Teaching Enterprise Architecture Management with Student Mini-Projects

Sabine Buckl, Alexander M. Ernst, Florian Matthes, Christian M. Schweda
Chair for Informatics 19
Technische Universität München
eMail: {buckls, ernst, matthes, schweda}@in.tum.de

Abstract: Enterprise architecture (EA) management is one of the major challenges of modern enterprises. It aims at aligning business and IT in order to optimize their interaction. Experts in this context are scarce and only limited proven practice to educate students in EA management is yet available. This paper presents a pattern on how to teach EA management based on experiences and best practices gained in a lecture at the Technische Universität München.

1 Introduction and Overview

While an increasing demand for experts in enterprise architecture (EA) management in practice exists, approaches and practical experience in teaching EA management are scarce. On the one hand the experienced gap may be explained by the existing plurality of EA management approaches and on the other hand by the diversity of practical problem statements, which are specific for the involved enterprise, its context and culture. Whereas several consultancies offer workshops for interested practitioners, which last for several days, universities have not yet adapted their curriculum to this demand of practice.

The challenge of teaching EA management is to find the right balance between theoretical foundations and practical experience. The difficulties arising in this context do not only result from the complexity of the management subject – the EA – but from the involvement of various stakeholders[1]. These stakeholders with business or IT background have different and often conflicting interests in the system, which need to be appropriately accounted for during EA management. Similarly, 'political' circumstances in an enterprise may negatively affect the prospects of the EA management endeavor.

A first attempt to address the aforementioned challenges and equip graduates with theoretical and practical experience in EA management was performed by the computer science department of the Utrecht University [KBB08]. Koning et al. use a defined method with a given set of problems to be addressed, complemented by predefined viewpoints used to describe the EA of an industry partner. While the approach can be applied in many different contexts, due to its general procedure, it does nevertheless not well account for

[1] A *stakeholder* is an individual, team, or organization with interests in, or concerns relative to a system (cf. [Int07]).

the aforementioned typical EA management challenges and the specificity of EA management concerns in the participating enterprises. Similarly, the need to adapt the method to the enterprises context and culture is neglected. Hence, we propose a different teaching approach, which is based on EAM patterns suitable to address the specific concerns of each participating industry partner. Furthermore, the patterns the method builds on are adaptable to the context and culture of the industry partner under consideration.

This article includes patterns, which are part of or related to the *EAM Pattern Catalog*, a *pattern language for enterprise architecture management* [BEL+07, BELM08, BEL+08, Ern08, BEMS09, Ern10]. The *EAM Pattern Catalog* uses a pattern based approach to EA management. It is available online at http://eampc-wiki.systemcartography.info/ [Cha09] and currently includes 164 EAM patterns[2]. The intention behind this article is to further extend the existing *EAM Pattern Catalog* by a M-Pattern documenting how to teach EA management.

1.1 Intended Audience

This article and the herein included patterns are intended for people concerned with teaching EA management. Thus, the article may not only be relevant for academics but may as a side effect also provide useful hints for in-house trainings on EA management in large companies. Put in other words, a large company could decide to let its new enterprise architects run through a mini-project likely EA management training.

1.2 EAM Pattern Map

This article includes the pattern TEACHING ENTERPRISE ARCHITECTURE MANAGEMENT. Figure 1 shows TEACHING ENTERPRISE ARCHITECTURE MANAGEMENT and its relationships to other patterns. MINI PROJECT EVALUATION is not included but may be helpful for evaluating student projects.

Related patterns about supervising thesis projects can be found in an article by Schümmer and Schmolitzky [SS08].

2 Teaching Enterprise Architecture Management

TEACHING ENTERPRISE ARCHITECTURE MANAGEMENT describes how to plan and conduct a lecture disseminating knowledge on EA management. Thereby, the approach emphasizes on the importance of giving the students the possibility to not only listen to theoretical lectures but to also gain practical experience in a real-world setting.

[2] For a detailed explanation of the concept of EAM patterns refer to [Ern08, Ern10].

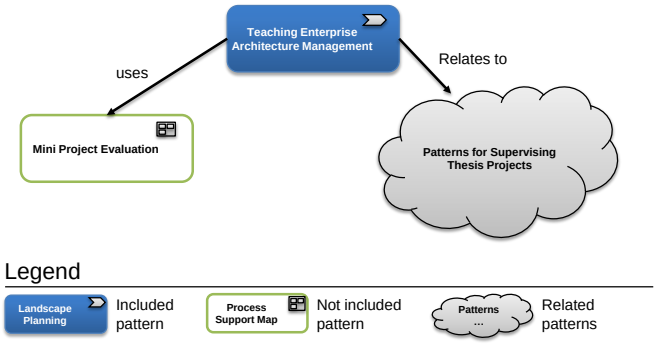

Abbildung 1: EAM Pattern Map

2.1 Example

The topic of EA management is an emerging one. Modern enterprises face the challenges of an ever changing environment they need to adapt to. At the same time, experts with practical experience in EA management are rare. In order to react to this increasing demand in practice the Technische Universität München has decided to include a lecture on the topic of EA management in her curriculum for the Wirtschaftsinformatik[3]-master. This lecture planned for 5 ECTS consisting of both a theoretical lecture and an accompanying lab course. The lecture should provide foundations on EA management and also include a practical part where students conduct so called mini projects in practical settings at an enterprise. In these mini projects the students work on problems, like *document visualizations and information models used for capturing the application landscape*, in real-world case studies at cooperating companies.

2.2 Context

An university wants to extend its Wirtschaftsinformatik-master curriculum with a lecture on the topic of EA management. The lecture should follow a twofold approach imparting theoretical knowledge in the area of EA management as well as providing the possibility for students to gain practical experience with real-world teaching cases in practical settings. The intended audience for the lecture are students in Wirtschaftsinformatik-master. The students can be expected to have an in-depth understanding of modeling with different languages, as e.g. UML or EPC, as well as an understanding for the economic environment, in which global acting companies have to compete nowadays.

[3]The term *Wirtschaftsinformatik* can be translated to business informatics or information systems.

2.3 Problem

You experience an increasing demand for EA management experts in industry. You as an university member want to equip students with the required theoretical background as well as practical experience to solve real world EA management problems.
How do you organize a lecture on the topic EA management, which on the one hand provides students with a theoretical background on the subject and on the other hand imparts practical experience in solving EA management problems in real world settings?

The following *forces* influence the solution:

- **Real-world teaching case versus artificial teaching case** What kind of teaching cases do you want to use? Real world teaching cases in cooperation with real companies or an artificial academic example? While real-world cases with a participating industry partner on the one hand enhance the motivation of the students, they on the other hand require a defined project goal limited to a certain part of the enterprise. In addition, confidentiality issues need to be discussed with the industry partner to allow anonymized publication of the project results.
- **One versus multiple teaching cases** Do you want to focus on one teaching case with better comparability or multiple teaching cases giving a broader introduction to EA management?
- **Maximal versus minimal termtime** What is a good duration for the accompanying practical project?
- **Size of student teams versus number of student teams** What is a good size for the student teams performing the teaching cases?

2.4 Solution

Solving the aforementioned problem, requires the involvement of different stakeholders, i.e. the university staff, who conducts the lecture, organizes, and evaluates the projects conducted at the industry partner, the practitioners from industry providing the problem to be solved, and students, who want to gain theoretical knowledge and practical experience in EA management. Figure 2 illustrates the single steps of the solution, a possible time frame of the single steps, and the main stakeholders involved.

2.4.1 Identify industry partners

As mentioned before, the objective to equip students with theoretical and practical knowledge in the field of EA management, can best be achieved if practitioners from industry are involved. This requires to contact potential industry partners during the planning phase,

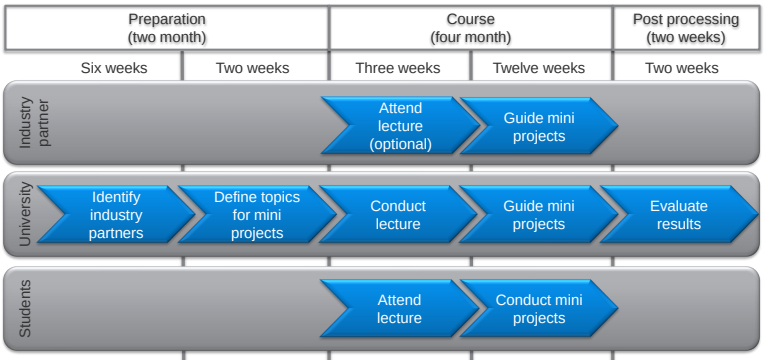

Abbildung 2: The solution process and the involved stakeholders

e.g. from previous research projects. Thereby, the parameters of the project to be conducted by the students, e.g. the tasks of the industry partner, the start, end date, and expected expenditure of time of the mini project as well as the benefits for the industry partner should be clearly outlined. Potential benefits for the industry partner are:

- Evaluating the EAM pattern approach at the industry partners enterprise.
- Early contact to graduates, who are interested in the topic.
- Meet other EA management practitioners with similar everyday problems.
- Possibility to attend lecture, e.g. for new employees.

To minimize travel times for the students, the industry partners should be located nearby. Nevertheless, the size of the company should be considered, as mainly global acting enterprises are concerned with the topic of EA management. Further, a considerable number of industry partners is required to keep the student mini project teams small in size, such that each student can be embedded well into the activities.

2.4.2 Define topics for mini projects

Together with the practitioners from industry possible topics for the student projects, the so-called mini projects, have to be identified. Due to the limited time frame of the project, the problem statement has to be narrow regarding the students' activity e.g. documenting, analyzing, planning, etc. and regarding the scope and reach, e.g. the application and information layer or the business and organization layer. Possible examples for mini project topics are *cost reduction analysis for an application landscape in a corporate environment* or *analysis of a risk management system with its components and interfaces at a financial service provider*. The diversity of EA management problems reflects the maturity of the different enterprises in terms of the established EA management function and emphasizes on the enterprise specificity of the topic.

Each mini project consists of the following activities:

- Analysis of the existing EA management practices and status of the current EA
- Project planning
- Meetings with stakeholders
- Information collection
- Creation of EA deliverables (meta models, models, process descriptions, recommendations)

2.4.3 Conduct and attend lecture

In the lecture, the students and attending industry partners are given an overview about the state-of-the-art in EA management, including prominent frameworks like TOGAF [The09] and Zachmann [SZ92]. In addition, theoretical foundations like models, metamodels, architectures in general and IT governance are presented. Based on these foundations, the EA management function and their interplay with other enterprise-level management functions, e.g. enterprise-wide demand management, project portfolio management, and strategies & goals management, is introduced [WMFH07], followed by an in-depth discussion of the main activities of the EA management function: envisioning, documenting, planning, analyzing, and enforcing (cf. [HW08, Nie06, Sch08, WvdBLvS05]). Completing the theoretical foundation, the EAM Pattern Catalog (EAMPC)[4] a collection of proven best-practice solutions is presented.

2.4.4 Conduct and guide mini projects

In order to apply the theoretical knowledge gained in the lecture, the students are given the chance to solve a real-world EA management problem at an industry partner during a mini project. The time frame of a mini project should be chosen carefully as a too short project might on the one hand prevent the students from getting deep experience in the topic. On the other hand, a too long mini project might discourage students from selecting the lecture. The time frame for the mini projects should at least be three months to give the students enough time to get involved. Figure 3 shows an exemplary schedule with possible milestones of a mini project.

In an initial presentation each student team introduces its specific EA management problem to the fellow students and industry partners. In order to solve the specific problems, existing EA management patterns contained in the EAMPC [Cha09] can be utilized or adapted. During the solution phase, the industry partner and the organizing university members provide guidance for the students. While the university members guide the execution of the project by providing theoretical background and information on other approaches,

[4] See http://eampc-wiki.systemcartography.info for more information.

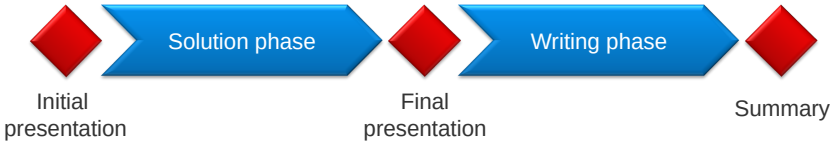

Abbildung 3: Exemplary time schedule for the mini projects

e.g. from scientific literature, the industry partner supports the student team in enterprise-specific contexts, as e.g. in making interview arrangements or providing access to internal knowledge sources like CMDBs.

To successfully complete the mini projects, the student teams have to provide three deliverables:

Initial presentation: Two weeks after the start of the project, the student teams should give an initial presentation, which introduces the respective problem to the other student teams and the participating industry partners. The objective of the presentation is to illustrate the idea of the chosen solution and discuss it with other student teams with possibly related problem statements. Furthermore, the industry partners may take part in the discussion to provide feedback to the proposed solution from a practitioners point of view and to get to know the students and other practitioners. The overall number of participants for such workshop should be carefully considered to foster discussion between the participants.

Final presentation: Two weeks prior to the project end, the final presentations should take place. The objective of each team's presentation is not only to present the developed solutions but also to discuss experienced pitfalls, surprises, and lessons learned from the student team perspective as well as the industry partner perspective.

Summary: Finally, the students have to submit a written summary of their mini project. These summaries can be formulated as EAM patterns, providing reusable solutions, or as case studies describing the used approach. These two forms for presenting the results are selected as they are simple to use for the students, while being further reusable for subsequent academic research.

In this phase related patterns, as e.g. *patterns for supervising thesis projects* [SS08] can provide guidance for supporting the student team in conducting their mini project.

2.4.5 Evaluate results

Finally, a grading for the lecture has to take place. Therefore, the deliverables of the mini projects as well as the results of an supplementary exam can be taken into account. The diversity of problem statements and the enterprise context of each project also have to be considered. A good starting point for evaluating the work of the students in the mini project are the two presentations as well as the final report. Furthermore, the industry partners can

be asked regarding their subjective impression of the single students and the student team as a whole. This can be supported by a compact questionnaire for the industry partners containing questions as the following:

- Did the students provide EA-related input and knowledge during the project?
- Was the mini-project outcome useful for you or your organization?

To make the grading process more explicit and provide feedback to the students positive and negative bullet points should be collected, which can then be used to explain the received results.

2.5 Implementation

TEACHING ENTERPRISE ARCHITECTURE MANAGEMENT can be implemented in all universities or other higher education institutions wanting to strengthen their offering for EA management. Depending on the selected teaching case type, you will either need cooperating companies or employees with in depth knowledge about EA management to prepare the teaching cases and to guide the students during their mini projects. One practical topic for each student team is advisable, while nevertheless one company can host more than one student mini-project. A research assistant from university can oversea up to five mini-projects, although the inception phase of each project may cause some workload peeks at the beginning. On the side of the industry partner, an employee supervising each project is needed. He or she should schedule meetings with the student team at least every two weeks to keep in touch with the progress. Especially, if the project is (partially) concerned with gathering architectural information, additional employees may be involved in executing the mini-project.

The presentation of the mini project results should preferably be conducted in a larger workshop, where all participating students and companies are attending. This will support the exchange between the different mini projects and will result in extended feedback from the participants.

2.6 Known Uses

The approach documented in TEACHING ENTERPRISE ARCHITECTURE MANAGEMENT is in use at the Chair for Software Engineering for business Information Systems (sebis) at the Technische Universität München. For more details on the lecture take a look on the website `wwwmatthes.in.tum.de/wikis/sebis/vorlesung-eam` or in the project report from 2009 [BMSS09].

2.7 Consequences

The solution for teaching EA management to Wirtschaftsinformatik-master students requires a good communication between the industry partners, the students, and the teaching staff from university. This is especially true for setting up the individual teaching cases. These cases can mostly not be reused in a subsequent term, as the industry partners advance in their EA management endeavors and are likely to rise different cases in the next iteration, which they would like to see addressed by a new student team.

Real-world teaching case versus artificial teaching case
Using a real-world teaching case for the mini projects results in a more realistic introduction to EA management, but it may be more difficult to prepare the teaching case to make it usable in the lecture. In addition, it requires that you have companies at hand, which participate in the mini projects and are willing to guide the students. An artificial teaching case can more easily be controlled and better be adapted to the students' demands. A drawback of an artificial teaching case is that it requires in-depth knowledge to create and prepare it.

One versus multiple teaching cases
Using multiple teaching cases offers a broader overview on the topic EA management. This may be an important fact for students, which are typically novices in this topic, because they get to know its diversity, e.g. during the presentations of the other mini projects, and also get to know that the enterprise-specific context plays an important role in developing the right solution. A drawback is that you initially have to prepare the teaching cases, possibly resulting in a high effort. In contrast, using only one teaching case has the benefit that the results of the different mini projects, which all work on the same teaching case, are far more comparable and require less effort to be prepared.

Maximal versus minimal termtime
Selecting the right termtime has an impact on the motivation of the participating students. In addition, it may also influence the intensity of their participation. Our experiences at Technische Universität München showed that a good term time for such mini projects is three months.

Size of student teams versus number of student teams
The selection of the right size for the student teams heavily impacts the motivation of the participating students. In too large teams, the individual student tends to invest himself less, while too small teams have difficulties to attain the expected results. A team size of four students seemed appropriate for the mini projects.

2.8 See Also

MINI PROJECT EVALUATION documents a form, which can be used to evaluate the students work in the mini projects.

A related approach was developed by Koning et al. [KBB08], who present a defined method with a given set of problems to be addressed, complemented by predefined view-

points used to describe the EA of an industry partner. Although the approach of Koning et al. turned out to be suitable for the case study, it would not be suitable in the above described context. Due to the different industry partners participating in the practical part of the lecture and the therefore different maturity levels of the mini projects, a standardized method like the one developed by Koning et al [KBB08] would not be applicable. This is especially visible, if the different goals of the mini projects are considered, which range from basic documentation and modeling initiatives to sophisticated risk management analysis [BMSS09]. Nevertheless, in different contexts, i.e. if only one industry partner is concerned or if multiple industry partners with similar goals and levels of EA management maturity take part, this might be different.

In addition, PATTERNS FOR SUPERVISING THESIS PROJECTS can be considered for additional support on supervising students (cf. [SS08]).

3 Acknowledgment, Critical Reflection and Outlook

This section includes acknowledgments to the people who supported the creation of this article and provides a critical reflection. Further an outlook on future topics in teaching EA management is given.

3.1 Acknowledgements

We want to thank all participants of the writer's workshop of the 2^{nd} European Workshop on Patterns for Enterprise Architecture Management 2010 (PEAM 2010) in Paderborn, Germany and especially our shepherd Andreas Krupinski for the time they spent for reading, commenting, and discussing this article. In addition, we also want to thank the students and cooperating companies, which participated in the lecture at the Technische Universität München and provided valuable feedback on the lecture.

3.2 Critical reflection

The TEACHING ENTERPRISE ARCHITECTURE MANAGEMENT} pattern presented in this article is a first step to the development of best practices for universities, which want to extend their curriculum with the EA management topic. However, the approach has only been applied once in practice at the Technische Universität München and therefore can on the one hand only be seen as a first step in the validation of the method. On the other hand the approach was used at nine different enterprises (cf. [BMSS09]) and can therefore be seen as nine different cases in which the method has proven to work. According to the often quoted *rule of three* [Cop96], a pattern describes an abstraction of at least three occurrences. When it comes to the evaluation of the method, the students' feedback as well as the practitioners' feedback provides valuable input. The majority of the students empha-

sized that the lecture prepared them well for the mini-projects, although minor remarks were made in the missing preparation for modeling tasks in the enterprise environment. An optional step of "practitioner bidding" may be helpful in selecting the "right" students for the right industry partner. In this step, the students would have to apply for an industry project giving a short curriculum vitae and some lines of motivation. Thereby, the university staff as well as the participating industry partners would be able to select the best suited students. This nevertheless rises the additional effort to create fall-back-solutions that can be performed by students that do not succeed in applying for an industry-partner.

3.3 Outlook

The initial application of the pattern in the context of an EA management lecture at Technische Universität München showed, that students can greatly benefit from getting "hands on" experience in applying EA management techniques. Nevertheless, not only students might be an interesting target group for EA management experience, but also practitioners might profit from getting in-depth training before actually conducting EA management in their enterprise. This is further reflected by the fact that a majority of industry partners are willing to host student mini-projects for a second time. The pattern can further provide a valuable starting point for creating training material for consultancies willing to provide EA management trainings. A minor problem might arise in this context from the highly practice-oriented setting of the method, which may pose a problem, as practical cases for training might be hard to find.

Literatur

[BEL+07] Sabine Buckl, Alexander M. Ernst, Josef Lankes, Kathrin Schneider und Christian M. Schweda. A pattern based Approach for constructing Enterprise Architecture Management Information Models. In *Wirtschaftsinformatik 2007*, Seiten 145–162, Karlsruhe, Germany, 2007. Universitätsverlag Karlsruhe.

[BEL+08] Sabine Buckl, Alexander Ernst, Josef Lankes, Florian Matthes und Christian M. Schweda. Enterprise Architecture Management Patterns – Exemplifying the Approach. In *The 12th IEEE International EDOC Conference (EDOC 2008)*, Munich, Germany, 2008. IEEE Computer Society.

[BELM08] Sabine Buckl, Alexander M. Ernst, Josef Lankes und Florian Matthes. Enterprise Architecture Management Pattern Catalog (Version 1.0, February 2008). Bericht, Chair for Informatics 19 (sebis), Technische Universität München, Munich, Germany, 2008.

[BEMS09] Sabine Buckl, Alexander M. Ernst, Florian Matthes und Christian M. Schweda. How to make your enterprise architecture management endeavor fail! In *Pattern Languages of Programs 2009 (PLoP 2009), Chicago*, 2009.

[BMSS09] Sabine Buckl, Florian Matthes, Christopher Schulz und Christian M. Schweda. Teaching Enterprise Architecture Management – A Practical Experience. Bericht,

Chair for Informatics 19 (sebis), Technische Universität München, Munich, Germany, 2009.

[Cha09] Chair for Informatics 19 (sebis), Technische Universität München. EAM Pattern Catalog Wiki. http://eampc-wiki.systemcartography.info (cited 2010-02-25), 2009.

[Cop96] James Coplien. *Software Patterns: Management Briefs*. Cambridge University Press, Cambridge, UK, 1996.

[Ern08] Alexander Ernst. Enterprise Architecture Management Patterns. In *PLoP 08: Proceedings of the Pattern Languages of Programs Conference 2008*, Nashville, USA, 2008.

[Ern10] Alexander M. Ernst. *A Pattern-Based Approach to Enterprise Architecture Management*. Dissertation, Technische Universität München, München, Germany, 2010. (in submission).

[HW08] Marting Hafner und Robert Winter. Processes for Enterprise Application Architecture Management. In *41st Hawaii International International Conference on Systems Science (HICSS-41 2008), Proceedings, 7-10 January 2008, Waikoloa, Big Island, HI, USA*, Seite 396, Los Alamitos, CA, USA, 2008. IEEE Computer Society.

[Int07] International Organization for Standardization. ISO/IEC 42010:2007 Systems and software engineering – Recommended practice for architectural description of software-intensive systems, 2007.

[KBB08] Henk Koning, Rik Bos und Sjaak Brinkkemper. A Lightweight Method for the Modelling of Enterprise Architectures. In Springer, Hrsg., *Service-Oriented Computing – ICSOC 2008 Workshops*, Seiten 375–387, Berlin, Heidelberg, Germany, 2008.

[Nie06] Klaus D. Niemann. *From Enterprise Architecture to IT Governance – Elements of Effective IT Management*. Vieweg+Teubner, Wiesbaden, Germany, 2006.

[Sch08] Marten Schönherr. Towards a common terminology in the discipline of Enterprise Architecture. In Stephan Aier, Pontus Johnson und Joachim Schelp, Hrsg., *Pre-Proceedings of the 3rd Workshop on Trends in Enterprise Architecture Research*, Seiten 107–123, Sydney, Australia, 2008.

[SS08] Axel Schmolitzky und Till Schümmer. Patterns for Supervising Thesis Projects. In *Proceedings of EuroPLoP 2008*, 2008.

[SZ92] John F. Sowa und John A. Zachman. Extending and Formalizing the Framework for Information Systems Architecture. *IBM Systems Journal*, 31(3):590–616, 1992.

[The09] The Open Group. TOGAF "Enterprise Edition" Version 9. `http://www.togaf.org` (cited 2010-02-25), 2009.

[WMFH07] André Wittenburg, Florian Matthes, Florian Fischer und Thorsten Hallermeier. Building an integrated IT governance platform at the BMW Group. *International Journal Business Process Integration and Management*, 2(4), 2007.

[WvdBLvS05] Roel Wagter, Martin van den Berg, Joost Luijpers und Marlies van Steenbergen. *Dynamic Enterprise Architecture: How to Make IT Work*. John Wiley, 2005.