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# Enterprise Architecture Management Education in Academia: An International Comparative Analysis

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**Abstract.** Enterprise architecture (EA), although matured in more than 30 years of ongoing research, receives more importance with the increasing dependency of business in IT and the growing complexity of IT systems. The integrated management of a companies' goals, structures, and processes with respect to the business and IT elements, as well as the representation of impacts triggered by planned changes is educated in different ways at many universities all over the world. There are several techniques, methods, tools, and approaches to transfer the knowledge from the educators to the students, giving them the qualification to support their future employers in handling the EA challenges modern companies are facing. This work gives a detailed comparative analysis of more than twenty international educational offers regarding Enterprise Architecture Management, carves out the commonalities and finds two prototypical courses as a best-practice combining the strongest matches for Business Informatics and Computer Science studies alike.

**Keywords:** Enterprise Architecture Management, Education, Survey, Course Design.

## 1 Introduction

The growing importance of Information Technology (IT) to help companies reach their business goals charges universities all over the world for offering education to qualify students to analyze, manage and transform the processes and resources in enterprises and governments. This topic is no longer IT specific but has moved more and more to the business side over the last years. Therefore it is no surprise that the emphasis of the providing institutions and affected study programs is the area of Business Informatics [1]. A wide range of education on this topic is offered. There are classes with only one or a few units about enterprise architecture (EA), e.g., as part of an IT-Management or IT-Strategy course, full courses, modules containing lectures and practical exercises, or even complete Master studies and certificates.

This article aims to identify and structure international offerings in Enterprise Architecture Management (EAM) education. With this research, we aimed to respond to the following research

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questions:

**RQ-1** What are the commonalities and differences in teaching Enterprise Architecture Management on an international scope?

**RQ-2** Is Enterprise Architecture Management taught differently at Business Informatics and Computer Science study programs?

**RQ-3** Can a "Best-Practice-Course" be derived that represents the maximum of common aspects for both Business Informatics and Computer Science studies?

To respond to these research questions, we searched for universities offering education about this topic, collected all accessible information, structured it according to a generic framework, and sent it back to the responsible educators for verification. The answers were used to update or complete the collected data. The main concern was to get an overview of the number of credits or ECTS, taught EA frameworks and modeling languages, used tools, recommended literature, and whether education was supported by practical work.

Although some of the found educational offerings had to be discarded from the list caused by a lack of information or being outdated, 22 entities remained for our analysis. The German-speaking area of Europe (Austria, Germany, Switzerland) could be extensively scanned because lists of all universities in this region were accessible, yielding approximately half of the results, the other half distributed all over the world. Another reason for this over-representation of central European universities might be the intensity of research on this topic in this area [2].

This article aims to present an overview of educational offerings regarding EAM from an organizational and content perspective, i.e., aspects that can be assessed without actually participating in the offerings. The work is structured as follows: First, a brief explanation of the concept of EAM is given in Section 2.1, followed by a presentation of related works in Section 2.2. Afterward, the methodology and research methods are explained in Section 3, and the similarities and commonalities are worked out in Section 4. Finding a "Best-Practice Education" through the most significant common aspects and the biggest differences between technical and business/management-oriented educational offers regarding this topic are described in Section 5. The limitations and implications of our research are discussed in Section 6. A final conclusion can be found in Section 7. Appendix 1 lists all observed EAM university offerings.

## 2 Background

### 2.1 Enterprise Architecture Management

Enterprises are more and more forced to transform. Reasons for such necessary changes range from business causes to IT-driven causes to external triggers such as changes in governmental rules and customer or competitors' behaviors [3]. Although this transformation process is critical, there are high failure rates reported in literature [4]. One of the main reasons for the collapse of these projects seems to be a lack of coordination and communication between stakeholders [5]. EA is an approach to aligning corporate strategy, business, and IT with a holistic view of their domains – organizational structures, business processes, and IT systems – and gives an individual detailed view of the correlation between them. EAM as a technique supporting EA is mainly seen as part of the IT management but needs a variety of intuition into the business needs and the understanding of IT as a supporting instrument for running the business without losing sight of IT. It must describe and control the strategy, structure, business processes, applications, systems, and technology of an organization at the current situation and give possibilities to deal with changes and modifications of both business and IT [6]. As Greefhorst and Proper mention: *"The purpose of enterprise architecture is to align an enterprise to its essential requirements."* [7]. To achieve

this goal, a large number of approaches have been developed, with tools, methods, frameworks, and modeling languages to give deciders and involved persons the possibility to take an enterprise-wide view on different levels and perspectives.

There exist several EAM frameworks reflecting proven best practices [4], [8]. They promote different approaches to capture the essentials and techniques for getting an overview of the landscape by identifying and relating different viewpoints for all relevant stakeholders and therefore preparing a joint communication base for every one of them. Modeling languages are needed for supporting the analysis across domain borders [6], tools, often included in frameworks, mainly support the exchange of data and visualization.

Literature locates the origin of EA discipline in the 1970s and 1980s as an outcome of academic research projects [9], [10]. These projects were the base for the following works, especially the developments of John Zachman, the Zachman framework, published in 1987 [11]. Since then, EAM has evolved from an engineering and IT management tool to a strategic one, as seen in Figure 1 in line with the importance of IT. Since then, many well-known frameworks and approaches have been developed and published with varying success.

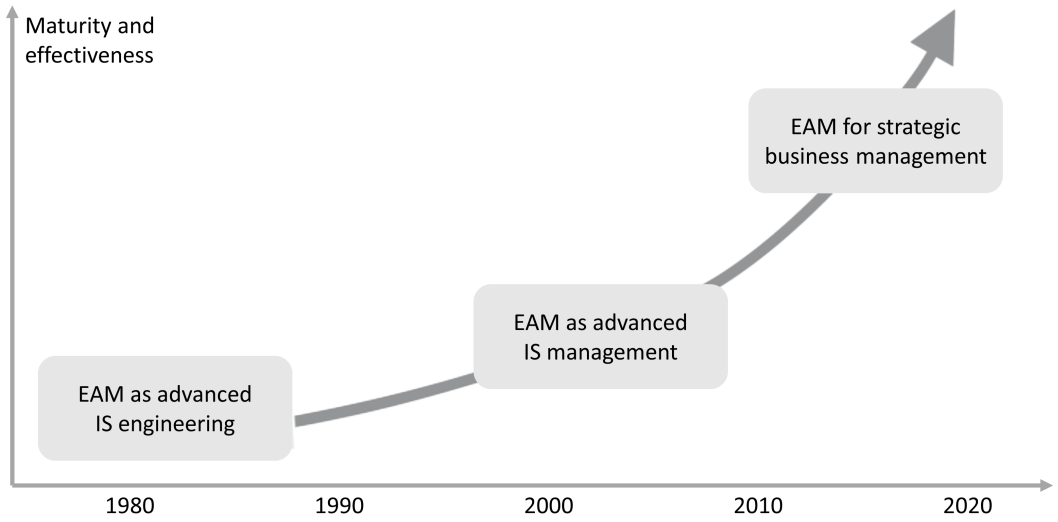


**Figure 1.** EAM development phases [12]

The growing dependency of organizations on IT has reached a critical value; even small organizations cannot operate without the support of IT systems, while large enterprises often use thousands of them [4]. New technologies like Big Data, Artificial Intelligence, Internet-of-things, Machine Learning, Cloud Computing, GPS, 5G, and Blockchain, to only name a few, cannot be ignored. The process of digital transformation forces companies into investments and strategic considerations, including the significance of subsequent needs like risk, security, and change management [13].

The need for highly educated specialists is – parallel to the increasing investments in IT systems – still growing. According to this demand, universities offer a broad range of EAM education worldwide. Students can choose from one-unit slots as part of a Bachelor's education to Master's study programs, which are "Master of Enterprise Architecture". Many courses, modules, study programs, and certifications teach EAM from basics to profound depths, different EA frameworks, EA modeling languages, and tools in various amounts of effort and time. The institutes responsible for these educational offerings address their audience broadly, from Computer Science to Business Informatics and Management Sciences. The article aims to structure the field and provide recommendations for best practices in EAM education.

## 2.2 Related Works

As mentioned earlier, the history of Enterprise Architecture is some decades-long, and the importance of the techniques included is still growing as its adoption in business is increasing.

Kappelman et al. [14] published 2008 results of a survey on 376 IT professionals, all deciders, answering several questions about their sight on EA. Although the primary impression was described as an *"IT thing' resulting in difficulty obtaining broad support from business managers for EA activities"*, significant benefits beyond IT were responded. Since then, the acceptance of business has massively increased, as mentioned before, and the education offerings, one of the postulations in the study, can cover the requirements. Schmidt et al. [15] presented in 2015 the empirical research "Benefits of Enterprise Architecture Management – Insights from European Experts" summarizing the answers of 263 IT experts from central Europe about the impact of several aspects on the benefit of EAM in enterprises. They showed that *"changing business requirements, IT Business Alignment, the complexity of Information Technology infrastructure as well as enterprise architecture knowledge of Information Technology employees are crucial impact factors to the perceived benefit of EAM in enterprises"*.

The concept and methodology of EA were adopted in many ways. Several reports and surveys were published during the last years describing the customization of EA to business needs. The education sector is no exception; many reports of the adaption of EA can be found; some examples are listed here: Nestori Syynimaa [16] published his research on an "Enterprise Architecture Adoption Method for Higher Education Institutions" in 2015, describing the usage of an improved EA Adaption Method in Finland. Samar Alamri et al. [17] describe their EA adoption for Higher Education Institutes in Saudi Arabia, called Higher Education Institution (HEI) methodology, based on the TOGAF Architecture Development Method (ADM). Olsen and Trelsgård [18] published their EA adoption case study in Norway in 2016. Araya-Guzmán et al. [19] describe the first steps of a project to implement EA for undergraduate teaching in Chile in 2018.

Furthermore, there are study programs published on the content of EA courses: Glenn Stewart [20] presented in 2006 *"a reflection on using an Enterprise Architecture approach to develop in graduate students a holistic and integrated view of complex enterprises"*, including changes of the course design during five semesters, held at the Queensland University of Technology. Wegmann et al. [21] published their experiences teaching EA and SOA at École Polytechnique Fédérale de Lausanne, Switzerland, based on their EA method SEAM (Systemic EA Methodology). Regev et al. [22] describe a method to train enterprise architecture students in the art of requirements elicitation by understanding the stakeholders' needs in 2015, with an interdisciplinary approach combining technical and social sciences students. Buckl et al. [23] *"describe how to plan and conduct a lecture disseminating knowledge on EA management"*, by focusing on practical experience and solving real-world problems with industry partners. Seppänen et al. [24] report on using EA modeling tools in an educational context and their experiences teaching a practical course on EA in Finland. Kudryavtsev et al. [25] describe in their *"Simplified Enterprise Architecture Management Methodology for Teaching Purposes"* how EA is taught in several universities, using a solid link between EA and strategic management.

A survey on EA education and the content taught at different universities is hard to find, therefore, some surveys on similar topics are listed here: Bandara et al. [26] give a detailed description about five courses on Business Process Management (BPM) held at universities in Australia, Austria, South Africa, and the USA. Agner and Lethbridge [27] published *"the results of a survey of tool use in software modeling education"* in 2017, representing 150 professors at universities in 30 different countries.

There are still some publications describing the use of EA in the education sector, both in handling knowledge transfer and the operation of high school institutions. This work extends these studies by providing a comparative analysis of 22 universities, listing and comparing their handling of EA topics towards the students. It would go beyond the scope of this article to include all aspects

covered in the listed publications, namely IT-management, IT governance, enterprise modeling, digital business, or Business/IT alignment. Therefore we focus on the topic of EAM.

## 3 Methodology

The applied methodology comprises a *search process* where the aim was on finding relevant educational EAM courses, followed by an *assessment process* where the identified EAM courses were analyzed and assessed. The two processes will be described in greater detail in the following.

### 3.1 Search Process

The search process started with the seed of renown EA experts and an internet search on publications and books containing the title "enterprise architecture". The authors of these matching studies and the reference lists in the found publications as well as the literature lists of specific books (e.g., [4], [6]) lead to their universities, serving as the next entry point for a scan.

The websites of these universities offer in most cases a search function, leading to educational offers, institutes, and employees. Not all requests ended in the desired result; often, neither a course nor the referenced person could be found. But notable answers were recorded, and the details for an educational offer were analyzed and stored in an assessment frame we prepared (see Table 1).

The lecturers and responsible persons were contacted by email, including a prefilled assessment frame with a request for completing or correcting the requested information. Eleven persons answered the request, three with the note that the course is no longer part of the education program. The graphical representation of the search process can be seen in Figure 2.

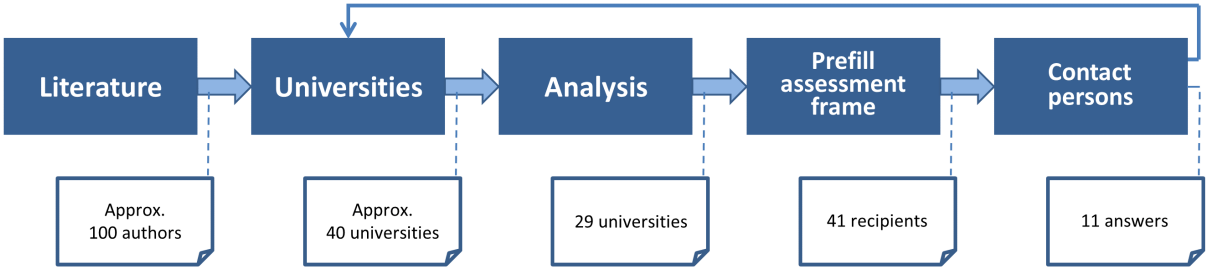


**Figure 2.** Overview of the search process steps

### 3.2 Assessment Process

For collecting and comparing the desired information, an assessment frame was developed. Table 1 lists the assessment criteria and provides a brief description of the data we expected to collect.

At the beginning of the assessment phase, the list of educational offerings was reduced by excluding the ones that are not offered anymore or lack information. Either the university's website did not provide enough details, or the lecturers or responsible people did not respond to the request for additional data. The detached entries had no or only rudimentary detailed descriptions and no data about taught frameworks, modeling languages, or tools. As these are the main areas for comparison, the named courses were removed. The assessment process steps can be seen in Figure 3.

The next step was to find commonalities in the observed offers. The attributes were separated into two groups regarding organizational or content-specific aspects. After classifying all observed offers, a smaller list was created, containing only courses and modules (with a summary of their elements, in all cases a lecture and a practical seminar). These items built the basis on finding prototypical courses as best-practice for technical and business/management-oriented education. For some findings, it was necessary only to choose courses and modules that exclusively cover EA,

whereas other facts were taken from courses with broader teaching content. The defined criteria were used on these entities to find differences and commonalities.

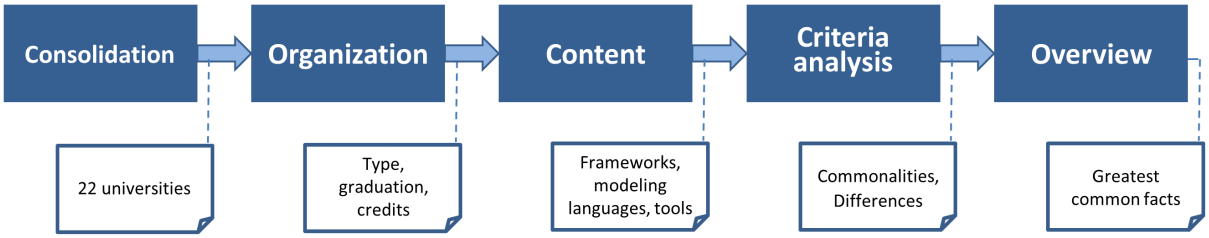


**Figure 3.** Overview of the assessment process steps

**Table 1.** Assessment frame with short explanation of the assessment criteria

| **Criteria** | **Description** |
|---|---|
| University | Name of the University. |
| Institute | Name of the institute/faculty. |
| Type | Type of the lecture (e.g. course/module/study). |
| Name | Name of the course/module/study. |
| Graduation | Study where the course/module/study is part of. |
| Responsible | Name of the responsible person(s). |
| Credits | Number of credits/ECTS the students earn. |
| Duration | Time period the course/module/study takes. |
| Content type | Type of content (e.g. lecture, lecture + exercises, ...). |
| Underlying framework(s) | Which frameworks are taught. |
| Modeling language(s) | Which EA modeling languages are taught. |
| Used tools | Which tools are used. |
| Recommended literature | List of recommended/used literature. |
| Number of students | How many students join the course/module/study at average/maximum. |
| Language | Spoken/teaching language. |
| Details | Additional details of the course/module/study. |
| Cooperations with companies | Do you have cooperations with companies regarding the course/module/study? |
| Guest lectures | Are there lectures of other persons than the responsible ones? |
| Assessment | Kind of assessment (e.g. oral/written exam, project, practical exercises in team, presentations). |

## 4 Current State of Enterprise Architecture Education

The information collected from the universities' websites and the responses with additional facts will now be analyzed. The University of Antwerp and Penn State University take a unique role on the list: both are full-time study programs worth at least 60 ECTS with approximately 30 ECTS covering EAM and similar topics and therefore not listed in every table. Alumni of these study programs earn a special master's grade: "MSc Executive Master in Enterprise IT Architecture" in Antwerp and "Master of Professional Studies (M.P.S.) in Enterprise Architecture and Business Transformation" in Pennsylvania. Not all desired information could be collected from every university. Consequently, some of the following statistics consist of less than 22 universities.

The aspects observed can be divided into areas such as organizational as well as content. The organization of the considered education consists of attributes like credits, type of knowledge transfer, whether EA is the main content element or if it is only a (maybe small) part of the course

(full vs. part), whether it is part of a technical or a business/management study, and so on. The content aspects include the taught frameworks, modeling languages, and (used) tools, as well as recommended literature.

### 4.1 Organizational Aspects

The graduation of the study the education is part of gives information on the direction or discipline: Is the course or study more focused on Business Informatics or Computer Science, or is it a mixture of both, and is it enclosed in a primary study (Bachelor) or a secondary (Master) education. Table 2 shows that two out of 22 are part of a Bachelor's studies, and the other 20 have finalized academic studies as a prerequisite and are therefore enclosed in Master's studies. The distribution between Computer Science and Business Informatics as the study discipline is about 1:2; two universities offer the course for students in both study directions (see Table 3). The separation of the study direction will be further discussed in the next section.

**Table 2.** Study graduation

| **Graduation** | **Count** |
|---|---|
| Master | 20 |
| Bachelor | 2 |
| **Total** | **22** |

**Table 3.** Discipline

| **Discipline** | **Count** |
|---|---|
| Business Informatics (BI) | 14 |
| Computer Science (CS) | 6 |
| BI + CS | 2 |
| **Total** | **22** |

The educational offers can be divided into different types: Is it a course, a module consisting of more than one course, a certification, or a whole study program? Figure 4 and the corresponding table show the spreading of the observed classes. The two study programs are both secondary studies with a Master's graduation.

| **Education type** | **Count** |
|---|---|
| Course | 15 |
| Module | 3 |
| Certification | 2 |
| Study program | 2 |
| **Total** | **22** |

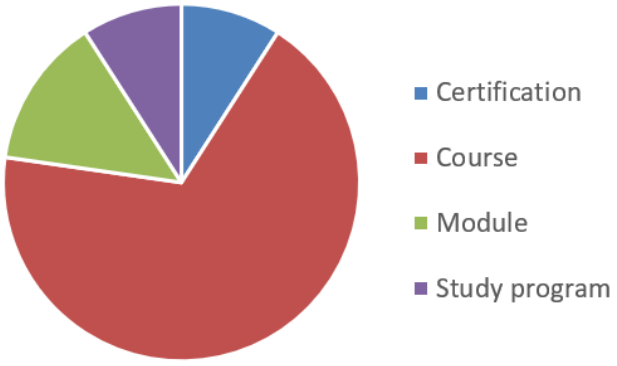


**Figure 4.** Education types

The level of intensity EAM is covered varies over the classes. Study programs, modules, and certifications highlight the theme as the ruling topic. Other courses only deal with this topic, whereas some focus on a broader view, and EAM is only a small part of the whole content. There are some courses with their core area on IT-Strategy, IT-Management, or Digital Transformation, having only a small amount of time covering EAM. The distribution can be seen in Figure 5.

| EAM intensity | Count |
|---|---|
| Full-time | 15 |
| Part-time | 7 |
| **Total** | **22** |

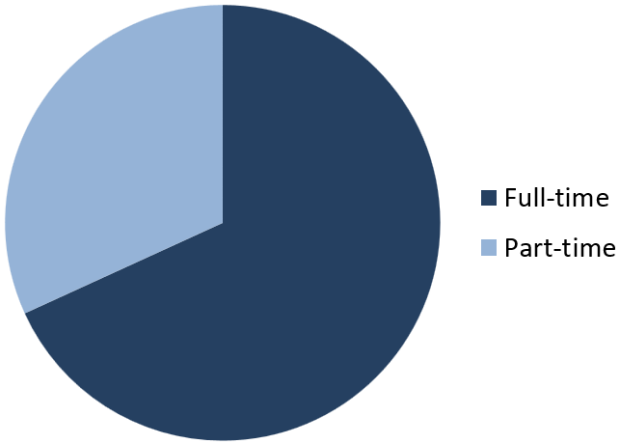


**Figure 5.** Share on content volume

The credit hours, based on the effort students must invest in passing an academic education unit, are in the following comparison only taken from courses. This attribute, called ECTS, is standardized in many European countries as a grading system, while USA and Australia work with an exchange system for most universities. These exchange factors make courses more comparable. Figure 6 and the corresponding table show the distribution of course credits.

| ECTS | Count |
|---|---|
| 6.0 | 4 |
| 3.0 | 3 |
| 5.0 | 3 |
| 7.5 | 3 |
| 4.0 | 2 |

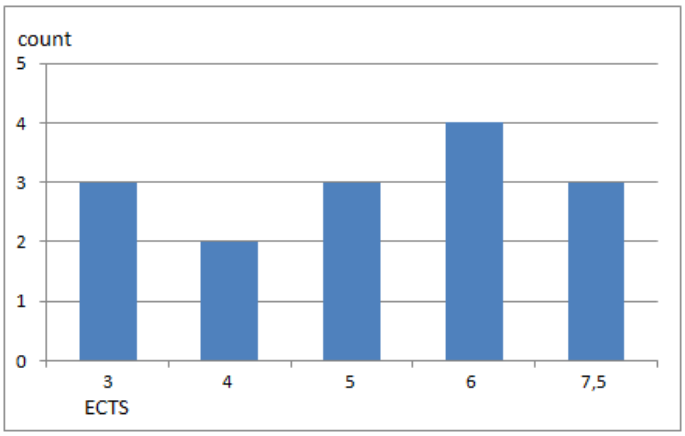


**Figure 6.** Course credits vs. number of courses

Half of the evaluated universities offering education regarding EA use English as the spoken language, but also the countries language is often used as can be seen in Figure 7.

## 4.2 Course Content

As mentioned before, various established frameworks covering EA exist. Although many different frameworks are taught in the observed education, TOGAF [28], The Open Group Architecture Framework, is by far the most taught one, followed by the Zachman framework [11] and the St. Galler House of Digital Business [29], which is taught in two universities. ITIL is called twice but cannot be seen as an EA framework as it is a best practice for IT service management and maintenance handling, covered by IT Management courses. Some education institutions teach more than one framework, but this information is missing from others. Table 4 gives an overview of the taught frameworks.

The favorite modeling language is ArchiMate [39], followed by Business Model Canvas [33], which can be seen in Table 5. The information about the modeling language could only be collected from seven institutes, two of them covering more than one modeling language.

| Teaching language | Count |
|---|---|
| English | 11 |
| German | 8 |
| Dutch | 1 |
| French | 1 |
| Latvian | 1 |

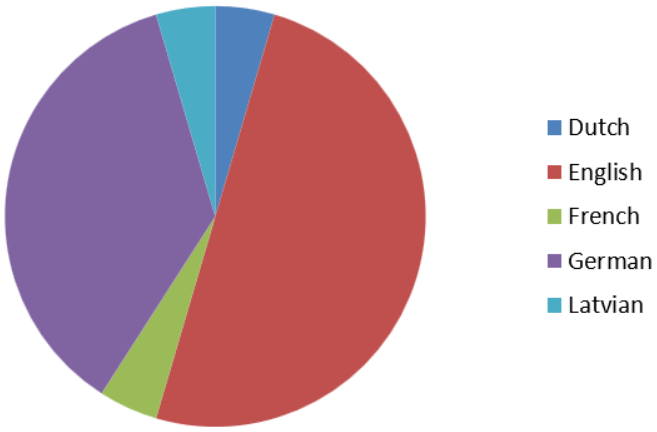


**Figure 7.** Teaching languages

**Table 4.** Taught frameworks

| Frameworks | Count |
|---|---|
| TOGAF [28] | 11 |
| Zachman [11] | 5 |
| ITIL [30] | 2 |
| St. Galler House of Digital Business [29] | 2 |
| Adaptive EA [31] | 1 |
| ARIS [32] | 1 |
| Business Model Canvas (BMC) [33] | 1 |
| e3Value [34] | 1 |
| EA3 "Cube" Framework [35] | 1 |
| EA6 [36] | 1 |
| IT4IT [37] | 1 |
| Requirement Engineering (RE) [38] | 1 |

**Table 5.** Taught modeling languages

| Modeling language | Count |
|---|---|
| ArchiMate [39] | 7 |
| Business Model Canvas (BMC) [33] | 2 |
| BPMN [40] | 1 |
| e3value [34] | 1 |
| UML [41] | 1 |
| 4EM [42] | 1 |

Considering the knowledge transfer applied by the compared universities yields a homogeneous picture. Most of the courses use a combination of lectures and exercises; also, the modules are composed of courses and exercises in small groups. All responses are summarized in Table 6.

The most used tool for the lecturers is Archi [43], an open-source tool. This is no surprise as Archi has become the world's most popular ArchiMate modeling tool and can be downloaded for free. Table 7 shows the used tools for the observed courses. The results show heterogeneity concerning the used tools. Some tools are open source (e.g., Archi [43] and Draw.io [44]), some are proprietary (e.g., ADOit [45]), and some are research prototypes that adopt ArchiMate (e.g., TEAM [46], [47]).

Table 8 summarizes the responses to the assessment of students' competencies. Many different assessment techniques were found and, naturally for these days, often also a combination of, e.g., a group (or individual) project work with a written exam or reports is employed. The assessment

techniques mentioned the most were group projects/assignments, presentations, and exams. The three named case studies are not explicitly assigned to a group or individual work.

**Table 6.** Type of knowledge transfer

| Content type | Count |
|---|---|
| Lecture + exercises | 11 |
| Lecture | 2 |
| Learning by doing collaborative work in small groups | 1 |
| Lecture, exercises in groups, presentation, discussion, documentation | 1 |
| Workshop | 1 |

**Table 7.** Used tools

| EAM tool | Count |
|---|---|
| Archi [43] | 9 |
| ADOit [45] | 1 |
| ArchiMate Templates [39] | 1 |
| Draw.io [44] | 1 |
| IBM requirements identification and management tools | 1 |
| Signavio [48] | 1 |
| TEAM [49] | 1 |

**Table 8.** Used assessments

| Assessments | Count |
|---|---|
| Group project/assignment | 11 |
| Presentations | 7 |
| Written exam | 7 |
| Research papers/reports | 5 |
| Case studies | 3 |
| Discussion | 2 |
| Individual report/assignment | 2 |
| Homework | 1 |
| Online quizzes | 1 |
| Oral exam | 1 |

The list of recommended literature is quite long. Therefore, only relevant books which were denoted more than once are listed in Table 9. For instance, the book “Enterprise Architecture at Work” by Marc Lankhorst [6] was mentioned four times. This is no surprise, as the book’s content is mainly about TOGAF and ArchiMate and explains the first steps and practical applications of TOGAF and ArchiMate. Inge Hanschke’s book “Strategic IT Management: A Toolkit for Enterprise Architecture Management” [50] was denoted three times; it gives an overview of IT systems management and, therefore, a broader view where EAM covers one chapter. It seems to be a good fit for courses with EAM only as a part of the content, as mentioned in Figure 5.

These presented classifications showed some commonalities and differences among the observed educational offers. In the following, we provide a refined view of the courses to elaborate on the possibility of sketching prototypical course education types for both technical and business/management-oriented studies.

**Table 9.** Recommended literature

| Literature | Count |
|---|---|
| Lankhorst, M. et al., Enterprise Architecture at Work - Modeling, Communication and Analysis. Springer, 2017 [6] | 4 |
| Hanschke, I.: Strategic IT Management: A Toolkit for Enterprise Architecture Management. Springer, 2009 [50] | 3 |
| TOGAF [28] | 2 |
| ArchiMate [39] | 2 |
| Feuerer, S.: Enterprise Architecture - An Overview. SAP Deutschland AG & Co. KG, 2007 [51] | 2 |

# 5 EAM Education Types for Business Informatics and Computer Science

In the preceding section, we classified all observed courses according to multiple criteria. In the following, we investigate whether or not typical elements for teaching EAM at Computer Science (CS) or Business Informatics (BI) students exist. For this investigation, we now only consider those courses of our comparative analysis that comprise a lecture and a practical part. This constraint is meaningful; otherwise, we would aim to converge offerings that are too different (e.g., entire EAM study programs and certification programs). The last section pointed out that 18 courses/modules are relevant for this purpose. These offerings are now separated into two categories as seen in Table 10: 13 courses considered for *Business Informatics (BI)* and seven for *Computer Science (CS)*. Two universities use the course in both study programs in both categories. This investigation aims to derive a prototypical EAM course that can be specialized to be conducted with CS or BI students alike. The following analysis is structured into organizational aspects (Section 5.1) and course content (Section 5.2).

## 5.1 Organizational Aspects

First, we classify the two groups concerning the intensity of the course regarding EAM. Table 10 shows a majority on both sides toward the handling of EAM as the main topic of the course, as already seen in the preceding section in Figure 10. The two courses used in both disciplines are IT Management courses and teach EA only in a fraction of the lectures. The majority (8 of 13) of the BI courses are held in their national language, and only five are in English. In contrast, four out of seven of the CS courses on EAM are taught in English (for three, English is the native language), and only the remaining two are in the national language. Using English as the instruction language obviously also allows international students to join classes. Moreover, most of the recommended literature is written in English. These results also map to the fact that most of the courses taken into account are conducted at the Master's level. As many universities are transitioning toward providing an English Master's program – while on the Bachelor level, most universities still mostly offer courses in the national language – one would expect this.

The assessments used for grading the students are similar but not equal: Interesting is the lack of exams (written or oral) in CS courses, whereas BI courses mainly use exams followed by presentations. Group projects or assignments, research papers, and case studies are often used for assessment in both disciplines. A detailed list of the used assignments can be found in Table 10. The borders of projects, case studies, and reports are blurred, and the information is not precise. The teaching format of many lectures is Distance Learning. However, whether this is due to the current Covid pandemic or the general way of operating the course is unclear.

So far, considering the organizational aspects, only subtle distinctions between Computer Science and Business Informatics oriented EAM offerings were observed. Next, we focus on the content dimension of the researched offerings.

**Table 10.** Comparative analysis of BI and CS oriented EAM courses

| Comparison criteria / Study program | BI | | CS | |
|---|---|---|---|---|
| | 13 | | 7 | |
| **EAM intensity** | | | | |
| Full-time | 7 | | 4 | |
| Part-time | 6 | | 3 | |
| **Course language** | | | | |
| English | 5 | | 5 | |
| National language | 8 | | 2 | |
| **Modeling language** | | | | |
| ArchiMate | 4 | | 1 | |
| BMC, e3value, ArchiMate | | | 1 | |
| UML, BPMN, ArchiMate | 1 | | 1 | |
| 4EM, ArchiMate, BMC | 1 | | | |
| **Used tools** | | | | |
| Archi | 3 | | 3 | |
| MDA, SOA.TOGAF, ADM | | | 1 | |
| TEAM, ADOit | 1 | | | |
| EAMTS | 1 | | 1 | |
| Draw.IO ArchiMate Templates. | 1 | | | |
| IBM management tools | 1 | | | |
| Signavio | 1 | | | |
| **Frameworks** | **Full-time** | **Part-time** | **Full-time** | **Part-time** |
| Adaptive EA | | | 1 | |
| ARIS | | 1 | | 1 |
| BMC | | | 1 | |
| e3Value | | | 1 | |
| IT4IT | | 1 | | 1 |
| ITIL | | 1 | | 2 |
| Requirement Engineering (RE) | | 1 | | |
| St. Galler House of Digital Business | 2 | | | |
| TOGAF | 5 | 2 | 3 | 2 |
| Zachman | 3 | 1 | 1 | 1 |
| **Assessments** | **Full-time** | **Part-time** | **Full-time** | **Part-time** |
| Case studies | 1 | 1 | 1 | 1 |
| Discussion | 1 | | | |
| Group project/assignment | 4 | 2 | 2 | 1 |
| Homework | | 1 | | |
| Individual report/assignment | 2 | | 1 | |
| Online quizzes | | | 1 | |
| Exam (oral or written) | 5 | 4 | | 1 |
| Presentations | 3 | 3 | 1 | 1 |
| Research papers/reports | 2 | 2 | 2 | 2 |

## 5.2 Course Content

We first analyze the taught frameworks (Table 10). Although the TOGAF and Zachman's frameworks are the most taught in both CS- and BI-oriented EAM courses, a closer look at the recorded items provides some additional insights. In the Business Informatics-oriented courses concentrating fully on EAM, only three different frameworks are taught: TOGAF, Zachman, and the St. Galler House of Digital Business. In the Computer Science courses with EAM as the main

topic, in three of four cases, a combination of two frameworks was denoted: TOGAF and Zachman, TOGAF and Adaptive EA, and e3value and BMC. In the part-time courses, interestingly, many similarities were found.

Contrary to the taught frameworks, only a few courses have published the taught modeling languages. But every one of these seven courses with an entry in this category has at least ArchiMate on the list. The languages UML, BPMN, and Business Model Canvas are called one time in every discipline. Analyzing the tools used during the course leads to a similar observation. Archi is most used in both disciplines; all the other tools are denoted only once.

Finding differences regarding the content between the two disciplines is tricky, as the details are all written in a textual form and therefore cannot be analyzed easily. The elements for comparison were taken only from courses entirely concentrating on the topic of EAM, not reflecting ones with a broader focus. Therefore only a small group of educational offerings were taken into account. We still aim to structure and converge the course descriptions to identify invariant content and specific content characteristic of an EAM course for BI and CS students, respectively. The information below is the result of analyzing and classifying the detailed course descriptions we found and received. The classification is thus based on and acknowledged by the professors teaching the individual EAM courses. We only harmonized and to some extent generalized the terms used in the individual course content descriptions to derive a consistent classification.

A summary of elements found in both disciplines' descriptions are classified into *Background*, *IT Strategy*, *EA frameworks*, *EA modeling*, and *Transfer* – see Table 11 for more details on the generic content identified.

**BI-oriented EAM Courses.** Particularly for Business Informatics oriented EAM courses, we identified the following characteristics in the course descriptions:

**Change Management:** Organizations are often forced into changes, e.g., by market changes, governmental rules, and technical reasons. How can these changes be handled concerning business processes, running IT systems, strategy, etc.?

**EA Value:** Value of EA when a particular organization wants to introduce new digital technology/transform from an information to a digital society.

**Socio-technical aspects:** Fundamental organization of a company as a socio-technical system. The mixture of human beings, IT systems, organizational hierarchies, and technical equipment has to be identified and managed through EA to run a successful business.

**Digitalization and Society:** Digitization of economy and society drives companies toward a transformation of their relationships with customers, partners, and employees. How can this transformation be handled with EA and what are the consequences?

**Outsourcing:** What are the consequences when IT is outsourced?

**CS-oriented EAM Courses.** Particularly for Computer Science oriented EAM courses, we identified the following characteristics in the course descriptions:

**EA Implementation:** What are the critical success factors for the implementation of common EA approaches. Who are the key players, what are the essential needs, and what are the biggest risks in successfully implementing an enterprise-wide IT project?

**Costs and Benefits:** How to get a realistic cost estimation, ROI calculation, and identify and name invaluable efforts for EAM implementation and maintenance?

**Comparative Assessment:** What are the opportunities and limitations of various EA frameworks, e.g., with respect to digital enterprise ecosystems [52]?

**IT Trends:** Implications of recent IT trends such as cloud computing, Artificial Intelligence [53], and ICT ecosystems [52]?

**Security:** Security as a key factor for protecting company, customer, and employee data.

**Technology Management:** How to handle technology changes, updates, maintenance aspects, migration, external devices, and services?

Another element found in some courses is the integration of guest lectures, preferably decision-makers in leading companies to present the realization of EAM in practice and to emphasize the importance of this topic. Some universities, but only a minority, cooperate with industry partners, allowing the students to work on exercises close to reality.

The final aspect is the definition of recommended literature. “Enterprise Architecture at Work” by Marc Lankhorst et al. [6] should be on the list, as it can be found four times in the descriptions of the educational offers. Furthermore, some literature regarding TOGAF and ArchiMate, if this framework and modeling language are chosen, should not be missed. In BI courses Inge Hanschke’s “Strategic IT Management” [50] is popular. Some lecturers prefer more business/economic-oriented books like Buchta et al. [54] or Bernhard et al. [55], [56]. Still, these seem to be available only in German. A good choice with more focus on the strategic aspect could be Ahlemann et al.’s ”Strategic Enterprise Architecture Management” [12].

Following the recommendations of the Austrian Bologna Follow-Up Group, the courses for both technical and business/management courses should get 6.0 ECTS credits, equivalent to approximately 150 hours of work/presence. Table 11 summarizes the course outline of a prototype EAM course. It shows the parts common to BI- and CS-oriented EAM courses and the individual characteristics that can be used to align a course to a particular discipline.

**Table 11.** A prototypical EAM course with specifics for BI and CS orientation

| Course Name | Enterprise Architecture Management | |
|---|---|---|
| Graduation | Master Business Informatics | Master Computer Science |
| Type | Course or Course and Seminar | |
| Credits | 6.0 ECTS | |
| Content type | Lecture and practical exercises | |
| Frameworks | TOGAF, Zachman, St. Galler House of Digital Business, Adaptive EA | |
| Modeling language(s) | ArchiMate, Business Model Canvas, e3value | |
| Tools | Archi, ADOit, Draw.io, Signavio, TEAM | |
| Literature | • Enterprise Architecture at Work - Modeling, Communication and Analysis [6]<br>• ArchiMate specification [39]<br>• Strategic IT Management: A toolkit for enterprise architecture management [50]<br>• Strategic Enterprise Architecture Management. Challenges, Best Practices and future development [12] | |
| Generic Content | **Background:** Introduction / Overview / Motivation EA / EAM<br>**IT Strategy:** IT Strategy / Strategic context / Strategy realization<br>**EA frameworks:** EA frameworks / EA artefacts<br>**EA modeling:** EA modeling languages / ArchiMate layers / EA tools<br>**Transfer:** Examples and exercises | |
| Specific content | • Change Management<br>• EA Value<br>• Socio-technical aspects<br>• Digitalization and Society<br>• Outsourcing | • EA Implementation<br>• Costs and Benefits<br>• Comparative Assessment<br>• IT Trends<br>• Security<br>• Technology Management |
| Guest Lectures | Industry speakers to get practical EAM insights and underline the importance. | |
| Assessments | • Group project (Case study)<br>• Presentation, Report<br>• Exam | |

# 6 Discussion

## 6.1 Results

The results of our research can be summarized as follows by responding to the research questions:

**RQ-1: What are the commonalities and differences in teaching EAM on an international scope?**

Our comparative international analysis did yield insights into how EAM is being taught on an international scale. The number of educational offerings was limited to free accessible information in English or German. There are many more universities with EAM in their studies programs, but they are unreadable without knowledge of the language. This article should also encourage lecturers and administrators to present their offerings with more details and a translation into English.

**RQ-2: Is EAM taught differently at Business Informatics and Computer Science study programs?**

We proposed and applied a generic assessment frame to compare the found course offering (see Table 10). Not all fields of our assessment sheet were filled in for all institutions and some are missing homogeneity. Frameworks, tools, and modeling languages seem to miss a shared preferences, but the answers also show the different aspects of teaching EAM.
Interestingly there is no significant disparity between courses for technical and business/management-specific studies. The main differences could be found in the depth of technical details which is higher for technical studies and social aspects which are more in focus for business/management-specific studies.

**RQ-3: Can a "Best-Practice-Course" be derived that represents the maximum of common aspects for both Business Informatics and Computer Science studies?**

The results indicate some consensus, e.g., with ArchiMate and TOGAF, while some universities follow an entirely different path. For this collection of facts, it was necessary only to take courses with a focus on EAM into account.
We were able to derive a prototype full-time EAM course that features generic content for both disciplines and offers specialization options for technical and business/management-oriented courses (summarized in Table 11).

## 6.2 Limitations

This comparative analysis of courses has several limitations, some of which are related to the individual research questions that have been discussed already; the generic ones will be addressed in the following. First, far more than 22 universities offer education on the topic of EAM. This study focused mainly on Higher Education Institutions, and, considering the courses we found and gained feedback from the educators, there is some focus on Central Europe. This is also aligned with the long history of solid European research on conceptual modeling and enterprise modeling. Notably, this study aims not to be comprehensive by surveying all EAM offerings at universities but rather to investigate the heterogeneity or convergence of EAM teaching on an international scale. We think we achieved this goal with nine countries from three continents included in the article. Nevertheless, future research should enlarge the sample to gain further insights.

Another limitation of our work is based on the fact, that we focused on entire EAM courses. Admitting that many courses have one or several lectures talking about EAM, we still need to

state, that our focus was on entire courses focusing/centering on EAM. It is often not possible as an outsider to narrow down the extent to which EA plays a role in a non-EA-specific course. Consequently, we followed search process that clearly focused on core EA courses and made additional efforts to get confirmation of the information we found on the course websites. Also for this limitation, we see the opportunity for future research to extend the search scope and also investigate e.g., in which other (most likely more general conceptual or enterprise modeling) courses EAM is being taught and how.

## 7 Conclusion

Enterprise Architecture Management is of increasing importance for successful companies. The need to synchronize the current state of business and IT and align changes and future requirements leads to high demand for specialists mastering the needed tasks for successful transformations. Many universities all over the world thus offer education in different flavors to cover these needs.

In this comparative international analysis, 22 courses, modules, certificates, and Master's studies were analyzed to identify commonalities and differences when considering how EAM is taught by the Computer Science and Business Informatics disciplines. The analyzed educational offers range from a highly concentrated view on EAM to small parts, sometimes only one or two lectures within a more general course, e.g., IT Management. We also identified a diversity of frameworks, methods, and tools used in these courses. The yielded insights were converged into a prototype EAM course that can be customized for Computer Science or Business Informatics study programs.

We believe this comparative analysis shows the international state of education on Enterprise Architecture Management. The prototype EAM course's potential for alignment to the CS and BI disciplines provides value for all EAM educators and study program designers.

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## References

[1] R. Jung and C. Lehrer, "Guidelines for education in business and information systems engineering at tertiary institutions," *Bus. Inf. Syst. Eng.*, vol. 59, no. 3, pp. 189–203, 2017. [Online]. Available: https://doi.org/10.1007/s12599-017-0473-5

[2] H. Österle, J. Becker, U. Frank, T. Hess, D. Karagiannis, H. Krcmar, P. Loos, P. Mertens, A. Oberweis, and E. J. Sinz, "Memorandum on design-oriented information systems research," *Eur. J. Inf. Syst.*, vol. 20, no. 1, pp. 7–10, 2011. [Online]. Available: https://doi.org/10.1057/ejis.2010.55

[3] R. Abraham, "Enterprise architecture artifacts as boundary objects – a framework of properties," in *Proceedings of the 21st European Conference on Information Systems (ECIS 2013)*, ser. ECIS: European Conference on Information Systems. Association for Information Systems, 2013. [Online]. Available: https://www.alexandria.unisg.ch/223501/

[4] S. Kotusev, *The Practice of Enterprise Architecture: A Modern Approach to Business and IT Alignment*. Svyatoslav Kotusev, 2018. [Online]. Available: https://books.google.at/books?id=7yBvtgEACAAJ

[5] J. L. G. Dietz and J. A. P. Hoogervorst, "Enterprise ontology in enterprise engineering," in *Proceedings of the 2008 ACM Symposium on Applied Computing (SAC), Fortaleza, Ceara, Brazil, March 16-20, 2008*. ACM, 2008, pp. 572–579. [Online]. Available: https://doi.org/10.1145/1363686.1363824

[6] M. Lankhorst, S. Hoppenbrouwers, H. Jonkers, E. Proper, L. van der Torre, F. Arbab, S. de Boer, M. M. Bonsangue, M. E. Iacob, A. W. Stam, L. Groenewegen, R. van Buuren, R. J. Slagter, J. Campschroer, M. Steen, S. F. Bekius, H. Bosma, M. J. Cuvelier, H. ter Doest, P. van Eck, P. Fennema, J. Jacob, W. Janssen, D. Krukkert, D. van Leeuwen, P. Penders, G. E. van Veldhuijzen Zanten, and R. J. Wieringa, *Enterprise Architecture at Work*. Springer, Berlin, Heidelberg, 2017. [Online]. Available: https://doi.org/10.1007/978-3-662-53933-0

[7] D. Greefhorst and E. Proper, *The Role of Enterprise Architecture*, ser. Architecture Principles. The Enterprise Engineering Series. Springer, Berlin, Heidelberg, 2011, vol. 4. [Online]. Available: https://doi.org/10.1007/978-3-642-20279-7_2

[8] S. Herden and U. Zenner, "Klassifikation von enterprise-architecture-frameworks: Eine literaturanalyse," *TechnicalReport_007-2011 (Internet)*, no. 007-2011, 2011.

[9] S. Aier, C. Riege, and R. Winter, "Unternehmensarchitektur – literaturüberblick und stand der praxis," *WIRTSCHAFTSINFORMATIK*, vol. 50, no. 4, pp. 292–304, 2008 (in German). [Online]. Available: https://doi.org/10.1365/s11576-008-0062-9

[10] D. Simon, K. Fischbach, and D. Schoder, "An exploration of enterprise architecture research," *Communications of the Association for Information Systems*, vol. 32, 2013. [Online]. Available: https://doi.org/10.17705/1CAIS.03201

[11] J. A. Zachman, "A framework for information systems architecture," *IBM Systems Journal*, vol. 26, no. 3, pp. 276–292, 1987. [Online]. Available: https://doi.org/10.1147/sj.263.0276

[12] F. Ahlemann, E. Stettiner, M. Messerschmidt, and C. Legner, *Strategic Enterprise Architecture Management*. Springer, Berlin, Heidelberg, 2012. [Online]. Available: https://doi.org/10.1007/978-3-642-24223-6

[13] T. K. Hazra and B. Unhelkar, *Enterprise Architecture for Digital Business: Integrated Transformation Strategies*. CRC Press, 2020. [Online]. Available: https://doi.org/10.1201/9781315120409

[14] L. A. Kappelman, T. McGinnis, A. Pettite, and A. Sidorova, "Enterprise architecture: Charting the territory for academic research," in *Proc. AMCIS*, 2008, p. 162. [Online]. Available: http://aisel.aisnet.org/amcis2008/162

[15] R. Schmidt, M. Möhring, R.-C. Härting, C. Reichstein, A. Zimmermann, and S. Luceri, "Benefits of enterprise architecture management – insights from european experts," in *The Practice of Enterprise Modeling*, J. Ralyté, S. España, and Ó. Pastor, Eds. Cham: Springer International Publishing, 2015, pp. 223–236. [Online]. Available: https://doi.org/10.1007/978-3-319-25897-3_15

[16] N. Syynimaa, "Enterprise architecture adoption method for higher education institutions," Ph.D. dissertation, University of Reading, 2015.

[17] S. Alamri, M. Abdullah, and A. Albar, "Enterprise architecture adoption for higher education institutions," *International Journal of Simulation: Systems, Science and Technology*, vol. 19, no. 5, pp. 16.1–16.8, 2018. [Online]. Available: https://doi.org/10.5013/IJSSST.a.19.05.16

[18] D. H. Olsen and K. Trelsgård, "Enterprise architecture adoption challenges: An exploratory case study of the norwegian higher education sector," *Procedia Computer Science*, vol. 100, pp. 804–811, 2016. [Online]. Available: https://doi.org/10.1016/j.procs.2016.09.228

[19] S. Araya-Guzmán, L. Cares-Monsalves, P. Ramírez-Correa, E. E. Grandón, and J. Alfaro-Perez, "Enterprise architecture proposal for undergraduate teaching in higher education institutions," *Journal of Information Systems Engineering and Management*, vol. 3, no. 3, article 21, 2018. [Online]. Available: https://doi.org/10.20897/jisem/2657

[20] G. Stewart, “Reflections on teaching enterprise architecture to graduate students,” in *AMCIS*, 2006.

[21] A. Wegmann, G. Regev, J. D. de la Cruz, L.-S. Lê, and I. Rychkova, “Teaching enterprise and service-oriented architecture in practice,” *Journal of Enterprise Architecture*, vol. 4, no. 3, pp. 15–24, 2007. [Online]. Available: http://infoscience.epfl.ch/record/112180

[22] G. Regev, L. Regev, Y. Naïm, J. Lang, and A. Wegmann, “Teaching an ethnographic approach to requirements elicitation in an enterprise architecture course,” in *Proceedings of the 1st International Workshop on Socio-Technical Perspective in IS Development (STPIS’15)*, vol. 1374. CEUR Workshop Proceedings, 2015, pp. 5–19. [Online]. Available: http://ceur-ws.org/Vol-1374/paper1.pdf

[23] S. Buckl, A. M. Ernst, F. Matthes, and C. M. Schweda, “Teaching enterprise architecture management with student mini-projects,” in *Software Engineering*, 2010. [Online]. Available: https://doi.org/10.1109/EDOC.2009.30

[24] V. Seppänen, M. Pulkkinen, T. Taipalus, and J. Nurmi, “Information systems students’ impressions on learning modeling enterprise architectures,” in *2020 IEEE Frontiers in Education Conference (FIE)*, 2020, pp. 1–8. [Online]. Available: https://doi.org/10.1109/FIE44824.2020.9273899

[25] D. Kudryavtsev, E. Zaramenskikh, and M. Arzumanyan, “The simplified enterprise architecture management methodology for teaching purposes,” in *Enterprise and Organizational Modeling and Simulation*, R. Pergl, E. Babkin, R. Lock, P. Malyzhenkov, and V. Merunka, Eds. Cham: Springer International Publishing, 2018, pp. 76–90. [Online]. Available: https://doi.org/10.1007/978-3-030-00787-4_6

[26] W. Bandara, D. R. Chand, A. M. Chircu, S. Hintringer, D. Karagiannis, J. Recker, A. van Rensburg, C. Usoff, and R. J. Welke, “Business process management education in academia: Status, challenges, and recommendations,” *Commun. Assoc. Inf. Syst.*, vol. 27, p. 41, 2010. [Online]. Available: https://doi.org/10.17705/1CAIS.02741

[27] L. T. W. Agner and T. C. Lethbridge, “A survey of tool use in modeling education,” *2017 ACM/IEEE 20th International Conference on Model Driven Engineering Languages and Systems (MODELS)*, pp. 303–311, 2017. [Online]. Available: https://doi.org/10.1109/MODELS.2017.1

[28] The Open Group, “The Open Group Architecture Framework (TOGAF),” https://www.opengroup.org/togaf/, 2021.

[29] Universität St. Gallen, “St. Galler House of Digital Business,” https://iwi.unisg.ch/forschung/#header, 2022.

[30] Axelos, “ITIL (formerly IT Infrastructure Library),” https://www.axelos.com/certifications/itil-service-management, 2022.

[31] J. J. Korhonen, J. Lapalme, D. McDavid, and A. Q. Gill, “Adaptive enterprise architecture for the future: Towards a reconceptualization of EA,” in *18th IEEE Conference on Business Informatics, CBI 2016, 29th August - 1st September 2016, Paris, France, Volume 1 - Conference Papers*, E. Kornyshova, G. Poels, C. Huemer, I. Wattiau, F. Matthes, and J. L. C. Sanz, Eds. IEEE, 2016, pp. 272–281. [Online]. Available: https://doi.org/10.1109/CBI.2016.38

[32] tadvisor, “ARIS IT Architect,” https://tadviser.com/index.php/Product:ARIS_IT_Architect, 2022.

[33] Strategyzer, “Business Model Canvas (BMC),” http://www.businessmodelgeneration.com/, 2022.

[34] Jaap Gordijn and Hans Akkermans, “e3value,” https://research.e3value.com/, 2022.

[35] Scott Bernard, “ea3 Cube,” https://internationaleainstitute.org/ea-approaches/ea-cube-framework/, 2022.

[36] S. Bernard, *An Introduction to Enterprise Architecture: Third Edition*. AuthorHouse, 2012. [Online]. Available: https://books.google.at/books?id=OkNMFI3_L_YC

[37] The Open Group, “IT4IT,” https://www.opengroup.org/it4it, 2022.

[38] K. Pohl, *Requirements engineering: fundamentals, principles, and techniques*. Springer, 2010.

[39] The Open Group, “ArchiMate,” http://www.opengroup.org/subjectareas/enterprise/archimate, 2021.

[40] Object Management Group, “Business Process Model and Notation,” https://www.bpmn.org/, 2022.

[41] UML, “Unified Modeling Language,” https://www.uml.org/, 2022.

[42] Universität Rostock, “For Enterprise Modelling Method (4EM),” https://www.wirtschaftsinformatik.uni-rostock.de/forschung/4em/home/die-methode/, 2022.

[43] The Open Group, “Archi,” https://www.archimatetool.com/, 2021.

[44] Draw.io, “draw.io diagrams,” https://www.draw.io/, 2022.

[45] BOC Group, “ADOIT Enterprise Architecture Suite,” https://www.boc-group.com/en/adoit/, 2022.

[46] D. Bork, A. Gerber, E.-T. Miron, P. van Deventer, A. van der Merwe, D. Karagiannis, S. Eybers, and A. Sumereder, “Requirements engineering for model-based enterprise architecture management with archimate,” in *Enterprise and Organizational Modeling and Simulation*, ser. Lecture Notes in Business Information Processing, R. Pergl, E. Babkin, R. Lock, P. Malyzhenkov, and V. Merunka, Eds. Springer, 2018, vol. 332, pp. 16–30. [Online]. Available: https://doi.org/10.1007/978-3-030-00787-4_2

[47] S. Eybers, A. Gerber, D. Bork, and D. Karagiannis, “Matching technology with enterprise architecture and enterprise architecture management tasks using task technology fit,” in *Enterprise, Business-Process and Information Systems Modeling - 20th International Conference, BPMDS 2019, 24th International Conference, EMMSAD 2019, Held at CAiSE 2019, Rome, Italy, June 3-4, 2019, Proceedings*, ser. Lecture Notes in Business Information Processing, I. Reinhartz-Berger, J. Zdravkovic, J. Gulden, and R. Schmidt, Eds., vol. 352. Springer, 2019, pp. 245–260. [Online]. Available: https://doi.org/10.1007/978-3-030-20618-5_17

[48] SAP Signavio, “SAP Signavio,” https://www.signavio.com/, 2022.

[49] OMILAB, “TEAM,” https://austria.omilab.org/psm/content/team/info?view=home, 2022.

[50] I. Hanschke, *Strategic IT management: A toolkit for enterprise architecture management*. Heidelberg: Springer, 2010. [Online]. Available: https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=511729

[51] S. Feurer, “Enterprise architecture – an overview,” Ph.D. dissertation, University of Applied Sciences, Karlsruhe / Germany, 2007. [Online]. Available: https://archive.sap.com/kmuuid2/90a744a3-55d9-2910-96b9-8a1513fefb1f/Enterprise%20Architecture%20-%20An%20Overview.pdf

[52] B. Pittl and D. Bork, “Modeling digital enterprise ecosystems with archimate: A mobility provision case study,” in *Serviceology for Services - 5th International Conference, ICServ 2017*, ser. Lecture Notes in Computer Science, Y. Hara and D. Karagiannis, Eds., vol. 10371. Springer, 2017, pp. 178–189. [Online]. Available: https://doi.org/10.1007/978-3-319-61240-9_17

[53] M. Smajevic, S. Hacks, and D. Bork, “Using knowledge graphs to detect enterprise architecture smells,” in *The Practice of Enterprise Modeling - 14th IFIP WG 8.1 Working Conference, PoEM 2021*, ser. Lecture Notes in Business Information Processing, E. Serral, J. Stirna, J. Ralyté, and J. Grabis, Eds., vol. 432. Springer, 2021, pp. 48–63. [Online]. Available: https://doi.org/10.1007/978-3-030-91279-6_4

[54] D. Buchta, *Strategisches IT-Management: Wert Steigern, Leistung Steuern, Kosten Senken*. Wiesbaden: Springer Gabler. in Springer Fachmedien Wiesbaden GmbH, 2004 (in German). [Online]. Available: https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=6299154

[55] M. G. Bernhard, *Strategisches IT-Management 1: Organisation, Prozesse, Referenzmodelle*, 1st ed., ser. Strategisches IT-Management. Düsseldorf: Symposion Publishing GmbH, 2003 (in German), vol. Bd. 1.

[56] M. G. Bernhard, *Strategisches IT-Management 2: Fallbeispiele und praktische Umsetzung*, 1st ed., ser. Strategisches IT-Management. Düsseldorf: Symposion Publishing GmbH, 2003 (in German), vol. Bd. 2.

# Appendix 1. List of Researched EAM Offerings

| Country | Academic Institute | Lecture name | Type | ECTS | CS | BI |
|---|---|---|---|---|---|---|
| AU | University of South Australia ”Australia - University of South Australia” [Online]. Available: https://study.unisa.edu.au/courses/101249 | Enterprise Architecture | course | 7.5 | x | |
| AU | University of Technology, Sydney ”Australia - University of Technology, Sydney” [Online]. Available: https://handbook.uts.edu.au/subjects/32570.html | Enterprise Architecture Practice | course | 7.5 | x | |
| AT | Johann-Kepler University, Linz ”Austria - Johann-Kepler University Linz” [Online]. Available: https://studienhandbuch.jku.at/134568 | Strategic IT-Planning | course | 6.0 | | x |
| AT | Technical University of Vienna ”Austria - Technical University of Vienna” [Online]. Available: https://tiss.tuwien.ac.at/course/educationDetails.xhtml?dswid=8602&dsrid=294&courseNr=194043&semester=2020W&locale=en | Enterprise Architecture | course | 3.0 | | x |
| AT | University of Klagenfurt ”Austria - University of Klagenfurt” [Online]. Available: https://campus.aau.at/studium/course/101576 | IT-Management | course | 4.0 | x | |
| AT | University of Vienna ”Austria - University of Vienna” [Online]. Available: https://ufind.univie.ac.at/de/course.html?lv=051261&semester=2021S | Enterprise Architecture: Design, Integration, Implementation | course | 3.0 | | x |
| BE | University of Antwerp ”Belgium - University of Antwerp” [Online]. Available: https://www.antwerpmanagementschool.be/en/program/executive-master-enterprise-it-architecture/program | Executive Master in Enterprise IT Architecture | study | 60.0 | | x |
| BE | University of Namur ”Belgium - University of Namur” [Online]. Available: https://directory.unamur.be/teaching/courses/INFOM422/2020 | Business Modeling and E-Business | course | 5.0 | x | |
| DE | Friedrich-Alexander-University Erlangen-Nürnberg ”Germany - Friedrich-Alexander-University Erlangen-Nürnberg” [Online]. Available: https://www.it-management.rw.fau.de/lehre/master/fundamentals-of-enterprise-wide-it-\protect\@normalcr\relaxarchitecture-management | Managing enterprise-wide IT architectures (MEITA) | module | 5.0 | | x |
| DE | UniBW Universität der Bundeswehr, Munich ”Germany - UniBW Universität der Bundeswehr, Munich” [Online]. Available: https://www.unibw.de/ia/lehre/enterprise-architecture-and-it-service-management/enterprise-architecture-it-service-management | Enterprise Architecture und IT Service Management | course | 6.0 | x | x |
| DE | University of Applied Sciences Erfurt ”Germany - University of Applied Sciences Erfurt” [Online]. Available: https://www.ai.fh-erfurt.de/studium/master-angewandte-informatik/studienplaene-spo | IT-Strategy and Architecture (ITSA) | course | 5.0 | | x |
| DE | University of Potsdam ”Germany - University of Potsdam” [Online]. Available: https://puls.uni-potsdam.de/qisserver/rds?state=verpublish&publishContainer=vvzpdfindexstgdoc&stgkz=WDT | Architectures of Enterprise Application Systems, Fallstudien betrieblicher Anwendungssysteme | module | 9.0 | | x |

| Country | Academic Institute | Lecture name | Type | ECTS | CS | BI |
|---|---|---|---|---|---|---|
| DE | University of Technologies, Munich ”Germany - University of Technologies, Munich” [Online]. Available: https: //wwwmatthes.in.tum.de/pages/1vmk5slozr2xl/ Strategic-IT-Management-Enterprise-Architecture/ Management-Strategisches-IT-Management-EAM | Strategic IT Management & Enterprise Architecture Management; EAM Miniprojekte | module | 8.0 | x | x |
| IT | University of Bolzano ”Italy - University of Bolzano” [Online]. Available: https://www.unibz.it/faculties/computer-science/ master-computational-data-science/ courses-offered/?academicYear=2018 | Enterprise Architecture | course | 6.0 | | x |
| LV | Riga Technical University ”Latvia - Riga Technical University” [Online]. Available: https://stud.rtu.lv/rtu/discpub/oe.28097 | Enterprise Architecture and Requirements Engineering | course | 6.0 | | x |
| NL | Open University of the Netherlands ”Netherlands - Open University of the Netherlands” [Online]. Available: https://www.ou.nl/en/-/enterprise-architecture | Enterprise Architecture | course | 7.5 | | x |
| CH | FHB Bern University of Applied Sciences ”Switzerland - FHB Bern University of Applied Sciences” [Online]. Available: https://www.bfh.ch/dam/jcr: 90ec26ad-e937-4849-b1a5-57050622fc11/ Factsheet_CAS_Enterprise_Architecture_ Management.pdf | CAS Enterprise Architecture Management | certif. | 12.0 | x | |
| CH | University St. Gallen ”Switzerland - University St. Gallen” [Online]. Available: https://tools.unisg.ch/handlers/Public/ CourseInformationSheet.ashx/semester/HS21/ eventnumber/7,002,1.00.pdf | Business Innovation II: Unternehmen gestalten und digital transformieren | course | 4.0 | | x |
| CH | ZHAW Zürich ”Switzerland - ZHAW Zürich” [Online]. Available: https://modulmanagement.sml.zhaw.ch/ StaticModDescAblage/Modulbeschreibung_w. MA.XX.EPA.20HS.pdf | Modul Enterprise Architectures | course | 3.0 | | x |
| US | Carnegie Mellon University ”USA - Carnegie Mellon University” [Online]. Available: https://execed.isri.cmu.edu/elearning/ programs/enterprise-architecture/index.html | Enterprise Architecture and Organizational Design | certif. | 28.8 | | x |
| US | Penn State University, Pennsylvania ”USA - Penn State University, Pennsylvania” [Online]. Available: https: //bulletins.psu.edu/graduate/programs/majors/ enterprise-architecture-business-transformation/ #text | Enterprise Architecture and Business Transformation | study | n/a | | x |
| US | University of Denver ”USA - University of Denver” [Online]. Available: https: //universitycollege.du.edu/courses/coursesdetail. cfm?degreecode=ict&coursenum=4010 | Enterprise Architecture | course | 5.0 | x | |