



# Academic Education in Enterprise Architecture Management

Review about the offerings regarding the topic  
Enterprise Architecture Management (EAM) on  
selected international universities.

BACHELOR'S THESIS

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by

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Wien, 30. November 2021

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Martin Robl



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# Abstract

Enterprise architecture, although more than 30 years old, receives more importance with the increasing dependency of business in IT and the growing complexity of IT systems. The description of a company's goals, structures and processes with respect to the business and IT elements, as well as the illustration of impacts triggered by planned changes is educated in many ways on more than a handful universities all over the world. There are several techniques, methods, tools and approaches to transport the knowledge to the students for giving them the qualification to support their future employers in handling the challenges modern companies are facing. This work gives a detailed description of more than twenty educational offers regarding Enterprise Architecture, carves out the commonalities and finds two prototypical courses as a best-practice combining the strongest matches for business/management and technical studies.

Keywords: enterprise architecture, enterprise architecture management, education, scholarship, course offerings, educational offers



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# Introduction

The growing importance of Information Technology (IT) to help companies reach their business goals provides universities all over the world for offering educations 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 wonder that the emphasis of the providing institutes and affected studies is the area of Business Informatics.

The target of this thesis is to present an overview of educational offerings regarding "Enterprise Architecture (EA)" or "Enterprise Architecture Management (EAM)", which is the name of the more IT-specific view of this topic. The work is structured as follows: At first a brief explanation of the concept EAM is given, followed by a detailed presentation of about two dozens of universities, offering educations on this manner. Afterwards the similarities and commonalities are worked out for finding a "Prototypical Education" but also showing the biggest differences between technical and business/management oriented educational offers regarding this topic. A final conclusion can be found at the end of this document.

## 1.1 A short explanation of EA

Enterprises are more and more forced to transform. The reasons for these necessary changes range from business over IT driven causes to external triggers such as changes in governmental rules and customer or competitors' behaviors [Abraham, 2013]. Although this transformation process is critical, there are high failure rates reported in literature [Kotusev, 2018]. One of the main reasons for the collapse of these projects seems to be a lack of coordination and communication between stakeholders [Dietz and Hoogervorst, 2008, "Enterprise ontology in enterprise engineering" cited in [Abraham, 2013]]. EA is an approach to align corporate strategy, business and IT with a holistic view to their domains – organizational structures, business processes, IT-systems – and gives an individual

detailed view on 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 the sight of IT. It must describe and control the strategy, structure, business processes, applications, systems and technology of an organization as an image of the current situation and give possibilities to deal with changes and modifications of both business and IT [Lankhorst et al., 2017].

There are more than a handful of frameworks available reflecting proven best practices [Kotusev, 2018][Herden and Zenner, 2011]. They represent different schools or 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 common communication base for every one of them. There are also description languages needed for modelling the different domains or viewpoints in a framework. They are also needed for linking the used tools and supporting the analysis across domain borders. [Lankhorst et al., 2017]

Literature locates the origin of EA in the 1970's and 1980's at frameworks as outcome of academic research projects [Aier et al., 2008]. These studies are nowadays no longer relevant but were the base for following works, especially the article of John Zachman, published in 1987 [Zachman, 1987], and his seminal work, the Zachman framework [Simon et al., 2013]. From that time on EAM has evolved from an engineering and IT management tool to a strategic one as seen in Figure 1.1 parallel to the importance of IT. Since then, a lot of well-known frameworks and different approaches were developed and published with various success. The most important and successful by means of acceptance are The Open Group Enterprise Architecture Framework (TOGAF), Federal Enterprise Architecture Framework (FEAF), and Department of Defense Architecture Framework (DoDAF) [Herden and Zenner, 2011]. For a practical realization of the chosen framework, specialized modeling languages are needed. ArchiMate, UML, BPMN and ARIS are the most important representatives of this group of languages [Kotusev, 2018].

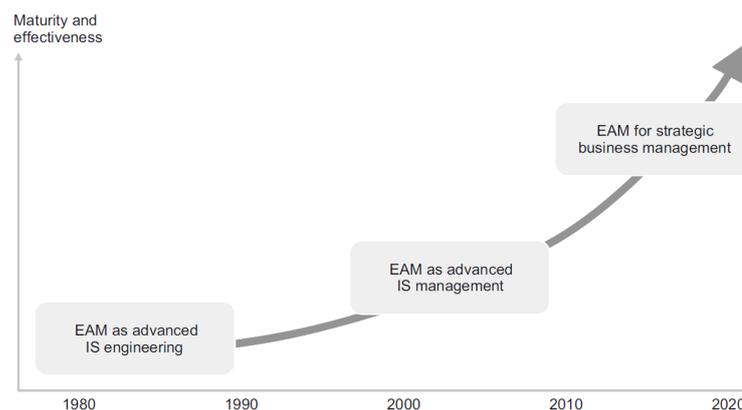


Figure 1.1: EAM development phases [Ahlemann et al., 2012]

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 [Kotusev, 2018]. New technologies like Big Data, Artificial Intelligence (AI), Internet of Things (IoT), Machine Learning, Cloud Computing, Global Positioning System (GPS), 5G, Blockchain, to only name a few, cannot be ignored. The process of Digital Transformation (DT) forces companies into investments and strategic considerations, including the significance of subsequent needs like risk, security and change management [Hazra and Unhelkar, 2020].

The need of highly educated specialists is - parallel to the increasing investments in IT systems - still growing. According to this demand, universities offer a broad range of education all over the world. Students can choose from one-unit slots as part of a Bachelor's education to Master studies giving the title "Master of Enterprise Architecture". A lot of courses, modules, studies and certifications teach EAM from basics to profound depths, different EA frameworks, EA modelling languages as well as tools in various amounts of effort and time. The institutes responsible for these educational offerings address their audience in a broad range from Informatics over Business Informatics to Management Sciences.



## Methodology

To support future IT managers in handling these transformation processes, many universities all over the world offer a wide range of education in this topic. There are classes with only one or a few units about EA, eg. as part of an IT-Management or IT-strategy course, full courses, modules containing of lecture and practical exercise or even complete Master studies and certificates. The idea of this paper was to find international universities offering education in EAM, collecting accessible details on their sites, as well as to find commonalities and differences. A main concern was the amount of credits or ECTS, the taught frameworks and modelling languages, the used tools, the recommended literature and if the education was supported by practical work. The goal was to find an amount of at least 20 universities to get a representative overview, with 29 universities this target could be reached by far. Although some of these educations had to be discarded from the list, caused by a lack of information details, the remaining amount of 22 universities fulfilled the requirements. The focal point was located at the German speaking area of Europe (Austria, Germany, Switzerland) with approximately half of the universities, the other half distributed all over the world. The goal was not to justice over quality, which is of course not possible without personally joining the course or study.

Starting point has been a full research on internet publications containing the title "enterprise architecture". The authors of these matching studies lead to their universities, serving as the next entry point for a scan. The reference list in the found publications was another path for a search. Specific books (e.g. [Kotusev, 2018], [Lankhorst et al., 2017]) lead by their reference lists to other books, authors and universities. And finally the publication list of the author's advisor Dominik Bork was a great source for lecturers and institutes.

### 2.1 Assessment frame

For collecting the desired information, an assessment frame was developed, prefilled with education descriptions and syllabus found at the universities' websites. After that the responsible person was contacted via email with a request for fill in on missing values and returns. The assessment frame with a short description of the fields can be found in Table 2.1.

29 mails sent resulted in 11 answers, some of them with the information that the course was terminated some years ago caused by a combination of decreasing interest among students and changed research focus among the teachers or simply a personal change.

As an additional response Erik Proper named the author further universities he was also involved. In addition to the University of Antwerp, the University of Namur was added to the author's list, while the other two universities did not match the requirements.

After one month, a friendly reminder was sent to the remaining universities. Meanwhile the search platform "studis-online.de" was used to find some other universities located in Germany offering Business Informatics studies. Websites and syllabus of the results were combed through to find courses or modules that could match the criteria and be added to the list. Three more universities could be found and were contacted but unfortunately achieved no response.

Afterwards the list of educations was reduced by the ones with lack of information. Either the university's website did not offer enough details and/or the request for additional data was not responded by the lecturers or responsible people. The detached entries had no or only rudimentary detailed descriptions and no data about taught frameworks, modelling languages or tools. As these are the main areas for comparison, the named courses were removed. As mentioned before, three entries were removed due to the assured knowledge of cancelled courses.

The next step was to find commonalities on the observed items. The attributes were separated in two groups regarding organizational or content specific aspects. After the classification on all observed items, a smaller list was created, containing only courses and modules (with a summary of their including elements, in all cases a lecture and a practical seminar). These items built the basis on finding prototypical courses for technical and business/management-oriented educations. For some findings it was necessary to only choose courses, that only cover EA, whereas other facts were taken also from courses with a broader teaching content.

Table 2.1: Assessment frame with short explanation of the fields

<b>Field name</b>	<b>description</b>
University	Name of the University
Institute	Name of the institute/faculty
Name	Name of the course/module/study
Graduation	Study where the course/module/study is part of
Type	Type of the lecture (e.g. course/module/study)
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 Frameworks	Which frameworks are taught
Modelling language(s)	Which EA modelling 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	Please give me some details of the course/module/study, feel free to expand the field, the more, the better
Cooperations /w Companies	Do you have cooperations with companies regarding the course/module/study?
Guest Lectures	Are there lectures of other persons than the responsible ones?
Assessments	What kind of assessments (e.g. oral/written exam, project, practical exercises in team, presentations)



## The Education Details

As mentioned earlier, a lot of universities all over the world present educational offers regarding the topic EA or EAM. It would go beyond the scope of this paper to handle all of them. Starting with universities in Austria, more than two dozens on three continents were taken into account, to receive a representative cross section and find commonalities, but also take care of the differences between them.

In this chapter the universities will be presented in alphabetical order by the name of the country, following by the name of the university.

### 3.1 Australia - University of South Australia<sup>1</sup>

The University of South Australia (UniSA) offers a course entitled "Enterprise Architecture" as part of the study "Master of Information Technology (Enterprise Management)". Credits are 4.5 unit values, which equates 7.5 ECTS<sup>2</sup>, lecturer is Jing Gao. The teaching method is a workshop with 2 hours by 13 weeks lecture and practice. Course aim is to critically compare and evaluate the main methodologies for the development of modern enterprise architectures in alignment with business context and priorities.

The following details were taken from the University's website<sup>1</sup>.

Course content:

- Enterprise architectures (EA) : Overview;
- Strategic alignment for innovative use of information technology;

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<sup>1</sup><https://study.unisa.edu.au/courses/101249> accessed at: 24.08.2021

<sup>2</sup>credit conversion for UniSA: <https://www.unisa.edu.au/global-experiences/study-overseas/student-exchange/credit-equivalencies/#Austria>

- EA and high-level design;
- Systems functional and non-functional requirements;
- EA frameworks, including Zachman's framework and TOGAF. Evaluation of alternative EA approaches;
- Critical success factors for implementation of common EA approaches;
- Planning for architectural change management;
- Architecture Governance;
- Documentation of an EA in standard formats;
- Views, viewpoints and stakeholders;
- Modelling approaches: MDA and SOA.TOGAF and the ADM.

Assessments are a group assignment, a case study and a research paper.

### 3.2 Australia - University of Technology, Sydney<sup>3</sup>

At the University of Technology, Sydney (UTS), students can take a course entitled "Enterprise Architecture Practice" worth 6 credit points, equating 7.5 ECTS<sup>4</sup>, held by Asif Gill as part of the study "Master of IT". The course has approximately 70 students and acts as learning by doing collaborative work in small groups.

The following details were taken from the University's website<sup>3</sup>.

The lecturer as well as six guest lectures per course give a deep insight into practice work covering the topics: Architecture Frameworks, Architecture Modelling, Architecture Vision, Business Architecture, Information Architecture, Social Architecture, Application Architecture, Platform Architecture, Infrastructure Architecture, Facility Architecture, Opportunities and Solutions, Implementation Planning and Governance, and Change Management. This course introduces students to the fundamentals of enterprise architecture for architecting software-intensive systems at a large enterprise scale and explores current trends and challenges in the practice of enterprise architecture. In small teams, students apply contemporary enterprise architecture practices to their architecture project work. They also learn to integrate and align different enterprise architecture layers to better support the business goals and objectives.

Upon successful completion of this course, students should be able to:

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<sup>3</sup><https://handbook.uts.edu.au/subjects/32570.html> accessed at: 24.08.2021

<sup>4</sup>credit conversion for TU Sydney: <https://www.uts.edu.au/study/international/study-abroad-and-exchange-students/study-abroad-or-exchange/subjects-and-academic-information>

- Describe enterprise architecture and its application to technical and business problems
- Describe the contribution of enterprise architecture and its alignment to organizational goals
- Apply enterprise architecture analysis practices to identify the current, transition and future states of the architecture
- Describe the enterprise architecture project stakeholders, concerns and constraints for the effective enterprise architecture discovery, implementation and governance
- Develop enterprise architecture and plan its implementation

Covered are in detail the frameworks TOGAF/Adaptive EA, ArchiMate as EA modelling language and the tool Archi.

Recommended literature is as follows:

- The Open Group Architecture Framework. [The Open Group, 2021b]  
Available at: <https://www.opengroup.org/togaf/>
- ArchiMate. [The Open Group, 2021a]  
Available at: <http://www.opengroup.org/subjectareas/enterprise/archimate>
- The OSGi Framework. [OSGi, 2021]  
Available at: <http://www.osgi.org/>
- Gill, A.Q. Adaptive Cloud Enterprise Architecture, World Scientific Publishing Co, 2015. [Gill, 2015]
- Godinez, M. Hechler, E., Koenig, K., Lockwood, S., Oberhofer, M. Schroeck, M. The Art of Enterprise Information Architecture: A Systems-Based Approach for Unlocking Business Insight, IBM Press, 2010. [Godinez et al., 2010]
- Pastor, O., and Molina J.C. Model-Driven Architecture in Practice, Springer, 2007. [Molina and Pastor, 2010]
- Model Driven Architecture. <http://www.omg.org/mda/> [OMG, 2021]

There are four assessment tasks:

- Research Report to demonstrate the ability to effectively describe the enterprise architecture both as a design and practice, its value and application to technical and business environments of different organizations and industry verticals.

- Online Quizzes to enable students to demonstrate that they can correctly describe the enterprise architecture theoretical and practical concepts, as taught by the subject and practiced by the individuals, and provide feedback to teaching staff about what is learnt or what is not.
- Architecture Project to demonstrate that the student can effectively apply the enterprise architecture theoretical and practical concepts to successfully deliver an industry strength architecture project as a team or company.
- Presentation to demonstrate that the student can effectively present enterprise architecture project artefacts to the intended audience and being able to answer relevant queries and questions.

### 3.3 Austria - Johann-Kepler University Linz<sup>5</sup>

As a student at Johann-Kepler-University (JKU) you can join the course "Strategic IT-Planning", worth 6.0 ECTS, as part of the Master's program "Business Informatics (Wirtschaftsinformatik)" held by David Rückel and Stefan Koch. The offering institute is the Institute of Business Informatics – Information Engineering, the course is taught in German as lecture with exercises in groups, presentation, discussion, documentation. The topic EAM is named as one of the potential occupational fields after successful graduating.

The following details were taken from the University's website<sup>5</sup>.

Recommended literature:

- Andriof, J.; Waddock, S.; Husted B.; Sutherland Rahmann, S.: *Unfolding Stakeholder Thinking*. Greenleaf Publishing, Sheffield, 2003. (selected chapters) [Andriof, 2017]
- Heinrich, L. J.; Stelzer, D.: *Informationsmanagement: Grundlagen, Aufgaben, Methoden*. Oldenbourg, Munich/Vienna, in the current edition. [Heinrich, 2011]
- Laudon, K.,C.; Laudon, J. P.; Schoder, D.: *Wirtschaftsinformatik*. Pearson, 2010. (selected chapters) [Laudon et al., 2006]

Learning objectives:

Students are aware of the strategic potential of information and communication technology and its importance for the achievement of strategic goals against the background of value creation through IT. Students know the strategic tasks of IT planning and the associated methods and tools.

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<sup>5</sup><https://studienhandbuch.jku.at/134568> accessed at: 20.06.2021

#### Subject

Overview of tasks in strategic IT management; IT investment evaluation; IT performance measurement; IT risk management; IT security management; Management of IT infrastructure; Decisions on outsourcing; Strategic tasks in IT project management.

### 3.4 Austria - Technical University of Vienna<sup>6</sup>

At the Technical University of Vienna (TUW) students can join the course "Enterprise Architecture" as part of the study "Master Business Informatics" with an amount of 3.0 ECTS held by the lecturer Henderik Proper, assisted by Christian Huemer. The course is based on the ArchiMate modelling language, Archi is the used tool.

The following details were taken from the University's website<sup>6</sup>.

#### Previous knowledge

Basic knowledge in object-oriented modelling and data modelling. These prerequisites are thought in the following modules of our bachelor curriculum: WIN/MOD - Modelierung (Modelling) and WIN(DBS Datenbanksysteme (Database Systems)

#### Teaching methods

In the course, the theoretical concepts will be presented in lectures on the different [sic!] thematic blocks. After each thematic block, the presented concepts will be used by the students to work on small example tasks during the course units. The solutions are presented by the students and the advantages and disadvantages of the solutions are discussed with the auditorium. After the lectures, each individual student has to solve an overall task that covers all aspects of an enterprise architecture. Finally, the students also receive feedback on their solution.

#### Examination modalities

Student work in small groups on smaller examples during the course and will present their solutions.

After the lectures the students will receive an assignment. Each student has to work on his/her own on this assignment to describe a full enterprise architecture on a specific case by means of all the modeling concepts introduced in the course.

#### Subject of course

1. Introduction

- Short discussion of what "EA might be"

- Samples of EA artefacts

- Structure of this course

2. ArchiMate:

- Background

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<sup>6</sup><https://tiss.tuwien.ac.at/course/educationDetails.xhtml?dswid=8602&dsrid=294&courseNr=194043&semester=2020W&locale=en> accessed at: 18.06.2021

Overview of the language + ArchiSurance case  
Business Layer + ArchiSurance case + exercise  
Application Layer + ArchiSurance case + exercise  
Technology Layer + ArchiSurance case + exercise

3. EA foundations
  - Steering change in Enterprises
  - The role of Enterprise Architecture in steering change
  - The role of models
4. Presentation of final assignment
5. Architecture Principles + ArchiSurance case + exercise

Recommended literature:

- M. M. Lankhorst, et al. Enterprise Architecture at Work - Modelling, Communication and Analysis. Springer, Heidelberg, Germany, 2005. ISBN: 3-540-24371-2 [Lankhorst et al., 2017]
- D. Greefhorst and H. A. Proper. Architecture Principles - The Cornerstones of Enterprise Architecture. The Enterprise Engineering Series. Springer, Heidelberg, Germany, 2011. ISBN: 978-3-642-20278-0 [Greefhorst and Proper, 2011]

Learning outcomes:

After successful completion of the course, students are able to understand the purpose of an enterprise architecture and an corresponding enterprise-wide system development, identify and assess relevant aspects of an enterprise architecture, select appropriate modeling concepts to describe an enterprise architecture, apply corresponding concepts and methods in order to describe an enterprise architecture by means of appropriate models.

The course is taught in English for a maximum of 40 students.

### 3.5 Austria - University of Klagenfurt<sup>7</sup>

At the University of Klagenfurt the topic "Enterprise Application Management" is part of the course "IT-Management" with Dietmar Jannach as responsible person, embedded in the study "Master Information Management". The offering institute is the Institute for Artificial Intelligence and Cybersecurity, the course is worth 4.0 ECTS and is seen as a broader lecture in IT management, focusing on IT Infrastructure Library (ITIL), EAM is covered in one lecture unit. Approximately 20 students join the course every semester, which is held in English.

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<sup>7</sup><https://campus.aau.at/studium/course/101576> accessed at: 18.06.2021

The following details were taken from the University's website<sup>7</sup>.

Recommended literature is

- Tiemeyer (ed.) Handbuch IT-Management : Konzepte, Methoden, Lösungen und Arbeitshilfen für die Praxis, 5. Auflage, Hanser 2013 [Bergmann et al., 2020]

Learning goals and content:

At the end of the course, students should be able to understand basics of IT management, e.g.,

- What is the role of IT in companies?
- How to develop an IT strategy?
- How to design and organize IT services (IT Service Management)?

Content:

- How to organize changes and IT projects?\* IT as a strategic factor for business, IT Strategy Management
- Enterprise Application Management
- IT Service Management with ITIL

At the end of the course a written exam has to be passed.

### 3.6 Austria - University of Vienna<sup>8</sup>

The course "Enterprise Architecture: Design, Integration, Implementation" at the University of Vienna is part of the Bachelor study "Business Informatics", therefore no academic degree is needed as a prerequisite. The course, held by Dominik Bork, is weighted with 3.0 ECTS and consists of a theoretical part and a case study for the practical implementation of the taught content throughout the complete course. The lectures present different EA frameworks(TOGAF, Zachmann Framework, St. Galler Ansatz (BEN)), but also other aspects like ITIL and COBIT, Cloud computing, Outsourcing, etc. The teaching language is German but the recommended literature is in English. The course is planned for a maximum of 50 students. One or two guest lectures are held by enterprise architects, consultants, or tool vendors. The used tools are TEAM<sup>9</sup> and ADOit.

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<sup>8</sup><https://ufind.univie.ac.at/de/course.html?lv=051261&semester=2021S> accessed at: 18.06.2021

<sup>9</sup><https://austria.omilab.org/psm/content/team/info?view=home>

### 3. THE EDUCATION DETAILS

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The following details were taken from the University's website<sup>8</sup>.

The goal of the course is the introduction to the management method "Enterprise Architecture Management".

The content of the course is divided into two theory and one practical blocks as follows:

Theoretical block I - Introduction and overview

- Motivation IT organization / Enterprise Architecture Management
- EAM basics
- Frameworks for EAM
- Cloud Computing, Outsourcing
- ArchiMate EAM standard

Theoretical block II - IT strategy and strategy realization

- IT development of an IT strategy
- Strategy realization: controlling
- Strategy realization: technical architecture

Exercise block - case studies in EAM

- EAM tools
- Basics of TEAM (meta model, model types, mechanisms & algorithms, etc.)
- Creation of models
- Analysing models

Recommended literature:

- Lankhorst, M. et al. (2009). Enterprise architecture at work (Vol. 352). Berlin: Springer. [Lankhorst et al., 2017]
- Hanschke, I. (2013). Strategisches Management der IT-Landschaft: Ein praktischer Leitfaden für das Enterprise Architecture Management. Carl Hanser Verlag GmbH Co KG. ISBN 9783446417021 [Hanschke, 2009]
- Bork and Sumereder (2017) Charlie's Aircrafts - An ArchiMate and TOGAF Case Study [Bork and Sumereder, 2018]

- Dominik Bork, AURORA Gerber, Elena-Teodora Miron, JP van Deventer, Alta van der Merwe, Dimitris Karagiannis, Sunet Eybers and Anna Sumeder (2018) Requirements Engineering for Model-Based Enterprise Architecture Management with ArchiMate [Bork et al., 2018]

The assessment of the course is composed of a written closed book exam, the case study as group work and the presentation and discussion about the results of the case study.

### 3.7 Belgium - University of Antwerp<sup>10</sup>

At the University of Antwerp a whole master study (MSc) called "Executive Master in Enterprise IT Architecture" can be consumed as a part-time study. The education takes two years, in-class sessions are organized every three to four weeks in blocks of two days, 11 times per academic year. The responsible institute is the Antwerp Management School AMS.

The following details were taken from the University's website<sup>10</sup>.

Centerpiece of the study are the courses "Digital Transformation: Strategy & Leadership" (12 ECTS), "Agile Enterprise Architecture & Engineering: Diagnosing the Enterprise Architecture" (6 ECTS) and "Agile Enterprise Architecture & Engineering: Engineering Agility & Evolvability" (12 ECTS), and of course the Master Project: An evolving project, spread over the entire duration of the master program (18 ECTS).

The experienced faculty will coach and assist the students during this program. All of them have an academic career (master, PhD or DBA) and international experience in terms of career, research, project management, advisory boards and/or consulting. Many of them have published about their practice-based research, business cases and management experiences. The faculty are experts in executive education, tailor-made programs and business consultancy: Steven De Haes, Jan Verelst, Koen Vandenbempt, Anant Joshi, Robin De Cock, Erik Proper, Hans Mulder, Martin Op 't Land

Details:

Modern organizations are operating these days in hypercompetitive environments, forcing them constantly to monitor their environment for new business opportunities and to aim for stakeholder satisfaction by delivering products and services of unprecedented quality. For most enterprises this has resulted in important challenges with increasing complexity and continuous change. Moreover, these challenges are requiring high evolvability, agility and flexibility of the organization and its information systems.

As there are obviously no simple solutions, enterprises are looking for advanced expertise grounded in research. In order to meet this demand, Antwerp Management School and the University of Antwerp established a unique partnership more than 20 years ago

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<sup>10</sup><https://www.antwerpmanagementschool.be/en/program/executive-master-enterprise-it-architecture/program> accessed at: 24.06.2021

### 3. THE EDUCATION DETAILS

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to offer a professional Executive Master in Enterprise IT Architecture. This executive master program is built upon state-of-the-art scientific research in the field of ‘enterprise engineering’ at both faculties.

This part-time master program provides an overview and scientific evaluation of frequently used enterprise architecture and systems development methodologies, i.e. TOGAF, Zachman, Archimate, Unified Process, Agile methodologies, etc. Furthermore, in order to establish the agile enterprise, Normalized Systems Theory and enterprise ontology (DEMO, Design and Engineering Methodology for Organizations) are put forward as important frameworks in both enterprise and IT architecture. In addition, participants will acquire a broad perspective and the managerial skills needed to lead and to succeed in a dynamic and fast evolving digital environment.

This internationally accredited Master of Science (MSc) in Enterprise IT Architecture, will trigger participants to confront practice with science. A highly interactive learning journey – supported by top faculty, visiting guest lecturers, peer-to-peer learning, case studies, individual and group assignments – will guarantee a well-balanced and unique mixture of rigor and practice.

This program is the only, double accredited Master of Science in Enterprise IT architecture in the Benelux

Learning objectives

After attending this program:

- You have broadened and deepened your knowledge of IT management and IT governance under the umbrella of general management;
- You can leverage information technology to help innovate the enterprise.
- You can design and implement the digital enterprise in a unified and integrated manner – including process models – required to realize the enterprise strategy;
- You will become a driver and leader for company-wide digital transformation projects;
- You can design and implement future-proof and evolvable IT systems;
- You are able to integrate enterprise IT architecture aspects with insights in IT governance and value creation management;
- You are well prepared to successfully obtain professional certifications such as the DEMO Professional 4.0 Certificate and ISACA’s CISA, CISM, CRISC and CGEIT certificates.

Degree

The master’s degree ‘Executive Master in Enterprise IT Architecture’ is AACSB and

NVAO accredited. Graduates obtain a “MSc” (Master of Science) diploma of Antwerp Management School.

#### Participants

This program is designed to accommodate experienced IT professionals as well as experienced business managers: Enterprise IT architects, IT analysts, IT managers, CIOs, business & IT consultants, business unit managers, digital marketers, business analysts, business & service architects, solution architects, program and project managers.

### 3.8 Belgium - University of Namur<sup>11</sup>

The University of Namur includes the topic EA in the course "Business modelling and E-Business" as part of the study "Master en sciences informatiques", weighted with 5.0 ECTS, with lecturers Henderik Proper, Anthony Simonofski, and Eric Dubois as substitute. The responsible institute is the Faculté d'informatique, the course is held in French as lecture with exercises.

The main taught frameworks are e3value and BMC. The taught EA modelling languages are business model canvas and e3value, ArchiMate is used as language and Archi as tool. Students are required to provide a final (individual) report and work on project group assignments during the course.

The following details were taken from the University's website<sup>11</sup>.

#### Learning outcomes

This course aims to provide students the methodological background to evaluate and develop innovative business models and their realization in terms of an enterprise architecture.

#### Objectives

1. Students will learn core concepts underlying conceptual modelling, such as used for business models and enterprise architecture models.
2. Students will learn to (1) express existing (as-is) business models, (2) express possible future (to-be) business models, and (3) evaluate these in terms of costs and benefits
3. Students will learn to express such business models in state of the art modelling approaches, including the business model canvas and e3value.
4. Students will learn to (1) express existing (as-is) enterprise architectures, (2) analyse the architectural alignment between the as-is business model and as-is enterprise architecture, (3) express possible future enterprise architectures, aligned to selected future business models.

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<sup>11</sup><https://directory.unamur.be/teaching/courses/INFOM422/2020> accessed at: 28.09.2021

5. Students will learn to express these enterprise architecture models in terms of the ArchiMate standard for enterprise architecture.

#### Content

The course is structured into six blocks of four hours each, while using a running case:

1. Conceptual Modelling Foundations.
2. ArchiMate modelling 1, focused on as-is modelling.
3. Introduction to the running case.
4. Business modelling 1, focused on as-is modelling, and architectural alignment.
5. Business modelling 2, focused on to-be modelling towards future scenarios.
6. ArchiMate modelling 2, focused on to-be modelling.

#### Teaching methods

The pedagogic method used in this course revolves around project groups, and the use of the running case to enable students to immediately apply what has been learned, towards the analyse and design business models and their architectural elaboration.

Recommended literature:

- M. M. Lankhorst, et al. Enterprise Architecture at Work - Modelling, Communication and Analysis. Springer, Heidelberg, Germany, 2005. ISBN: 3-540-24371-2 [Lankhorst et al., 2017]
- D. Greefhorst and H. A. Proper. Architecture Principles - The Cornerstones of Enterprise Architecture. The Enterprise Engineering Series. Springer, Heidelberg, Germany, 2011. ISBN: 978-3-642-20278-0 [Greefhorst and Proper, 2011]

### 3.9 Germany - Friedrich-Alexander-University Erlangen-Nürnberg<sup>12</sup>

At the Friedrich-Alexander-University Erlangen-Nürnberg (FAU) the module "Fundamentals of Enterprise-wide IT Architecture Management" is held as part of the study "Master International Information Systems" consisting of a lecture course and a case study seminar, both worth 2.5 ECTS. The maximum number of participants is 32 students, the responsible institute is IS Chair for IT Management, with lecturer Michael Amberg, the spoken language is English.

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<sup>12</sup><https://www.it-management.rw.fau.de/lehre/master/fundamentals-of-enterprise-wide-it-architecture-management/> accessed at: 3.10.2021

The following details were taken from the University's website<sup>12</sup>.

The lecture "Fundamentals of Enterprise-wide IT Architecture Management" contains five major sections:

- Business Process (Management)
- Data Standards and Process Standards
- SOA and Webservices
- Business-IT Alignment
- IT Service Management
- Implementation of Big Data Systems

Hence, the course has a strong focus on technical, especially architectural elements of a companies' IT. Additionally, students are confronted with scientific literature dealing with the lectures' content blocks. In groups, students have to deal with high-impact journal articles and learn to work with such content.

The course consists only of ONLINE lectures for self study. Videos will be provided and the students are able to watch the videos via Studon.

Contents:

Lecture:

The lecture "Fundamentals of Enterprise-Wide IT Architecture Management" provides the fundamentals of business process management and the underlying IT architecture. The course has a strong focus on concepts of business-IT alignment e.g., service oriented architectures, cloud computing, and enterprise-wide IT systems as well as important paradigms to (re-) design enterprise IT architectures.

Case Study Seminar

Managers and business leaders in the field of information technology must make decisions with limited information and a swirl of business activities going on around them. They are required to evaluate options, make choices, and find solutions to the challenges they face every day. In this seminar, students will take on the perspective of a decision-maker by analyzing and discussing complex management challenges illustrated in different case studies from leading business schools.

Learning objectives and skills

Lecture students...

- know about the major differences of process and workflow management,
- know about the main models of IT Service Management and Business-IT alignment,

- can understand the impact of Big Data Technologies on Value Creation, can assess and implement different types of Big Data Systems,
- can explain the major differences of automated communication concepts like EDI, XML and EDIFACT,
- can assess process standardization in different environments.

Case Study Seminar students should...

- know about real-world challenges in the area of IT management, as well as methods for analyzing case studies,
- be able to apply the vocabulary, theory, and methods they have learned in the lecture,
- be able to develop solutions to business problems, as well as defend their solutions and discuss them critically in a group setting
- be able to present solutions to case study problems in English.

Recommended literature:

- Lecture:  
Rood, M. A. Enterprise architecture: Definition, content, and utility, in Proceedings of the Third Workshop on: Enabling Technologies: Infrastructure for Collaborative Enterprises, 1994, pp. 106-111. [Rood, 1994]
- Case Study Seminar:  
Ellet, W. The Case Study Handbook: How to Read, Discuss, and Write Persuasively About Cases. Harvard Business Review Press, 2007. [Ellet, 2007]

Assessments:

Lecture: written examination 60 minutes (100%)

Case Study Seminar: Presentation (2 times á 90 minutes) (33,33%), class participation/discussion (33,33%) and discussion paper (33,33%).

Course and seminar are held in English.

### **3.10 Germany - UniBW Universität der Bundeswehr, Munich<sup>13</sup>**

At UniBW, the Military University of Germany in Munich, students can join the course "Enterprise Architecture und IT Service Management", worth 6.0 ECTS as part of both

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<sup>13</sup><https://www.unibw.de/ia/lehre/enterprise-architecture-and-it-service-management/enterprise-architecture-it-service-management> accessed at: 7.9.2021

master studies "Informatics" and "Business Informatics". The responsible people Andreas Karcher, Peter Hillmann, Erik Heiland are part of the institute "Softwarewerkzeuge und Methoden für integrierte Anwendungen" - "Software tools and methods for integrated applications".

The following details were taken from the University's website<sup>13</sup>. As the course description is only available in German, a translation in English was necessary and can be found below:

The service-based architecture concept (Service Oriented Architecture SOA) has been an important cornerstone for the design and adaptation of complex IT landscapes to the continuously changing requirements of the business process environment of a company or organization for some time. The aim is to map requirements from the business processes in a structured, targeted and as effective and efficient as possible, to the basic services of an underlying IT service layer as well as to make these available to the application level across locations and technologies, for example in the form of cloud-based services. Therefore frameworks for the description of architectural components typical for a type of company or an application area and relationships between the "Building Blocks" (Enterprise Architecture Frameworks) form an increasingly important basis. The module introduces the subject of the architecture-based design of complex IT landscapes.

In the first part of the course, the development history and the central basic idea of company frameworks will be presented and discussed while using introductory examples and an overview of the relevant standards will be given. Using individual selected standards such as The Open Group Architecture Framework (TOGAF), individual aspects of the application of enterprise architecture give a deeper insight when using case studies.

The second part of the module focuses on the management of complex IT landscapes based on service-oriented architecture..

On one hand, IT service management as an umbrella term for all approaches and methods to support the mapping of business processes to basic IT services forms, is an important foundation of today's IT governance. On the other hand, this paradigm presents companies and users with the challenge of a continuous, systematic and optimal mapping of company processes on IT modules and standard application systems - also known as business-IT alignment. Standards and frameworks - above all the IT Infrastructure Library (ITIL) - play a central role in this matter. In addition to anchoring the basic concepts and methods of IT service management, the focus of this module will be on the application of frameworks, mirrored in practical examples.

Furthermore application experts from different areas will give deeper insights into the current status.

Qualification goals:

The "controllability of complex IT landscapes (IT governance)" is increasingly becoming a central, strategic competitive factor for companies, organizations and, last but not least, armies such as the Bundeswehr. Enterprise architecture and IT service management

form the two central pillars for mastering this complex task. The module enables you to classify the relatively young research area in its current status and its importance for the design of complex IT landscapes based on specific case studies and discussions with external experts. The participants also acquire the necessary knowledge to apply and transfer the methods and approaches in the context of domains.

The assessment basis are group assignments, case studies and a research paper.

#### **3.11 Germany - University of Applied Sciences Erfurt<sup>14</sup>**

The University of Applied Sciences Erfurt offers a course entitled "IT-Strategy and Architecture (ITSA)" as part of the study "Master Angewandte Informatik" (Master of Applied Informatics) weighted with 5.0 ECTS. Lecturer is Volker Herwig, the course is planned for 15 students per semester and is mandatory for the profile line „Enterprise and Mobile Computing“.

The following details were taken from the University's website<sup>14</sup>.

Qualification goals

The students are able to:

- define the terms IT strategy und IT architecture
- understand the importance of both topics in regards to an enterprise IT
- present and describe a process of IT strategy development
- work as part of a team developing an IT strategy for an enterprise
- use and apply the methodical instruments typically used as part of an IT strategy process
- document an IT architecture

Contents

- Terms and Definitions
- IT in an Enterprise
- Value Proposition of an IT Strategy
- IT Strategy Process
- Input Analysis (As-Is Situation, Trends, External Factors)

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<sup>14</sup><https://www.ai.fh-erfurt.de/studium/master-angewandte-informatik/studienplaene-spo> accessed at: 3.10.2021

- IT Analysis and SWOT (Mission, Vision, IT Targets)
- IT Principles and Special Strategies
- Enterprise IT Architecture
- IT Project Portfolio Planning
- IT Governance
- IT Controlling
- Execution of an IT Strategy Process

Recommended literature:

- Slides of the lecture and handouts given
- Rupp, C.: Systemanalyse kompakt, 2008. [Rupp, 2009]
- Dern, G.: Management von IT-Architekturen: Leitlinien für die Ausrichtung, Planung und Gestaltung von Informationssystemen, 2006. [Dern, 2009]
- Durst, M.: Wertorientiertes Management von IT-Architekturen, 2007. [Durst, 2008]
- Hanschke, I.: Strategisches Management der IT-Landschaft - Ein praktischer Leitfaden für das Enterprise Architecture Management. [Hanschke, 2009]
- Tiemeyer, E.: IT-Strategien entwickeln, IT-Architekturen planen, 2007. [Tiemeyer, 2007]

As assessments serve homeworks and presentations, the course is held in English.

### 3.12 Germany - University of Potsdam<sup>15</sup>

At the University of Potsdam students enrolled for the Master study "Business Informatics and Digital Transformation" must pass a mandatory module entitled "Architectures of Enterprise Application Systems" consisting of a lecture element and a seminar with practical exercises on scenarios and case studies. The responsible institute is the "Chair of Business Informatics Processes and Systems" with Prof. Norbert Gonau as chairholder and Alina Zaiser, Benedict Bender, and David Kotarski as lecturer or contact persons.

The main focus lies on Enterprise Resource Planning (ERP) but also EAM and Enterprise Architecture Integration (EAI) are taught during some lectures.

The following details were taken from the University's website<sup>15</sup>.

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<sup>15</sup><https://puls.uni-potsdam.de/qisserver/rds?state=verpublish&publishContainer=vvzpdfindexstgdoc&stgkz=WDT> accessed at: 2.10.2021

The goal of this module is to highlight the basics and research questions in Enterprise Architecture Management. Students must take up different perspectives to recognize the topic in a comprehensive view. Thereby the views of a CIO, a software architect and an IT security officer are used to represent the topic from different angular fields.

The course consists of the following lectures:

- Introduction Architecture Management
- ERP systems and their architecture
- Procedure models in Architecture Management
- Recording and Visualising of application landscapes
- Grading of application landscapes
- Frameworks for Architecture Management
- Enterprise Application Integration
- From Business Process to Software architecture (key)
- classical software pattern
- Using tools in Architecture Management
- Changeability

As the specter of the module is rather broad the list of recommended literature is also very extensive. The key books are as follows:

- BITKOM (2011): Enterprise Architecture Management – neue Disziplin für die ganzheitliche Unternehmensentwicklung, [www.bitkom.org](http://www.bitkom.org), 2011, zuletzt zugegriffen am 31.05.2016. [BITKOM, 2011]
- Buckl, S.; Matthes, F.; Schweda, C. (2010): Future Research Topics in Enterprise Architecture Management – A Knowledge Management Perspective, *Journal of Enterprise Architecture*, August 2010. [Buckl et al., 2010]
- Dern, Gernot: *Management von IT-Architekturen*, Vieweg + Teubner 2009 [Dern, 2009]
- Matthes, D. (2011): *Enterprise Architecture Frameworks Kompendium*, Springer-Verlag Berlin Heidelberg, 2011. [Matthes, 2011]
- Shah, H.; El Kourdi, M. (2007): *Frameworks for Enterprise Architecture*, IEEE, 1520-9202/07/, September/ October 2007. [Shah and Kourdi, 2007]

- TOGAF: TOGAF® VERSION 9.1 – A POCKET GUIDE, Van Haren Publishing, zuletzt zugegriffen Juni 2016. [The Open Group, 2021b]
- Zachman, J. (1987): A framework for information systems architecture. IBM Systems Journal VOL 26, No 3 S. 276 - 292, 1987. [Zachman, 1987]
- Zachman, J. (1997): Enterprise Architecture: The Issue of the Century - Artikel im Magazin Database Programming and Design. Miller Freeman, Publisher 415-905-2552, 1997 [Zachman, 1997]

For a successful graduation of the module, students have to pass a written exam regarding the course and prepare some case studies in small groups with presentations for the seminar.

### 3.13 Germany - University of Technologies, Munich<sup>16, 17</sup>

The Technical University of Munich has two courses with EA in their titles: "Strategic IT Management & Enterprise Architecture Management (SITM & EAM)" as lecture held by Florian Matthes and Phillip Schneider and "Master Seminar - EAM Miniprojekte" as practical exercises with Florian Matthes, Gloria Bondel, Fatih Yilmaz, and Ömer Uludağ as lecturers. The responsible institute in both cases is the "Chair of Software Engineering for Business Information Systems (sebis)", therefore the effort will be weighted as one, worth 8.0 ECTS, split in 3.0 ECTS for the lecture and 5.0 ECTS for the practical exercises. The successful participation of the lecture works as a prerequisite for the seminar, both are part of a Master study in Informatics or Business Informatics.

The following details were taken from the University's website<sup>16, 17</sup>.

Some details for the lecture:

The taught EA frameworks are Zachman framework, TOGAF, ARIS, and IT4IT, modelling languages are UML, BPMN, ArchiMate, domain-specific modelling languages (sebis chair has a strong research focus on EAM pattern languages<sup>18</sup>), Enterprise Architecture Management Tool Survey EAMTS<sup>19</sup> is the used tool. Approximately 350 students join the course every winter semester.

Recommended literature:

- M.G. Bernhard, R. Blomer und J. Bonn: Strategisches IT-Management Band 1: organization & Prozesse & Referenzmodelle. 1 ed. Düsseldorf: Symposion Publishing, 2003. ISBN 3-936608-34-2. [Bernhard, 2003a]

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<sup>16</sup><https://wwwmatthes.in.tum.de/pages/1vmk5slozr2xl/Strategic-IT-Management-Enterprise-Architecture-Management-Strategisches-IT-Management-EAM> accessed at:

<sup>17</sup><https://campus.tum.de/tumonline/wbLv.wbShowLVDetail?pStpSpNr=950402126> accessed at: 30.9.2021

<sup>18</sup><https://wwwmatthes.in.tum.de/pages/ugsy119wmmv1/EAMPC-V2-Enterprise-Architecture-Management-Pattern-Catalog-V2>

<sup>19</sup><http://wwwmatthes.in.tum.de/pages/1wdia0twywb0w/EAMTS2008>

### 3. THE EDUCATION DETAILS

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- M.G. Bernhard, R. Blomer und J. Bonn: Strategisches IT-Management Band 2: Fallbeispiele und praktische Umsetzung. 1 ed. Düsseldorf: Symposion Publishing, 2003. ISBN 3-936608-51-2. [Bernhard, 2003b]
- D. Buchta, M. Eul, H. Schulte-Croonenberg: Strategisches IT-Management. 1 ed. Wiesbaden: Gabler Verlag, 2004. ISBN 3-409-12527-2. [Buchta, 2004]
- I. Hanschke: Strategic IT Management: A Toolkit for Enterprise Architecture Management. Springer, 2009. [Hanschke, 2010]

The lecture shows the different facets of strategic IT management from a practical point of view and explains the connections between the different processes of strategic IT management. The main learning objectives are:

- To understand the most important IT management and value creation processes in terms of content and their interrelationships
- Being able to discuss the fundamental strategic decisions in IT management and their implications
- Identification of typical problems in the practical implementation of IT management and propose appropriate solutions
- Get familiar with relevant methods, standards and best practices.
- Understand the socio-economic and technical relationships in IT management
- Gain an overview of typical job profiles of specialists and managers in IT organizations

The course is held in English, guest lectures are part of the program, cooperation with external companies emphasize the importance of the topic.

The covered topics in the lectures:

- IT Strategy
- IT Governance
- EAM Motivation
- EAM Foundations
- Capability Based Planning
- Case study (voluntary): IT Transformation Project
- Agile EAM and EAM Patterns

- EAM in Scaled Agile IT Organizations
- Guest lecture: Cybernetic EAM
- EAM Standards, Frameworks and Tools
- Exercises and Q&A

The Master seminar "EAM Miniprojekte" works as a practical consolidation of the acquired knowledge. In small "mini projects" students have the possibility to work with industry partners on concrete problems and topics, thereby getting familiar with different facets of EAM and exhibiting practical results in the end. No specific EA frameworks or modelling languages are taught, the used frameworks and languages depend on the problem definition given by the industry partner.

Learn objectives: After successful completion of the course, students are able to

- develop approaches of solution for real world problems regarding EAM
- execute relevant methods, standards, and practices
- recognize typical problems in the practical realization of EAM methods and propose adequate solutions
- explain socio-economic and technical correlations regarding EAM in concrete examples

Keyfacts: Small teams with 2-4 students develop a solution for a concrete EAM case at an industry partner of the institute. A paper (10 pages) and two presentations are the outcomes and the base for the grade.

Expectations on the students are

- independent work,
- methodical proceed,
- modelling knowledge,
- time and project management,
- teamwork,
- contact with the companies and the institute on a regular basis,
- follow the escalation paths, fairness in the team
- soft skills and presentation ability

#### 3.14 Italy - University of Bolzano<sup>20</sup>

The University of Bolzano offers the course "Enterprise Architecture", worth 6.0 ECTS, as part of the study "Master in Computational Data Science". As lecturer acts Giancarlo Guizzardi, the responsible institute is "SPL 5 - Computer Science and Business Informatics". The course is held in English.

The following details were taken from the University's website<sup>20</sup>.

The course relies mainly on the framework TOGAF with ArchiMate as the modelling language and Archi as tool or the Draw.IO Archimate Templates. The tool is available online and can be used free of charge by the students.

Recommended literature:

- Marc Lankhorst et al., Enterprise Architecture at Work: Modeling, Communication and Analysis [Lankhorst et al., 2017]
- Archimate Specifications, The Open Group, available online [The Open Group, 2021a]
- Maria-Eugenia Iacob, Henk Jonkers, Dick Quartel, Henry Franken, Harmen van den Berg, Delivering Enterprise Architecture with TOGAF and Archimate [Iacob et al., 2012]
- Articles on Specific Topics of the Course

The course belongs to the type "caratterizzanti – discipline informatiche" in the curriculum "Data Management".

This course is designed for acquiring contemporary professional skills and knowledge. After successful completion, the student should have a well-founded, basic understanding of what is involved to successfully model and analyze complex aspects of organization that provide a context for the structuring and interpretation of Enterprise Data. The course will not teach mastery of specific tools, but educate on best practices and processes. The course will be taught from a perspective that is strongly based on modelling. For that, the students will learn to produce, read and reason with architecture models ranging from Strategy Models (Business Models and Goal Models), passing by Service and Business Process Models, as well as models of IT services and infrastructures that support the business layer.

- Business strategy and goal modelling
- Enterprise ontologies
- Relating data modelling and process modelling in organizational contexts

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<sup>20</sup><https://www.unibz.it/faculties/computer-science/master-computational-data-science/courses-offered/?academicYear=2018> accessed at: 21.10.2021

- Service modelling, management and governance
- Problem-solving with enterprise models
- Modelling of business applications and computational infrastructure to support business operations

As assessments serve a group project and an oral exam.

### 3.15 Latvia - Riga Technical University<sup>21</sup>

The Faculty of Computer Science and Information Technology at the Riga Technical University offers the course "Enterprise Architecture and Requirements Engineering", worth 6.0 ECTS, held by Mārīte Kirikova as part of the study "Master of Business Informatics".

The following details were taken from the University's website<sup>21</sup>.

The course presents basic approaches to requirements engineering. Students learn to identify and design enterprise/business architectures and specify requirements for organizational information systems viewing people and computer systems as nodes of information processing. They learn to analyse and design information flows in organizations and organizational networks and how to develop the information logistics model. IBM requirements identification and management tools are used in the course. Acquired knowledge is beneficial not only for requirements identification for information and communication technology solutions; it is applicable also for the design of products and services in general.

Content:

- Requirements engineering (RE) for the design of products services and information systems. Design methods.
- Requirements acquisition, amalgamation and modelling. Ethical and cognitive-psychological aspects of RE
- Information logistics, management and information systems
- Enterprise, business and information systems architectures
- RE approaches (value, architecture, process, object, business rules, and agent oriented methods)
- Requirements management
- RE for information systems and software design (for different life-cycle models)

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<sup>21</sup><https://stud.rtu.lv/rtu/discpub/oe.28097> accessed at: 30.9.2021

The goal of the course is to provide knowledge and skills of requirements identification, management and documentation, as well as to provide competence in decision-making with respect to the choice of appropriate requirements engineering methods and tools.

Learning outcomes and assessments:

- Students understand common and specific issues of requirements engineering and systems design. - Examination question that requires demonstration of common and specific issues in requirements engineering and systems design.
- Students are able to acquire requirements without overstepping ethical principles of business, systems analysis, and information systems design. - Analytical evaluation of video-recorded teamwork.
- Students are able to use and evaluate requirements engineering methods and tools. - Assessment is based on the results of individual assignments and examination.
- Students are able to use and evaluate requirements management methods and tools. - Representation of requirements changes in the requirements management tool.
- Students are able to design models of information logistics and information systems that conform to requirements. - At the examination it is required to identify requirements for the given case and to design appropriate models of information logistics and information system.
- Students recognize, can evaluate and use different enterprise/business architecture frameworks and their models. Can design enterprise architecture. - At the examination it is necessary to choose the most appropriate architecture framework for a given case. In individual assignments models are developed involving several enterprise arches.

Recommended literature

- Pohl, Klaus. Requirements engineering. Springer, Heidelberg, 2010. [Pohl, 2010]
- Robertson, Suzanne; Robertson, James. Mastering the requirements process : getting requirements right. Upper Saddle River (N.J.). Addison-Wesley, 2013. [Robertson, 2013]
- K.Sandkuhl,J.Stirna, A.Persson, M.Wißotzki. Enterprise Modeling : Tackling Business Challenges with the 4EM Method. Springer, Heidelberg, 2014. [Sandkuhl, 2014]
- Evernden, Roger. 101 lessons from enterprise architecture. Lielbritanija :Izdevejs nav zinams, 2015. [Evernden, 2015]
- Evernden, Roger; Evernden, Elaine. Enterprise architecture: the eight fundamental factors. Lielbritanija :Izdevejs nav zinams, 2015. [Evernden and Evernden, 2015]

- Desfray, Philippe; Raymond, Gilbert. Modeling enterprise architecture with TOGAF : a practical guide using UML and BPMN. Morgan Kaufmann, Amsterdam;Boston, 2014. [Desfray, 2014]

### 3.16 Netherlands - Open University of the Netherlands<sup>22</sup>

The Open University of the Netherlands (OU) is specifically dedicated to online education and research. The educational program is deliberately chosen so that students can study part-time. OU offers the course "Enterprise Architecture", worth 7.5 ECTS, with lecturers Rogier van de Wetering and Ben Roelens. The course is held as lecture with exercises, as part of the master program "Master Business Process Management and IT" graduation study, the responsible institute is "Informatiekunde".

The following details were taken from the University's website<sup>22</sup>.

The taught EA frameworks are Zachman's framework and TOGAF, modelling languages are 4EM, ArchiMate, and Business Model Canvas, the used tool is Archi (<https://www.archimatetool.com/>). Approximately 200 students join the course with English materials every year, the guidance is Dutch. Students perform a practical group assignment in existing organizations. As OU is a university for long distance learning, the students are also usually employed in these companies.

An essential part of this course is applying enterprise architecture management knowledge and skills in practice. Students do this through the course (research) project, i.e., writing a research paper. A team of four students will explore various aspects of enterprise architecture management within an organization.

Students will also hand in an individual assignment, which determines 35% of the passing grade. For this assignment, OU expect them to take on the role of an 'EA consultant'. This consultant tries to convince a CIO of an organization (potential client) on the value of EA when this particular organization wants to introduce new digital technology (e.g., big data analytics, artificial intelligence/machine learning, IoT, robotics process automation, digital security, augmented reality, 3D printing, cloud, mobile and social media platforms). As such, the student will think about a novel digital technology or innovation and try to 'pitch' his/her story using a video presentation.

Course details:

Enterprise Architecture (EA) was put on the map in the late 1980s by John F. Zachman. The framework he developed is still widely used worldwide and generated considerable interest in this new domain over time. With an EA, an organization can get more out of itself by aligning business processes and IT and by adapting to a constantly changing environment. An EA is usually represented with several layers, with each layer consisting of interrelated elements. This creates structure in what would otherwise appear to be chaos.

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<sup>22</sup><https://www.ou.nl/en/-/enterprise-architecture> accessed at: 22.9.2021

In this course we understand by EA the 'fundamental organization of a company as a socio-technical system, together with the principles that guide the design and development of the company.' This implies that an EA contains all relevant components necessary to describe a company (or more generally: organization). This includes the organizational structure, operational model, business processes, data, applications and technology of the organization.

In the course we will discuss how business managers, IT managers, but also other business executives can use EA to fully realize the benefits of an EA. In doing so, we choose a slightly different approach than much of the existing EA literature, which focuses on technical aspects, such as modeling and associated tools, design or architectural patterns, (reference) architectures or frameworks. Not that we're neglecting all of these things, but they are secondary to our chosen approach because they allow better use of EA's full potential.

Course book

Ahlemann, Stettiner, Messerschmidt and Legner, editors (2012). Strategic Enterprise Architecture Management. Challenges, Best Practices and future development. Berlin - Heidelberg: Springer [Ahlemann et al., 2012]

### 3.17 Switzerland - FHB Bern University of Applied Sciences<sup>23, 24</sup>

At the University of Applied Sciences in Bern you can join the part time module "CAS Enterprise Architecture Management" to earn the "Certificate of Advanced Studies EAM", worth 12.0 ECTS. The lecturers are Andreas Spichiger, Stephan Haller and Thomas Jarchow, the spoken language is German. As a prerequisite it is necessary to have an academic degree and at least three years job experience and basic knowledge of requirement engineering.

The following details were taken from the University's website<sup>23,24</sup>. As the course description is only available in German, a translation in English was necessary and can be found below:

Sold and self-developed IT applications are very important parts of organizations these days. Midsize companies usually have between 100 and 1.000 applications in use. Core applications are often used for ten to 30 years (and more) and are enriched with new technologies to keep up with the racy IT development. This leads to confusing and complex IT system landscapes containing a big number of interfaces and dependencies. Such complex IT systems are amongst others expensive in maintenance and have big idleness against changes. Additionally they possess redundancies making innovation and renewal expensive and complicated.

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<sup>23</sup>[https://www.bfh.ch/dam/jcr:90ec26ad-e937-4849-b1a5-57050622fc11/Factsheet\\_CAS\\_Enterprise\\_Architecture\\_Management.pdf](https://www.bfh.ch/dam/jcr:90ec26ad-e937-4849-b1a5-57050622fc11/Factsheet_CAS_Enterprise_Architecture_Management.pdf) accessed at: 1.12.2021

<sup>24</sup><https://www.bfh.ch/de/weiterbildung/cas/enterprise-architecture-management/> accessed: 1.12.2021

Given that the success of an organization is increasingly dependent on the speedy and flexible enhancement of digital competencies, it is needed to have a superior view in form of enterprise architecture and the enhancements in form of enterprise architecture management. In this module students develop ideal landscapes based on business models/capabilities and company/IT strategies to compare them with the actual situation. Out of comparison they develop possible proceeding variants as target architectures and evaluate them. Thereby a step wise migration is planned and the development is consolidated with the whole applications landscape and the fitting process-oriented organization.

The target participants are

- Enterprise and Business architects
- Product manager, Business Developer, Business Analysts, Process manager
- Data architects and analysts
- Software developer/architects
- IT leaders and other manager, business and IT project manager, business and IT strategists

Learning goals:

- Development of ideal landscapes: based on the business model and the company strategy the ideal enterprise architecture is gathered. For this the fitting business architecture is developed consisting of business competencies with business objects and processes and the appropriate process organization and the derived ideal IT architecture.
- Description of the actual enterprise architecture and application landscape: collect, present and analyse the actual situation of a company.
- Insertion of target scenarios: development, plan and valuation of different target scenarios, deepened knowledge how possible proceeding variants and scenarios can be evaluated.
- Anchoring the architect change processes and their interlacing with projects and business processes in a company. Step wise migration planning and development and consolidation of the results for the complete applications landscape. The architecture management process is continuously enhanced based on the maturity level.

Contents:

- Enterprise digitisation, introduction (3 days)
- Modelling languages for architects (2 days)
- Enterprise architecture (5 days)
- Architecture evolution (2 days)
- Process organization (2 days)
- Information system architecture (4 days)
- Future architecture (2 days)

The module is organised in parts of in-classroom teaching, coaching, group works and self studies in a strong iterative way. The case studies are related if possible to the companies the students are employed to, at first individually afterwards consolidated in small groups and later on presented and discussed at the whole class.

As assessments serve transfer reports, describing the step wise development and refining of the created architecture, and learning reports for the documentation of the learned contents.

#### 3.18 Switzerland - University St. Gallen<sup>25</sup>

The University of St. Gallen (UniSG) offers a course entitled "Business Innovation II: IT - Embedding in enterprise architecture" (the original title in German is "Business Innovation II: Unternehmen gestalten und digital transformieren") worth 4.0 ECTS held by Jan Marco Leimeister and Christoph Peters as part of the study "Master in Business Innovation" based on the EA framework St. Gallen House of Digital Business. The course language is German, the slides in English, approximately 200 students join the course per semester. Assessments are open book exam, group presentation, assignments (with peer-feedback review process), the course is held as lecture and exercises.

The following details were taken from the University's website<sup>25</sup>.

Recommended literature:

- Brenner et al. (2014). User, Use & Utility Research, *Wirtschaftsinformatik* (56:1): pp. 65-71. [Brenner et al., 2014]
- Fließ & Kleinaltenkamp (2004). Blueprinting the service company: Managing service processes efficiently. *Journal of Business Research* (57:4): pp. 392-404. [Fließ and Kleinaltenkamp, 2004]

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<sup>25</sup><https://tools.unisg.ch/handlers/Public/CourseInformationSheet.ashx/semester/HS21/eventnumber/7,002,1.00.pdf> accessed at: 30.9.2021

- Gordijn (2002). E3-Value in a Nutshell. [Gordijn, 2002]
- Krcmar (2015). Informationsmanagement. Berlin Heidelberg: Springer Gabler. [Krcmar, 2015]
- Leimeister (2020). Dienstleistungsmanagement und -engineering, Berlin: Springer Gabler. [Leimeister, 2012]
- Leimeister (2015). Einführung in die Wirtschaftsinformatik (12. Auflage), Berlin: Springer Gabler. [Leimeister, 2015]
- Österle, Höning & Osl (2011). Methodenkernel des Business Engineering. [Österle et al., 2011]

The course has its focus on the digital transformation: The digitization of our society changes the way we consume, work, live, and communicate with each other. By digitization a new period of prometerism comes into being, moving digital users and their changed needs into the center and let new markets arise. This results in a multitude of possibilities for start-ups and new companies, and forces well established organizations to adjust to the changed needs of digital society. The transformation from an information to a digital society is one of the biggest challenges for companies - existing business models become ineffective, value creation chains change to networks and systems, high costs arise for the management of digitization, and new organizational forms and function profiles form.

Coming from the orientation on digitized users and their needs organizational strategies, processes and systems, as well as leading tasks, products and services have to be designed for a best fit of their needs. Business engineering as a holistic, method and model based design theory with the goal to create innovative business solutions and assist companies with their digital transformation.

The target of this course is therefore to build decision-making and responsibility for design and digital transformation of companies, with active consideration of digitization of economy and society.

The course is structured following the St. Galler House of Digital Business and its antecedents and impacts.

0. Introduction and Organizational Matters
1. Business Innovation and Digital Economy
2. U3 - User is King
3. Create and Capture Value
4. Everything Becomes a Service
5. Implementing Services

6. Business Strategy
7. Business Processes
8. Modular Processes
9. Embedding in Enterprise Architecture
10. IT Management
11. New Ways of Work and Agility
12. Agile Transformation and Change Management

The students will exercise the taught methods in form of a self-study running case. The solutions of the fellow students will then be examined and assessed. This increases the acting and transfer competencies. Practice lectures held by deciders from "real world" companies will give interesting insight views into the practical relevance of the course content.

#### 3.19 Switzerland - ZHAW Zürich<sup>26</sup>

The Zürich University of Applied Sciences (ZHAW) offers at the "Institut für Wirtschaftsinformatik" the module "Enterprise Architecture" which is mandatory for the study "Master in Business Informatics", worth 3.0 ECTS, with the responsible person Philipp Matter. The course is held as lecture and exercises with the flipped classroom method, letting students read the upcoming topics at home and practice the learned content at school.

The following details were taken from the University's website<sup>26</sup>.

The course concentrates at TOGAF 9.2 as EA framework, ArchiMate as the taught EA modelling language and Signavio as the used tool. As a prerequisite the students must understand modelling, IT architectures and internet technologies.

Recommended literature:

- TOGAF 9.2 documentation [The Open Group, 2021b]  
(<https://pubs.opengroup.org/architecture/togaf9-doc/arch/index.html>)
- ArchiMate 3.1 documentation [The Open Group, 2021a]  
(<https://pubs.opengroup.org/architecture/togaf9-doc/arch/index.html>)
- Bass, L., Clements, P., & Kazman, R. (2013). Software architecture in practice (3rd ed). Addison-Wesley. [for architectural Patterns and Tactics, Quality Attributes]. [Bass, 2013]

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<sup>26</sup>[https://modulmanagement.sml.zhaw.ch/StaticModDescAblage/Modulbeschreibung\\_w.MA.XX.EPA.20HS.pdf](https://modulmanagement.sml.zhaw.ch/StaticModDescAblage/Modulbeschreibung_w.MA.XX.EPA.20HS.pdf) accessed at: 30.9.2021

- Kotusev, S. (2018). The Practice of Enterprise Architecture: A Modern Approach to Business and IT Alignment. SK Publishing. [for history of Enterprise Architecture Management] [Kotusev, 2018]

Learning objectives: The students ...

- have a clear understanding what EA encompasses and how it is used in companies
- can apply a specific EA framework onto a practical example
- can adopt an EA standard modelling notation
- can use IT supported tools for modelling

Course content:

- Introduction to TOGAF and ArchiMate
- modelling of the motivation and entrepreneurial situation
- modelling of the strategy
- modelling of the business activities based on capabilities
- modelling of the application architecture
- modelling of the technical architecture (including tactics and quality attributes)

Details:

The intention of an enterprise architecture is to optimize the often fragmented processes (manual and automated) and to transform them into an integrated environment that can react to changes and supports the realization of enterprise strategies. The effective administration and use of information by IT are key factors for business success and an unmissable tool for getting competitive advantages. An EA addresses these requirements by offering a strategic context for the development of IT as a reaction to the permanent changing expectations of the business environment.

Enterprise architecture = motivation + strategy + business + technology

### 3.20 USA - Carnegie Mellon University<sup>27</sup>

The Carnegie Mellon University offers the "Certified Enterprise Architect" (CEA) program consisting of three integrated courses:

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<sup>27</sup><https://execed.isri.cmu.edu/elearning/programs/enterprise-architecture/index.html> accessed at: 2.10.2021

EA Fundamentals

Advanced EA

EA for Mergers and Acquisitions

The following details were taken from the University's website<sup>27</sup>.

Topics covered in the CEA certification program are based on the Knowledge, Skills and Abilities (KSAs) that enterprise architects and domain architects need to know to do their jobs in various analysis and design projects at each level of an organization, as well as to successfully progress in your career. Each course is worth 4.8 credit points which equates to 9.6 ECTS.

Students in the CEA program learn current EA approaches and best practices from leading public and private sector organizations around the world. This includes the basics of the Zachman EA Framework, Spewak's EA Planning Method, The Open Group Architecture Framework, Bernard's EA3 Cube Framework, the U.S. Federal EA Framework, the DoD Architecture Framework, and the Government Accountability Office's EA Management Maturity Framework. The course teaches the EA6 holistic architecture approach that is described in the primary textbook. No software tools are used, this is a concept instruction curriculum. This allows students to apply the EA6 concepts in using a wide variety of analysis and modeling tools that are commercially available. Tool selection is discussed as part of the Advanced EA course.

The CEA curriculum is designed with working professionals in mind, with each 12-week course being taught online through Carnegie Mellon University's robust learning environment. Students should expect to spend 6-8 hours per week on assigned readings, a weekly video lecture and discussion posting, monthly phone conference sessions, a short topic paper, and a final course research paper. The outcome is that the CEA's are able to understand and apply EA concepts in their work which allows them to scale their analysis, design, and management abilities at the highest and most detailed levels of large complex organizations in a consistent manner – a unique and valuable skill.

Recommended literature:

An Introduction to Enterprise Architecture, 4th Edition, by Scott A. Bernard, Author-House, ISBN: 978-17283588055 [Bernard, 2012]

Each course can be selected individually with "EA Fundamentals" as a prerequisite for the others. A Certified Enterprise Architect certificate is awarded for completion of the 3 part series: EA Fundamentals, EA Architecture for Mergers and Acquisitions and Advanced EA courses. Certification is in addition to the certificates awarded in the individual courses.

A Challenge Exam is an option for students who have experience in EA, giving them an opportunity to "test out" of the EA Fundamentals course. This examination evaluates an applicant's knowledge of fundamental enterprise architecture (EA) concepts and practices

in a way that is consistent with the EA Fundamentals course offered by Carnegie Mellon University. The approach to EA used in the EA Fundamentals course is the EA3 "Cube" Framework and methodology that is explained in the book: "An Introduction to Enterprise Architecture" ISBN 1-4208-8050-0. Some questions come from the book, which is available through on-line bookstores.

The design of the challenge examination ensures that applicants understand EA and the EA3 Cube Framework, also used in the Advanced EA course. Completion of the Fundamental, the Advanced EA and the EA Architecture for Mergers and Acquisitions courses are required to earn designation as a "Certified Enterprise Architect" from Carnegie Mellon-ISR, for which a separate certificate is issued. There is no challenge examination for the Advanced EA or EA Architecture for Mergers & Acquisitions courses.

### **3.21 USA - Penn State University, Pennsylvania<sup>28</sup>**

At Penn State University you can earn a degree in "Master of Professional Studies (M.P.S.) in Enterprise Architecture and Business Transformation". The Graduate Program Head is Mary Beth Rosson, Prof. of Information Sciences and Technology at the University Of Texas At Austin.

The following details were taken from the University's website<sup>28</sup>.

The requirements for joining the study are as follows (one of the criteria is needed)

- An approved baccalaureate degree with a minimum grade point average of 2.75 or above, (on a 4.0 scale) a minimum of five years of relevant work experience, three letters of reference, and a personal statement of relevant experience and goals.
- An approved baccalaureate degree with a minimum of a 3.00 (on a 4.00 scale) grade point average, a minimum of two years of relevant work experience, three letters of reference, and a 1-3 page personal statement of relevant experience and goals.
- A graduate degree, a minimum of one year of relevant work experience, three letters of reference, and a 1-3 page personal statement of relevant experience and goals.
- An approved baccalaureate degree, successful completion of three courses in the program with a minimum of a 3.50 (on a 4.00 scale) grade point average as a non-degree graduate student, at least two years of relevant work experience, and a 1-3 page personal statement of relevant experience and goals.

The language of instruction at Penn State is English. English proficiency test scores (TOEFL/IELTS) may be required for international applicants.

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<sup>28</sup><https://bulletins.psu.edu/graduate/programs/majors/enterprise-architecture-business-transformation/#text> accessed at: 30.9.2021

### 3. THE EDUCATION DETAILS

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The Master of Professional Studies Program in Enterprise Architecture and Business Transformation (MPS/EABT) is a unique program designed for professionals aspiring to advance to roles with enterprise wide scope and authority, such as that embodied by an enterprise architect. The MPS/EABT provides a comprehensive educational experience in the principles and practice of enterprise architecture (EA) and integrates both business and enterprise technical knowledge. The program includes courses in:

- enterprise architecture foundations,
- business architecture,
- information technology architecture,
- enterprise security and risk architecture,
- organizational leadership,
- strategic management, and
- financial management.

Required courses:

- Enterprise Architecture Foundations I
- Enterprise Modeling
- Enterprise Information Technology Architecture
- Architecting Enterprise Security and Risk Analysis
- Managing and Leading People in Organizations
- Financial Management
- Global Strategic Management
- Strategic Business Architecture

Elective concentrations are available in Supply Chain, Security Architecture, Business Architecture, and Project Management. A list of courses required for each concentration is maintained by the graduate program office.

Each degree candidate must complete a capstone project on a topic related to enterprise architecture and agreed upon between the candidate and faculty member-in-charge.

Learning outcomes

1. **KNOW** Demonstrate knowledge of effective Enterprise Architecture concepts that align with business strategy.
2. **APPLY/CREATE** Design, develop and apply an effective risk strategy across the enterprise.
3. **COMMUNICATE** Communicate the value of Enterprise Architecture with business and technology stakeholders.
4. **THINK** Graduates will be able to think analytically and critically about the application of concepts and methods in enterprise architecture frameworks.
5. **PROFESSIONAL PRACTICE** Understand the importance of effective modeling and project portfolio management in the Enterprise Architecture process.

### 3.22 USA - University of Denver<sup>29</sup>

At the University of Denver (DU) the course "Enterprise Architecture" is offered, students can earn four DU credits, this corresponds to 5.0 ECTS<sup>30</sup>. The responsible persons/lecturers are Rick Bauer, Lisa Meacham and Galina Pildush.

The following details were taken from the University's website<sup>29</sup>.

In this course, students will learn how to integrate information and communications technologies to effectively and efficiently support business goals. The course examines how enterprise architecture (EA) informs business and technology strategy, including defining, designing, and delivering Information and Communications Technology (ICT) systems and solutions. The course will explore the basics of EA, such as reference architectures, architecture patterns, and a comparison of EA and other architecture types. Students will also examine the opportunities and limitations of various EA frameworks. Students will apply the methods and tools of one of those frameworks, TOGAF, to design and document an EA initiative. Additionally, EA implications of recent ICT trends such as cloud computing, global privacy and data protection, artificial intelligence, and ICT ecosystems will be explored.

Course outcomes

At the end of this course, students will be able to:

- Analyze the fundamental concepts and applications of Enterprise Architecture to enable an organization to accomplish business goals, improve performance, and effectively manage complex 21st-Century organizations

<sup>29</sup><https://universitycollege.du.edu/courses/coursedetail.cfm?degreecode=ict&coursenum=4010> accessed at: 30.9.2021

<sup>30</sup>credit conversion for DU: [https://abroad.du.edu/\\_customtags/ct\\_FileRetrieve.cfm?File\\_ID=71%20/](https://abroad.du.edu/_customtags/ct_FileRetrieve.cfm?File_ID=71%20/)

### 3. THE EDUCATION DETAILS

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- Compare leading Enterprise Architecture approaches, frameworks, and tools to distinguish their contexts, characteristics, and uses
- Explain the interrelationships among Business Architecture, Information Systems (Data and Applications) Architectures, and Technology Architecture, including where Governance and Security intersect across these domain architectures
- Combine software tools and documentation techniques to design key TOGAF® artifacts
- Explain the implications of recent trends on Enterprise Architecture

#### Required readings

- Ross, Jeanne, Peter Weill, and David Robertson. 2006. Enterprise Architecture as Strategy: Creating a Foundation for Business Execution. N.p.: Harvard Business Review Press.; ISBN-13: 9781591398394 [Ross, 2014]
- Ismail, S., Michael Malone, and Yuri Van Geest. 2014. Exponential Organizations: Why New Organizations are Ten Times Better, Faster, and Cheaper than Yours (and what to do about it). N.p.: Diversion Books.; ISBN-13: 9781626813588 [Ismail et al., 2014]

#### Covered topics

- The Strategic Role of Enterprise Architecture in Economic Disruption and Transformation
- Understanding Enterprise Architecture Methodologies
- Business Architecture - Vision, Strategy, Capabilities and More
- Information System Architecture - Applications and Data
- Technology Architecture - Infrastructure
- Enterprise Architecture Artifacts and Tools - Exploring Archi and ArchiMate
- Role of Security in Enterprise Architecture
- The Role of Reference Architectures in Enterprise Architecture
- The Impact of the Regulatory Environment on Enterprise Architecture
- How ICT Trends Affect Enterprise Architecture - Agile, Cloud, AI, and Vendor Ecosystems

## Assignment overview

See the assignment grid below for an overview of the course assignments and point values.

Week	Assignment Due	Point Value
Weeks 1-10	Class Participation/ Discussion Posts	10 pts x 2/week): Total 200 points
Week 2	Enterprise Architecture Role Analysis Paper	100 points
Week 6	Analyzing the TOGAF® Archinsurance Case Study	200 points
Week 7	Archinsurance Case Study and Security	100 points
Week 9	Analyze impact of global data privacy and data sovereignty regulations on the case study	100 points
Week 10	Portfolio Assignment - Enhance the Case Study to incorporate cloud-based AI	300 points
Total		1000 pts



# Classifications and Meta Analysis

The information collected from the universities' websites and the responses with additional facts will now be analyzed for commonalities. The University of Antwerp and the Penn State University take a unique role on the list: they are both fulltime studies worth at least 60 ECTS with approximately 30 ECTS covering EAM and similar topics and therefore not listed in every table. Alumni of these studies earn a special master 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. As seen in the detail view of the educational offers in chapter 3, not all desired information could be collected from every university, why institutes with a lack of information were further omitted in the specific case. Saying that some of the following statistics consist of less than 22 universities.

The aspects observed can be divided in areas such as organizational as well as content aspects. The organization of the considered educations consists of attributes like credits, type of knowledge transfer, if EA or EAM is the main content element or if it is only a (maybe small) part of the course (full vs. part), if it is part of a technical or a business/management study, and so on. The content aspects include the taught frameworks, modelling 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/management or Informatics side or is it a mixture of both, and is it enclosed in a primary study (Bachelor) or a secondary (Master) education? Table 4.1 shows that two out of 22 are part of a Bachelor's study, the other 20 have a finalized academic study as a prerequisite and are therefore enclosed in Master studies. The distribution between Informatics and Business Informatics as the study discipline can be read off in table 4.2 and is about 1:2, two

universities offer the course for students in both study directions. The separation of the study direction will be further discussed in more detail in the next chapter, Best Practice.

Table 4.1: Study graduation

Graduation	count
Master	20
Bachelor	2
sum	22

Table 4.2: Discipline

Discipline	count
Business Informatics (BI)	14
Informatics (Inf)	6
BI + Inf	2
sum	22

The educational offers can be divided into different types of offers. Is it a course, a module consisting of more than one course, a certification or a whole study? Figure 4.1 and the corresponding table show the spreading of the observed classes. The two studies are both secondary studies with Master graduation.

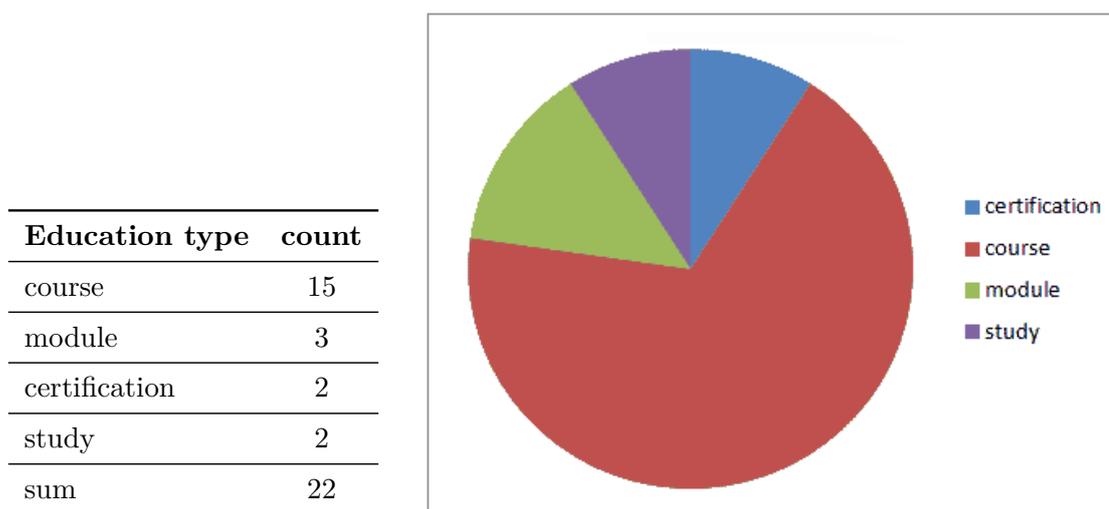


Figure 4.1: Education types

The level of intensity the topic EAM is covered, varies over the classes. Studies, modules, and certifications highlight the theme as the ruling topic. Other courses deal with only this topic, whereas some courses focus on a broader view and EA or EAM are 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 EA. The distribution can be seen in figure 4.2.

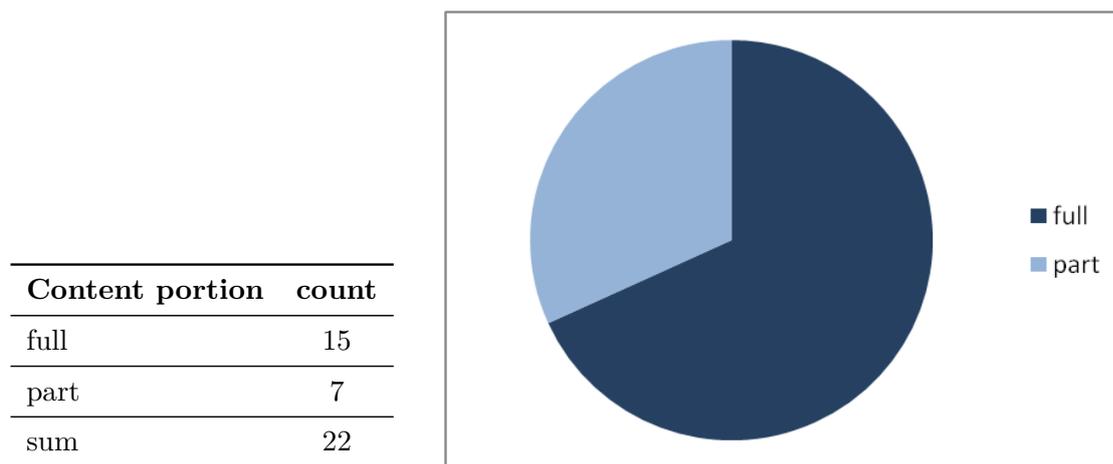


Figure 4.2: Share on content volume

The credit hours, based on the effort students must invest to pass an academic education unit, are in the next comparison only taken from courses. This attribute, called European Credit Transfer and Accumulation System (ECTS), is standardized in many European countries as a grading system while USA and Australia work with exchange system for the most universities. These exchange factors make courses more comparable. Figure 4.3 and the corresponding table show the distribution of course credits.

Half of the evaluated universities offering educations regarding EA use English as spoken language, but also the countries language is often used as can be seen in figure 4.4.

## 4.2 Content

As mentioned in the Introduction chapter, various established frameworks covering EA exist. Although a lot of different frameworks are taught in the observed educations, TOGAF, The Open Group Architecture Framework, is by far the most taught one, followed by the Zachman framework, also the St. Galler House of Digital Business is taught at two universities. ITIL is called twice but cannot be seen as EA framework as it is a best practice for IT service management and maintenance handling, covered by IT Management courses. Some educations teach more than one framework, while this information is missing from other ones. Table 4.3 gives an overview of the taught frameworks.

ECTS	count
6.0	4
3.0	3
5.0	3
7.5	3
4.0	2

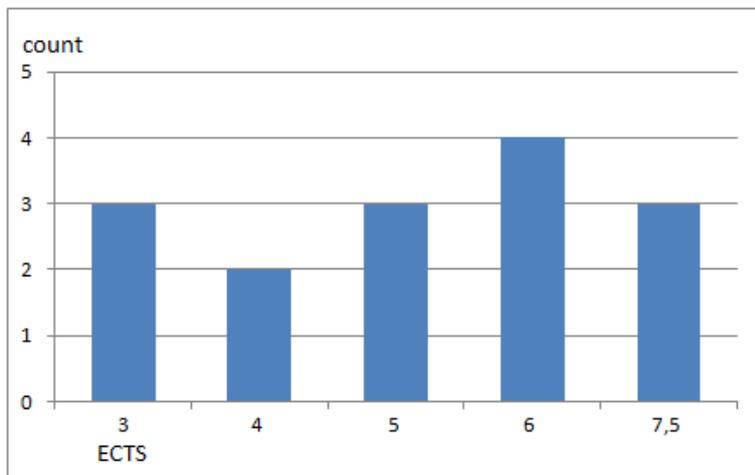


Figure 4.3: Course credits vs. number of courses

Teaching language	count
english	11
german	8
dutch	1
french	1
latvian	1

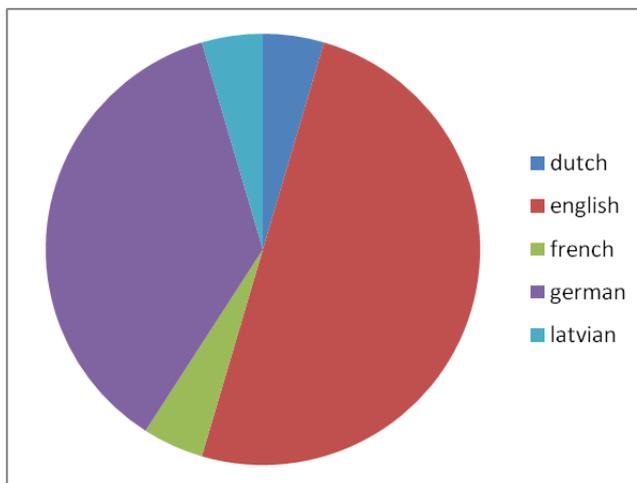


Figure 4.4: Teaching languages

Table 4.3: Taught frameworks

<b>Frameworks</b>	<b>count</b>
TOGAF	11
Zachman	5
ITIL	2
St. Galler House of Digital Business	2
Adaptive EA	1
ARIS	1
BMC	1
e3Value	1
EA3 „Cube“ Framework	1
EA6	1
IT4IT	1
Requirement Engineering (RE)	1

The favorite modelling language is ArchiMate followed by Business Model Canvas, which can be seen in table 4.4. The information about the modelling language could only be collected from seven institutes, two of them covering more than one.

Table 4.4: Taught modelling languages

<b>Modelling Language</b>	<b>count</b>
ArchiMate	7
Business Model Canvas	2
BPMN	1
e3value	1
UML	1
4EM	1

The most used tool for the lecturers is easily Archi, an open-source tool. This is no surprise as Archi has become the world's most popular ArchiMate modelling tool and can be downloaded for free. Table 4.5 shows the used tools for the observed courses.

The combination of TOGAF - Archi is called six times, the combination ArchiMate - Archi and TOGAF - ArchiMate five times, these are by far the most called combinations.

Table 4.5: Used tools

<b>Used tools</b>	<b>count</b>
Archi	9
ADOit	1
ArchiMate Templates	1
Draw.IO	1
EAMTS	1
IBM requirements identification and management tools	1
Signavio	1
TEAM	1

The evaluation of the kind of knowledge transfer the universities use, gives a homogeneous image. Most of the courses use a combination of lectures and exercises, also the modules are made up of courses and exercises such as seminars or workouts in small groups.

Table 4.6: Type of knowledge transfer

<b>Content type</b>	<b>count</b>
lecture + exercises	11
lecture	2
learning by doing collaborative work in small groups	1
lecture, exercises in groups, presentation, discussion, documentation	1
workshop	1

As seen in table 4.7, the list of assessments for grading the student's success has more than a handful of lines. The most mentioned items were group projects or assignments, presentations and exams. The three named case studies are not explicitly assigned to group or individual work.

The list of recommended or used literature is quite long, therefore only relevant books, which are named more than once are listed in table 4.8. For example the book "Enterprise Architecture at Work" by Marc Lankhorst and a lot of co-authors is mentioned four times. This is no surprise, as the book's content is mainly about TOGAF and ArchiMate and gives some good explanations about the first steps and practical proceedings using

Table 4.7: Used assessments

<b>Assessments</b>	<b>count</b>
group project/assignment	11
presentations	7
written exam	7
research papers/reports	4
case studies	3
discussion	2
individual report/assignment	2
homework	1
online quizzes	1
oral exam	1
transfer report	1

this exact framework and modelling language. Inge Hanschke's book "Strategic IT Management: A Toolkit for Enterprise Architecture Management" is nominated three times giving an overview regarding the management of IT systems and therefore a broader view and EA only as one chapter. It is recommended for courses with EA only as a part of the content as mentioned in figure 4.2.

Table 4.8: Recommended literature

<b>Literature</b>	<b>count</b>
Lankhorst, M. et al., Enterprise Architecture at Work - Modelling, Communication and Analysis. Springer [Lankhorst et al., 2017]	4
Hanschke, I.: Strategic IT Management: A Toolkit for Enterprise Architecture Management. Springer, 2009. [Hanschke, 2010]	3
TOGAF [The Open Group, 2021b]	2
ArchiMate [The Open Group, 2021a]	2
Feurerer, S.: Enterprise Architecture - An Overview. SAP Deutschland AG & Co. KG., 2007. [Feurerer, 2007]	2

These classifications found some commonalities among the educational offers observed. The next step is a refined view on the courses in the list to possibly find prototypical courses for both technical and business/management oriented studies. The next chapter

focuses on this topic.

## Best Practice

During the last chapter Classifications and Meta Analysis the attributes were classified, and the educations assigned to the resulting classes. In this chapter only the courses are taken into consideration and separated into groups covering technical versus business or management aspects. The goal is to find a prototypical course that includes most of the given attributes for both disciplines. For achieving this target the modules - all consisting of a lecture and a practical exercise seminar - are taken as courses and in this chapter included in this category.

The last chapter pointed out that there are 18 courses/modules that can be taken for this works purposes. These items are now separated into two classes as seen in table 5.1, giving 13 courses in class BI and seven in class Informatics. Again, two universities use the course in both studies and are therefore used in both directions.

Table 5.1: Discipline of courses vs. all educations

<b>Discipline</b>	<b>courses</b>	<b>complete</b>
Business Informatics (BI)	11	14
Informatics (Inf)	5	6
BI + Inf	2	2
sum	18	22

Following the sequence of the last chapter two groups are classified by the intensity of the course content regarding the topic EA or EAM. Table 5.2 shows a little majority on both sides towards the handling of EA as the main topic of the course as already seen in the last chapter in figure 4.2. The two courses used in both disciplines are IT Management courses and teach EA only in a fraction of the lectures.

Table 5.2: Intensity of EA on courses

<b>Content portion</b>	<b>BI</b>	<b>Inf</b>
full	7	4
part	6	3
sum	13	7

## 5.1 Organizational aspects

The spoken language during the course is listed in table 5.3. Although the majority (75%) of the BI courses are held in their national language and only 25% in English, controversy to the Inf courses, showing the opposite distribution, the recommendation is to use English as the instruction language giving also international students the possibility to join classes. In most cases the recommended literature is written in English.

Table 5.3: Course language

<b>Language</b>	<b>BI</b>	<b>Inf</b>
English	3	5
National language	9	2

For the knowledge transfer some methods are used, as seen in table 5.4. This attribute could not be identified in all courses, therefore this list results smaller than expected. All in all the combination of lecture and practical exercises has a majority and is therefore recommended for both prototypical courses.

So far there were only subtle distinctions between technical and business/management oriented programs caused by the organizational aspects of these attributes. The observations regarding the content should show some differences.

Table 5.4: Type of knowledge transfer

<b>Content type</b>	<b>BI</b>	<b>Inf</b>
learning by doing collaborative work in small groups		1
lecture	1	1
lecture + exercises	8	2
lecture, exercises in groups, presentation, discussion, documentation	1	
workshop		1

## 5.2 Content aspects

The first content attribute to compare is the one of taught frameworks (table 5.5). Although the first place taught in all categories is in both cases held by TOGAF and Zachman's framework, the recorded items are worth to survey:

- In the business/management courses concentrating full on EA (BI full) only three different frameworks are taught: TOGAF, Zachman, and the St. Galler House of Digital Business.
- The taught frameworks in BI courses containing only partially the topic EA (BI part) are similar to the partial Informatics courses with some exotic or non-EA entries like ITIL or Requirement Engineering (RE).
- The Informatics courses with EA as the main/only topic nominated in 3 of 4 cases two frameworks: TOGAF/Zachman, TOGAF/Adaptive EA, e3value/BMC, the fourth course named TOGAF alone.

It's worth to mention that the same lecturer teaches in a BI course TOGAF and in an Informatics course e3value/BMC.

Table 5.5: Taught frameworks per discipline/volume

Frameworks	BI		Inf	
	full	part	full	part
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

Opposite to the taught frameworks only a small amount of courses published the taught modelling 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.

Table 5.6: Modelling languages per discipline

Modelling language	BI	Inf
ArchiMate	4	1
Business Model Canvas, e3value, ArchiMate		1
UML, BPMN, ArchiMate	1	1
4EM, ArchiMate, Business Model Canvas	1	

Analyzing the used tools during the course lead to a similar image. Archi is the top dog in both disciplines, the other tools are all named only once.

Table 5.7: Used tools per discipline

Used tools	BI	Inf
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	

The assessments used for grading the students are similar but not equal: Interesting is the lack of exams (written or oral) in Informatics courses, whereas BI courses mainly use exams near presentations. Group projects or assignments, research papers, and case studies are often used for reviews in both disciplines. A detailed list of the used assignments can be found in table 5.8. The borders of projects, case studies, reports are blurred, the information regarding this topic is not precise. The teaching format of many lectures is Distance Learning, therefore discussions are, caused by the actual situation, not possible in most cases.

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 analysed in tabular or listed form. The elements for comparison were taken only from courses completely concentrating on the topic EA, not reflecting ones with a broader focus. Therefore only a small group of education was taken into account. Although the University of Potsdam was considered in some other statistics caused by the integrating topic of ERP, the main focus of the course, was excluded for getting true commonalities and separations.

A summary of the elements found in both disciplines' descriptions can be found below:

Table 5.8: Used assessments per discipline

<b>Assessments</b>	<b>BI</b>		<b>Inf</b>	
	<b>full</b>	<b>part</b>	<b>full</b>	<b>part</b>
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

- Introduction / Overview / Motivation EA / EAM / modelling language(s)
- IT strategy / strategic context / strategy realization
- EA artefacts / frameworks / modelling languages / tools
- EA model elements / ArchiMate layers
- examples and exercises

Noticeable are the following differences in the course descriptions:

### 5.2.1 BI content

In BI courses the following contents of teaching can be found:

- Steering change  
Organizations are often forced for changes, eg. by market changes, governmental rules, technical reasons. How can these changes be handled with respect to business processes, running IT systems, strategy, ...?
- Value of EA when a particular organization wants to introduce new digital technology / transformation from an information to a digital society
- Fundamental organization of a company as a socio-technical system  
The mixture of human beings, IT systems, organizational hierarchies, technical equipment, stakeholders, shareholders, ... has to be identified to run a successful business

- Digitization of economy and society  
Society behavior changes and works as a driver for companies to transform their association with customers, partners and employees. How can the change of an organization onto new digital technologies be handled and what are the consequences.
- Outsourcing  
What are the consequences when IT is handed over to a specialized company outside?

### 5.2.2 Informatics content

Informatics courses have as ingredients

- Critical success factors for implementation of common EA approaches  
Who are the key players, what are the essential needs, biggest risks and what is only nice-to-have in successful implementing an enterprise wide IT project?
- Costs and benefits  
How to get a realistic cost estimation, Return on Investment (ROI) calculation, and identify and name invaluable efforts.
- Opportunities and limitations of various EA frameworks
- Implications of recent IT trends such as cloud computing, global privacy and data protection, artificial intelligence, and ICT ecosystems.
- Security in EA  
Security as a key fact for data handling and protecting company, customer, employee data.
- Technology and infrastructure aspects  
How to handle technology changes, updates, maintenance aspects, migration, external devices and services, ...? How to get the desired know how.

Another element found in some courses is the integration of guest lectures, preferring decision makers in leading companies, to present the realization of EA in practice and to emphasize the importance of this topic. Some universities, but only a small minority, have a cooperation with industry partners to give the students the possibility to graduate their exercises close to reality.

The final aspect of finding a prototypical course for technical and business/management specific studies is the definition of recommended literature. "Enterprise Architecture at Work" by Marc Lankhorst et al. [Lankhorst et al., 2017] 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/or ArchiMate, if this framework and modelling language are chosen, should not be missed. In BI courses Inge Hanschke's "Strategic IT

Management" [Hanschke, 2010] is popular. Some lecturers prefer more business/economic oriented books like Buchta et al. [Buchta, 2004] or Bernhard et al. [Bernhard, 2003a], [Bernhard, 2003b], but 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" [Ahlemann et al., 2012].

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.

Using the table 2.1 from chapter Methodology the appropriate fields are presented in table 5.9.

Table 5.9: Assessment frame per discipline

Name	Enterprise Architecture	
Graduation	Master Business Informatics	Master Informatics
Type	course or course+seminar	
Credits	6.0 ECTS	
Content type	lecture + exercises	
Underlying Frameworks	TOGAF, Zachman, St. Galler House of Digital Business	TOGAF
Modelling language(s)	ArchiMate	ArchiMate, Business Model Canvas
Used Tools	Archi	
Recommended Literature	see list below Section 5.3	
Language	english	
Details	Introduction / Overview / Motivation EA / EAM IT strategy / strategic context / strategy realization EA artifacts / frameworks / modelling languages / tools EA model elements / ArchiMate layers in detail examples and exercises	
Discipline specific content	BI specific content see Section 5.2.1	technical content see Section 5.2.2
Guest Lectures	industry speaker to underline the importance	
Assessments	group projects (case study) presentations, individual report/assignment exam	

### 5.3 Recommended literature

Recommended literature:

- M. Lankhorst: Enterprise Architecture at Work - Modelling, Communication and Analysis. [Lankhorst et al., 2017]
- ArchiMate [The Open Group, 2021a]
- I. Hanschke: Strategic IT Management: A toolkit for enterprise architecture management. [Hanschke, 2010]
- Ahlemann et al. Strategic Enterprise Architecture Management. Challenges, Best Practices and future development. [Ahlemann et al., 2012]

# CHAPTER 6

## Conclusion

The topic Enterprise Architecture has a dynamic increasing importance for successful companies. The need to synchronize the current state of business and IT, align changes and future requirements lead to a high demand of specialists mastering the needed tasks for successful transformations.

Many universities all over the world offer educations in different flavors to cover these needs. In this study 22 courses, modules, certificates and Master studies were analyzed to find commonalities in the disciplines Informatics and Business Informatics, representing a more technical vs. a more business/management orientated education. These educational offers range from a highly concentrated view on the topic EA to small parts, sometimes only one or two lectures, from lectures to practical workshops, in some cases at industrial partners. And with different approaches, content, tools and systems for grading the student's success.

The search for highest accordance lead into a prototypical course for both directions with a lot of congruence but also with differences that make the courses special for the specific education.



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# Acronyms

**AI** Artificial Intelligence. 3

**DoDAF** Department of Defense Architecture Framework. 2

**DT** Digital Transformation. 3

**EA** Enterprise Architecture. 1–3, 5, 6, 9, 11, 19, 27, 33, 36, 38, 39, 47, 49, 55, 58–61, 63

**EAI** Enterprise Architecture Integration. 25

**EAM** Enterprise Architecture Management. 1–3, 5, 9, 12, 16, 25, 29, 47, 49, 55, 59, 61

**ECTS** European Credit Transfer and Accumulation System. 49

**ERP** Enterprise Resource Planning. 25, 58

**FEAF** Federal Enterprise Architecture Framework. 2

**GPS** Global Positioning System. 3

**ICT** Information and Communications Technology. 43, 44, 60

**IoT** Internet of Things. 3

**IT** Information Technology. 1–3, 39

**ITIL** IT Infrastructure Library. 14, 49

**RE** Requirement Engineering. 57

**ROI** Return on Investment. 60

**TOGAF** The Open Group Enterprise Architecture Framework. 2



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