted in Figure 2.

3.2. Data Analysis

We used the Analysis of Variance (ANOVA) method to cluster the roles in the Architecture Skills Framework. This method comprises a selection of models to test the null hypothesis of whether mean values between three or more groups are equal, i.e. $H_0 = \mu_1 = \mu_2 = \dots = \mu_k$. In other words, we investigated the claim that *mean skills proficiency levels* of all groups (roles) are statistically similar to each other. Rejecting H_0 would indicate that the roles' mean proficiency levels deviate significantly from each other. The two objectives of the ANOVA have been to review the ten roles of TOGAF 9.2, and empirically group and reduce the number of roles appropriately.

To avoid committing a Type I error, we tested the two assumptions "normality of observations" and "homogeneity of variance" [19]. A histogram was used to verify the normal distribution of the skill proficiency levels. After performing the ANOVA, the insights from the histogram have been controlled with the analysis of normality of residuals via a Quantile-Quantile plot (Q-Q plot). The homogeneity of variance required testing whether the variances in skill proficiency levels among the roles were similar. Initially, Levene's test was performed. The test turned out to be significant, indicating a violation of the homogeneity of variance, $F(9, 780) = 3.089, p < 0.001, \omega^2 = 0.320$. In line with [19], we performed a Welch's F instead of a basic ANOVA.

Welch's F involved one response variable (skill proficiency level) and ten control groups (roles from TOGAF 9.2) as the independent variable. Welch's ANOVA was conducted with the intention of rejecting its H_0 . A rejection would support the clustering of roles into groups of similar skill requirements. To further explore the between-role differences between the roles' means *Bonferroni* correction, has been conducted (see Table 1. Statistically relevant p-values ($p < 0.05$) suggest significant differences between two roles. Insignificant differences were therefore used to propose clusters of groups.

3.3. Survey Design

The goal of the third phase was condensing the skills for the clustered groups. The Architecture Skills Framework defines seven skill groups, hence all seven matrices were compiled into one large matrix, containing all 79 skill rows, as well as the roles that have been clustered via ANOVA. Subsequently, the authors reduced the skills based on the following criteria.

- Skills with equal proficiency values for all roles were eliminated as the roles would have been indistinguishable based on these particular skills. Eliminated skills based on these criteria are "Teamwork", or "Business Metrics", which seem to have equal importance for all ten roles (cf. Figure 1).
- If two or more skills were too similar in terms of their definition and mean values, they have been reduced to one or combined with an existing skill.
 - "Information Consumer Applications" ($\bar{x} = 2.8$) and "Information Provider Applications" ($\bar{x} = 2.7$) were reduced to "Information Applications (consumer and provider)".
 - "Written Communications" ($\bar{x} = 3.6$), and "Oral Communications" ($\bar{x} = 3.7$) were combined with "Inter-personal" skills ($\bar{x} = 3.8$).

- "Managing Business Change" ($\bar{x} = 3.3$) was combined with "Change Management" ($\bar{x} = 3.2$).
- "Business Process Design" ($\bar{x} = 2.6$) was combined with "Business Modeling" ($\bar{x} = 2.8$).
- "Solutions Modeling" ($\bar{x} = 3.0$) was combined with "Modeling Skills" ($\bar{x} = 3.1$).
- "Data Interchange" ($\bar{x} = 2.6$) and "Data Management" ($\bar{x} = 2.7$) was reduced to "Data Management and Interchange".
- "Security" ($\bar{x} = 2.8$) was combined with "Identity Management" ($\bar{x} = 2.6$).

One author discussed the results with three practicing enterprise architects in a workshop setting. Before the workshop, the enterprise architects were informed on the study and were provided with the reduced skills framework. The goal of the workshop was identifying further skills that do not adhere to the above-mentioned criteria but deem as generic or not relevant. There was a consensus on removing "Contract Law" and "Fraud" from the Legal Environment set, "International Operations", "Graphics Image" from the Technical IT Skills set, as well as "End User Support", "Systems", and "Web-based Services" from the IT General Knowledge Skills set. Note that those skills are removed only after reaching an agreement among the workshop participants. In case of differing opinions, the respective skill was kept in the matrix.

The result was a matrix including 59 skills, based on which a survey¹ was generated. The survey participants were asked to identify five distinct skills per clustered role. This approach was favored to prevent an overlap of the same skill for two different roles. Five enterprise architects participated in the survey. Section 4 documents and discusses the findings.

4. Results and Findings

4.1. Clustering the EA Roles

Due to the potential violation of the assumption of homogeneity of variance (See section 3.2), Welch's ANOVA was performed. Welch's adjusted F-ratio has shown high statistical significance, $F(9, 317.23) = 40.424, p < 2.2e - 16, \omega^2 = 0.310$, which supports the rejection of H_0 . Thereby, we reject the null hypothesis that mean skills proficiency levels of all roles are statistically similar to each other. In other words, the roles' mean proficiency levels in Architecture Skills Framework deviate significantly from each other.

Based on the insights from Welch's ANOVA, the between-group differences in means were checked via post-hoc test. The Bonferroni correction examined which of the roles were significantly different from, or similar to, each other using p-values in a pairwise comparison matrix. Table 1 shows p-values < 0.05 highlighted in blue, which indicate a significant difference between means while p-values = 1 indicate potentially equal means. Some roles share statistically similar means with others while having distinctly different means from the rest of the roles.

Based on the Bonferroni correction, following clusters were determined.

- Cluster 1: Architecture Board Member, Architecture Sponsor

¹The survey can be downloaded here.

Table 1
Bonferroni correction table with p-values

| Roles | p-Values | | | | | | | | | |
|---------------------------------|----------|---------|---------|---------|---------|---------|---------|---------|---------|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Application Architect | - | | | | | | | | | |
| Architecture Board Member | <2e-16 | - | | | | | | | | |
| Architecture Sponsor | <2e-16 | 1 | - | | | | | | | |
| Business Architect | 0.114 | 8.9e-15 | 8.7e-16 | - | | | | | | |
| Data Architect | 1 | <2e-16 | <2e-16 | 0.381 | - | | | | | |
| Enterprise Architecture Manager | 1 | <2e-16 | <2e-16 | 0.212 | 1 | - | | | | |
| IT Designer | 1.3e-11 | 3.0e-03 | 8.6e-04 | 5.6e-04 | 1.9e-10 | 5.0e-11 | - | | | |
| Program/ Project Manager | 5.3e-08 | 7.6e-06 | 1.6e-06 | 0.082 | 5.2e-07 | 1.7e-07 | 1 | - | | |
| Solution Architect | 9.0e-05 | 2.5e-09 | 3.7e-10 | 1 | 5.6e-04 | 2.3e-04 | 0.381 | 1 | - | |
| Technology Architect | 1 | <2e-16 | <2e-16 | 0.082 | 1 | 1 | 6.4e-12 | 2.9e-08 | 5.6e-05 | - |

- Cluster 2: Application Architect, Business Architect, Data Architect, Enterprise Architecture Manager, Technology Architect
- Cluster 3: Program/ Project Manager, IT Designer, Solution Architect

The results were mostly in line with our initial analysis, except for Cluster 3. Cluster 3 included the two roles *Solution Architect* and *IT Designer*, which have a slight overlap as shown in Figure 2. This cluster might contradict the commonly accepted state of the literature regarding the *Solution Architect* role, a view supported by [20, 21]. [20] argues that there are “important differences” between the *Solution Architect* and the *IT Designer*. Hence, we decided to perform an additional ANOVA on the roles of the third cluster.

The data set was reduced to only the three roles, ANOVA’s assumptions (cf. Section 3.2) have been checked. According to the histogram the reduced data was normally distributed. The Q-Q plot, however, revealed an under-dispersion, within ANOVA’s residuals, relative to a normal distribution. Although the results of these two methods contradict each other, the F-ratio of an ANOVA can still be robust to violations of normality when the sample sizes are equal [19], which is the case here ($n=79$). Levene’s test was not significant suggesting homogeneous variances across all three roles $F(2, 234) = 1.814, p = 0.165, \omega^2 = 0.019$. To successfully verify this outcome, the Residuals vs. Fitted plot was inspected afterwards. After fulfilling its assumptions, a basic one-way ANOVA was performed. The test produced a significant F-ratio, $F(2, 234) = 3.314, p = 0.038, \omega^2 = 0.019$, therefore supporting the rejection of H_0 and indicating that at least one of the roles in Cluster 3 had a significantly different mean skill proficiency level.

Two post-hoc tests were applied to this reduced data set to identify the between-group differences in the roles’ means. The Bonferroni correction revealed that the *Program / Project Manager* shares significant similarities with both other roles, which coincides with Figure 2. The *Solution Architect* and the *IT Designer* differ significantly from each other based on their mutual p-value ($p = 0.032$). Tukey’s honesty significance difference (HSD) multiple comparisons test, as well as its 95% confidence intervals confirm the observations from Bonferroni test with significant differences between the *Solution Architect* and the *IT Designer*, $t = -2.574, p = 0.029$. The result of the HSD test is shown in Table 2. In other words, the proficiency levels required for *IT Designer* and *Solution Architect* roles in Architecture Skills Framework deviate significantly from each other. Due to its lower mean estimate value (0.165 vs. -0.177), *Program/ Project*

Table 2

Tukey's HSD multiple comparison results

| Linear Hypothesis | Mean Estimate | lower CI | upper CI | SE | t-Value | p (> t) |
|--|---------------|----------|----------|-------|---------|----------|
| IT Designer - Solution Architect == 0 | -0.342 | -0.655 | -0.029 | 0.133 | -2.574 | 0.029 |
| Program/ Project Manager - Solution Architect == 0 | -0.177 | -0.490 | 0.136 | 0.133 | -1.335 | 0.377 |
| Program/ Project Manager - IT Designer == 0 | 0.165 | -0.149 | 0.478 | 0.133 | 1.239 | 0.431 |

Table 3

Respondent's vote counts per skill, per role

| Enterprise Architect | Votes | Solution Architect | Votes |
|--|--------------|---|--------------|
| Strategic Planning | 4 | Systems Integration | 3 |
| Modeling Skills | 3 | Data Design | 2 |
| Enterprise Architecture Tools | 3 | Application Design | 2 |
| Architecture Principles Design | 2 | Migration Planning | 2 |
| Architecture Views & Viewpoints Design | 2 | Network & Communications Infrastructure | 2 |

| Architecture Sponsor | Votes | Program / Project Manager | Votes |
|-----------------------------|--------------|----------------------------------|--------------|
| Business Culture | 3 | Stakeholder Management | 4 |
| Value Management | 3 | Project Management | 4 |
| Business Scenario | 2 | Business Case | 2 |
| Visioning | 2 | Change Management | 2 |
| Legacy Investments | 2 | | |
| IT Industry Standards | 2 | | |

Manager was kept within the same cluster as the IT Designer.

Based on the post-hoc tests correction, the clusters were finalised as follows.

- Cluster 1: Architecture Board Member, Architecture Sponsor
- Cluster 2: Application Architect, Business Architect, Data Architect, Enterprise Architecture Manager, Technology Architect
- Cluster 3: Program/ Project Manager, IT Designer
- Cluster 4: Solution Architect

4.2. Skill Sets for the Role Clusters

As mentioned in Section 3.3, we created a matrix comprising of 59 skills and four representative roles for each cluster. For evaluation purposes, the respondent's answer matrices were rearranged and regrouped by roles, resulting in four new matrices. In this context, the clusters were named as Enterprise Architect, Architecture Sponsor, Program/Project Manager, and Solution Architect, respectively.

The survey was completed by the practicing enterprise architects which were contacted based on convenience sampling. To derive the skills for each cluster, the vote counts of the roles were compared. Skills with less than two votes have been sorted out. If the same skill had votes among two or more roles, the skill with the lower vote count was dropped. If the skills had equal vote counts among two or more roles, a subjective decision has been made in accordance with the approval of an enterprise architect. This decision was based on whether the other roles already had a representative skill assigned with a similar definition to the skill in question.

Five of the ten participants answered the survey. In each matrix, the number of respondent votes per skill has been counted. The skills with the highest agreement among respondents were *Strategic Planning* for Enterprise Architects, as well as *Stakeholder Management* and *Project Management* for Program/ Project Managers. The final selection of representative skills per role cluster is shown in Table 3.

EAM is a holistic discipline, and it uses the methods of Enterprise Modeling. This is reflected within the most voted three skills of the *Enterprise Architect* cluster. In modeling the as-is and to-be of the organization, the Enterprise Architect defines the underlying rules and guidelines, i.e. the architecture principles. Since the resulting models need to be communicated with the leadership, appropriate report types need to be designed and selected. Knowledge within this domain is represented within the Architecture Views & Viewpoints Design skill.

Any EAM project faces the risk of having reluctant information providers [22]. Removing blockers, promoting and championing the EA projects, *Architecture Sponsors* need to know the Business Culture of the company, its vision and legacy investments. Taking an external perspective, they need to be able to create sustainable value for the organization, and its stakeholders. Skills in IT Industry Standards seem to be perceived as helpful in this role.

Solution Architects have the responsibility for architectural design and documentation at a system or subsystem level [3]. Compared to other roles in our cluster, their skills are rather on the technical side with the goal of ensuring the Business-IT alignment. In developing and implementing the technical solutions for business problems, solution architects need to be skillful in systems integration and Migration Planning. Also, Data Design and Application Design skills are critical for aligning the IT Strategy to the needs of business.

Program and Project Managers obviously need skills in managing the stakeholders and projects. Their knowledge in Business Cases might be helpful in defining pilot scenarios in the early phases of the EAM projects, where modelling patterns, meta-models and conventions are created. Change Management skills are needed to use the results of the pilot scenarios, and raise the awareness of the EAM projects, which is a key success factor as studied in [23].

5. Discussion and Recommendations

The research question this study aims to answer is "how can the roles and skills of the TOGAF Architecture Skills Framework be clustered for a practical use in designing EAM teams". Our investigation suggests four prominent role clusters, which we termed as "Enterprise Architect, Architecture Sponsor, Program/ Project Manager", and "Solution Architect" in EAM.

The literature review shows that consensus between the resources is limited due to the divergence of the approaches mentioned in section 2.2. A reoccurring role is the *Architect* that in some publications appears as one independent role [13, 24], while being split up in other works into various roles based on their scope of duties [16, 3, 10, 11]. *Change Agent* is only found in the publications from the second approach [13, 14]. The *Standards Manager*[11] or *Standards Enforcer* [13], as well as the *Solution Architect* [3, 11] share the same definition in their respective papers. But apart from that all publications examined propose considerably distinct sets of roles. As a consequence, Architecture Skills Framework of TOGAF 9.2 was used as a foundation to establish a set of roles that was used for further analysis.

We produced a total of twenty skills as illustrated in Table 3 for the four role clusters derived from the Architecture Skills Framework. The *Enterprise Architect* and the *Solution Architect* included five, the *Architecture Sponsor* included six, and the *Program/ Project Manager* included four skills that are representative for each role, according to the survey respondents. Except for the *Architecture Sponsor*, which has one skill (IT Industry Standards) that does not comply with the role-skill matrices of the framework, the skills from the survey, and their allocation to the roles, generally coincides with the skill proficiency levels in the matrices. The "IT Industry Standards" skill was mentioned also once for the *Solution Architect* role cluster.

The skills "Strategic Planning", "EA Tools", as well as "Architecture Principles Design" and "Architecture Views & Viewpoints Design" are mentioned only in the *Enterprise Architect* role cluster. This is in line with the key characteristics of an enterprise architect proposed in [24]. "Modeling Skills" are also attributed to the *Solution Architect* role. Indeed, migration planning is a task where the *Solution Architect* should be able to model the future landscapes of the organization.

The characteristic skills of the *Architecture Sponsor* role are "Visioning", "Business Culture", "Legacy Investments", and "Business Scenario". This might translate to the practice that *Architecture Sponsors* should be helpful in providing support in terms of resources/ information from various teams and units. Furthermore, they should provide the EA teams with requirements for strategic decision making, since the sponsors define the company vision, and are aware of the "Business Scenario" within which the EA Project is being implemented. Having profound knowledge on the business culture, they should serve as a point of escalation and remove blockers within their control sphere.

"Stakeholder Management" is the single skill which is attributed to all groups, except for the *Enterprise Architect* role cluster. Given the amount of dependency on the organisational units in the EA projects, we interpret this finding that enterprise architects certainly need support especially when other stakeholders are involved. This finding should not be understood in a way that enterprise architects do not need this skill at all. On the contrary, managing the stakeholder requirements is one key task of every enterprise architect. Hence, our interpretation is that in an environment where skills do not overlap much, "Stakeholder Management" is not a characteristic attribute of an *Enterprise Architect*, but of the *Program/ Project Manager*. Furthermore, one common EAM challenge cited frequently in the literature is the lacking influence of EA on activities of organizational development [25]. To overcome this challenge, EAM practitioners should ensure to include team members who are skillful in managing the stakeholders.

6. Summary and Future Work

This study presented an initial quantitative approach that aims to reduce the complexity of Architecture Skills Framework in designing Enterprise Architecture Management teams. The approach consisted of i) grouping the roles in EAM via ANOVA, ii) Reducing the number of skills, and iii) Creating a well-defined set of competencies for each group using a survey. Against this background, two main contributions of this work are creating role clusters for designing EAM teams and attributing a representative set of skills for them.

Although our results are generally in line with the Architecture Skills Framework of TOGAF 9.2, their generalizability is limited due to the small sample size of the survey. Out of the ten architects, only five have responded to the survey. That made it difficult to find a significant consensus between the respondents about which skills are truly representative, as some of the skills were determined to be representative based on two votes. Future work considers performing the study with a larger sample of practicing architects. Potential benefits of reducing skills are tied to the risk of information loss. In order to mitigate this risk, we plan to involve the participants of the study already during the skill reduction step (cf. Step ii above). Doing so should allow us to gather insights on the problems that might arise due to the reduction.

TOGAF 10 was published in 2022 by The Open Group as the newest version of the TOGAF framework, also including the Architecture Skills Framework [24]. In an initial analysis, the newer framework has proven to have the same structure, roles, skill categories, skills, and proficiency levels. The notional alignment of maturity/skill level versus role has not been checked. Thus, we are planning to perform further analysis with the newer data set, which possibly requires involving the utilization of robust methods against the violations of the ANOVA assumptions and investigate whether our findings still hold.

Currently and using the results of our study, we are developing an "EA Roles and Skills" test that asks job candidates for their own perceived proficiency levels for the skills shown in Table 3. For each skill, the candidates should be able to select a skill proficiency level value between one and four. That is the same scale that Architecture Skills Framework introduced for its role-skill matrices [3]. That way, the responses should be easily compared to the matrices for evaluation. Based on the evaluation, the candidate's role should be predicted. A further step in this endeavour relates to designing a personality test, which is tied to the identified skills in this study. The reviewed literature provided only very few insights for straightaway applicable personality test. Especially in the domain of EAM, there seems to be no study conducted regarding the development of such tests. Instead, some publications have conducted research about tests in domains partly related to EAM, such as software engineering. While literature reviews of [26] and [27] are focused on the popular psychometric test methods, such as MBTI or FFM, [28] and [29] present more complex analysis methods, e.g. k-Nearest Neighbors (k-NN) or the FLORA personality test method.

We hope to contribute to the literature and practice by creating role clusters when designing EAM teams as well as skill sets thereof. Rather than limiting oneself to the role names that might vary depending on the circumstances, competence-based role clusters can be used. The fact that the clusters were created with a smaller sample calls for further broadening the data basis to improve the generalizability of the outcomes. Initial results indicate that EA leaders and practitioners can take this representative set of skills into consideration when putting together a team of architects.

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