Academic Media Architecture for Digital Learning Environments in Higher Education

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Abstract. Digitalization and emerging technologies influence higher education and especially students and lecturers in many ways. The following paper develops two artefacts: First of all, a meta-model for student profiles as a basis for understanding their requirements and secondly, an academic media architecture bridging the gap between the changing requirements of students, institutions, companies and the government. The requirements evolve with the ongoing digitalization and the different possibilities of effective media use in higher education. The academic media architecture allows for universities to analyze their current media use but also to support the target-oriented implementation of a redesigned architecture in order to remain competitive with competitors entering the higher education market, such as Udacity and eVersity.

Keywords: academic media architecture (AMA), requirements for e-learning, digital learning environments

1 Introduction

Khan Academy, Udacity, Coursera, eVersity and quite a few other names could be mentioned to mark a fundamental turn in higher education representing two things: On the one hand, they are a mirror of today´s society being more mobile and more online. On the other hand, they address the need of people gaining knowledge in specific topics rather than taking a full study program [1]. At first sight they currently do not seem to be a direct competition for traditional universities, but they might very well be in the future. Therefore, a rethinking of the goals, roles and positions of universities in the future has to take place. This can only be done systematically if the students and the requirements of the institutions, companies and political actors are well known and addressed within the transformation process.

The goals of the paper are first the modelling of student profiles as a decision basis for the provision with educational products and services and secondly, based on step

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one, the design of an academic media architecture (AMA), which is a conceptual framework of media for higher education. The student profile illustrates the demand side of the market and the AMA the supply side catering for higher education students. To reach these goals the following research questions have to be answered:

(1) What are the requirements of institutions, companies and politics with respect to skills and competencies of future employees? (2) What are the emerging characteristics of students with respect to university education in a digital environment? (3) How can – based on these parameters – the AMA for higher education be modelled? In the following section we conceptualize the topic before we take a closer look at the current knowledge on modelling student profiles and the design of AMA in scientific literature. Therefore, we discuss the requirements for digital learning environments set by institutional, corporate and political stakeholders. The analysis of the student profile is based on metadata of surveys whose elements are verified in literature (section 3). The resulting student profile is the basis for designing an AMA presented in section 4.

2 Background and Conceptual Foundation

We focus on students of higher education which includes regular on-campus students at universities but also part-time and remote-learning students with full-time jobs or a background which makes it impossible to attend lectures personally (e.g. family responsibilities and physical impediment) [**2**]. Due to their educational, family and ethnic backgrounds students show a high level of diversity which has never seen before at universities [3] and thus makes it also interesting for research because existing concepts are not fitting to the emerging requirements brought up by digitalization. In higher education the traditional top-down ways of disseminating knowledge through face-to-face tutorials and in-class lectures are in need of reform.

2.1 Institutional, Corporate and Political Requirements

Digital technology assists universities in meeting the academic needs of an increasingly heterogeneous student body. In addition digital teaching poses a new challenge for universities to face the current changes and to reform and internationalize university curricula and exam regulations [**2**] in order to enable the graduates to meet the demands of the digital working life. While digitalization has produced a new student target group and clientele due to easier access to higher education as described above [**3**], it also forces the institution in charge to come up with a different qualification profile for professors and a willingness to integrate digital media in teaching. The professors' role is no longer that of mere communicators or imparters of knowledge but they themselves need to have the digital skills and technical expertise for digital teaching [**2**]. Implementing digital technology at universities does not merely mean digitizing academic knowledge [**3**] but involves establishing the appropriate digital infrastructure while at the same time teaching students how to utilize this infrastructure. Apart from providing the

necessary digital infrastructure, institutions should encourage and support the teaching staff to use digital technology efficiently for teaching by providing incentives to integrate digital media into the curricula [**2**].

One of the universities' main goals today must be to bridge the digital literacy skills gap between graduate students and the expectations of the corporate world.. The pervasive use of digital technology leads employers to expect a different, i.e. higher, level of digital literacy from their employees. In the digital age, universities – apart from providing students with the necessary specialist knowledge required in the student's course of study – must enable students to develop the interdisciplinary digital literacy skills required by a globalized professional world [**4**]. In order to improve employability graduates should know how to search databases and how to use digital technology for a better work result. Furthermore, they should be able to analyze digital information, to respond to digital developments quickly, to utilize and benefit from digital media such as social and professional online networks and platforms, apps, cloud storage, etc.

The changing institutional and corporate requirements also influence the political discussion and underline the necessary adjustments of the political surroundings allowing for the transformation of the educational sector to be supported. This is especially important as the higher education is mainly governed by political decisions, regulation and laws. Initiatives like [**2**,**5**] outline the political actions to enable this transformation. Furthermore the legal implications going hand in hand with the digital development, such as the (changing) provisions relating to copyright in particular, intellectual property law in general and data protection laws have to be addressed by political decisions. To sum up and answer the first research question, the AMA has to fulfil the following requirements: to address the needs of a heterogeneous student body, to support the qualification of students for digital working life, to assist the professors in their teaching, to provide the necessary infrastructure for the higher education facilities, to support the digital literacy of the students and has to relate to the political and legal framework conditions.

2.2 Conceptualization

Digitalization influences students' behavior and needs with respect to their learning processes. Universities recognize this change and try to meet the emerging needs and resulting requirements. Some of these requirements have already been analyzed and are briefly presented in the following, being important for the concepts addressed by the AMA (Figure 1). Most students possess digital literacy skills, which means they are able to use laptops, mobile technologies like smart phones, iPods, and tablets for research, information capturing or communication [6]. Flexibility is another important factor for students. Flexible learning is defined as "a movement away from a situation in which key decisions about learning dimensions are made in advance by the instructor or institution, toward a situation where the learner has a range of options from which to choose with respect to these key dimensions" [7]. Key flexibility dimensions are related to time, to content, to entry requirements, to institutional approach and resources, to delivery and logistics [7]. Flexible learning in this sense

enables the students to learn anywhere, anytime and to decide on the amount of learning content they like to study at a given point in time. A recent study states that students are getting "easily bored in the absence of diversity" [8]. In order to reach the students not only flexibility is an important factor, but involvement and collaboration as well as sharing have to be addressed [9]. A way to involve students into the learning process is by working with case studies [10], allowing the group members to collaboratively develop own solution. Working in groups also implements the *sharing of knowledge*, the exchange of knowledge between students.

Besides the mentioned requirements of students, different learning methods need to be considered by universities. *Blended learning*, for example, combines online and offline learning modalities [**11**]. The concept of *authentic learning*, a practical and specific design concept, refers to the idea of embeddedness of learning in the student's endeavors. The main goal of an authentic task is to encourage students to find ways of solving problems [**12**]. In *case- and scenario-based learning*, students receive a problem set in an everyday context [**13**].

The different learning methods and the students' requirements influence the learning environment. A *learning environment* can be defined as a "social system, focusing on the continuous development and validation of human knowledge and skills in a particular domain" [**14**]. Learning environments for the students can be regarded as mainly *digital learning environments* [**15**].

Following these concepts, we develop an AMA, describing the relationships between different media used in the learning process. These are used to address the preferred learning method of the students and their requirements. The resulting AMA considers these media elements – such as social media and learning applications – interfaces, functionalities, and communication relationships [**16**]. The challenge for universities is that they cannot control and influence the constituents that a learning environment depends on. As a consequence, students gain more control over their learning processes and the design of "their" AMA [**16**]. This is a typical characteristic of social media, where control over relationships and communication processes switches from the supply to the demand side. Figure 1 summarizes the relevant concepts for the AMA.

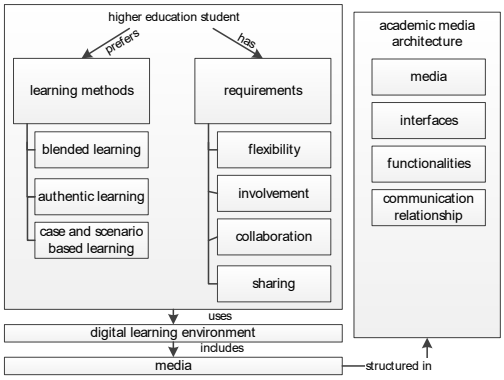

Figure 1. Concepts addressed by the AMA

Nonetheless, universities as the supply side for higher education have to understand future needs of the students. To arrange the needs and resulting requirements, student profiles are derived supporting the design of an AMA which is regarded as a conceptual framework for analyzing and adapting the current design of higher education courses. In the following, the state of the art for deriving student profiles and respective modelling approaches is briefly presented.

2.3 State of the Art

Student profiles are already an object of research and are discussed in different areas of research with various main focuses of interests and goals. A profile in this context is defined as a cluster of properties describing a certain and coherent group of entities, [**17**]. One example is the profile of students with full-time jobs in Germany [**18**]. The profile both influences and supports decisions concerning the offered study programs for this group of students and allows for the systematic testing of a successful mapping [**19**]. Other researchers use profiles to define the requirements of students with different social backgrounds concerning the learning environment [**20**]. The research on and use of student profiles is internationally accepted. The focuses are reaching from technological backgrounds of students [**10**], technology usage [**21**], learning processes [**22**], demographic details [**23**], and competences of students [**24**] to pedagogic and psychological characteristics [**25**]. However, most profiles are specialized and restricted to certain topics. For a broader use in higher education a more comprehensive profile is needed, which bases on a meta-model of properties and allows for the instantiation of various different profiles for an individualized offer. In this paper we therefore aim at designing a meta-model for a holistic student profile taking into account demographic aspects, personal careers and career plans, learning habits and preferences, further training and the students´ state of health. This is important for describing the students as some students may have physical impediments which influence the requirements for learning material or media.

In order to meet the special requirements in the educational context past research has shown that it is important to choose the media with respect to the specific requirements and goals of the teaching field [**26**]. The selection process for the media has also to consider the profile of the "target" students and the subject of interest.

We design an AMA which considers the elements of the architecture: media, interfaces, functionalities and communication relationships. Architectures in the context of media are discussed in research, e. g. [**27**], but AMAs are not discussed in literature so far. The AMA focuses on the conceptual design and not on the technical implementation as various technical solutions are already available.

3 Student Profile

Based on the first and second research question answered in section 2, the following section models the student profile by taking the emerging characteristics of students

with respect to university education in a digital environment into account, which is necessary to develop the AMA in a next step.

3.1 Modelling Approach

The design process of the meta-model for the student profiles is based on conceptual modelling. This is an eligible approach to develop and modify information systems [**28**]. In order to derive a suitable basis for the AMA we looked for a modelling approach which allowed for a comprehensive overview of the relevant properties for the architecture. For the student data model we thus decided on the s*tar schema* approach. The approach's main advantages are the ease to use, that it can be interpreted intuitively, and that it can be updated and accommodates flexibly [**29**]. For this paper we focus on a higher degree of abstraction concentrating on *metadata* in a first step. The classes of the holistic meta-model can be used for instantiating profiles, matching specific scenarios and goals.

Our metadata is structured in three components as classes, properties, and the encoding scheme [**30**]. A star schema consists of a fact table and numerous dimension tables. The fact table represents facts about the situation which should be viewed and modelled. When combining the star schema with the elements of metadata, the facts correspond to the classes. Facts can be characterized by properties [**31**]. Dimension tables consist of nonnumeric attributes whereas fact tables can have numeric as well as nonnumeric data [**29**]. The encoding scheme includes the different characteristics of a dimension, e.g. male or female for the dimension gender.

With this, the basis for developing the meta-model for student profiles and deriving an AMA is built.

3.2 Meta-model of Student Profiles for Digital Learning Environments

The design of the meta-model for the student profile is based on metadata of five surveys for different student target groups: university entrants, students in higher semesters, new graduates, graduates, who have finished university several semesters ago and student drop-outs. The surveys were designed on the one hand using generally accepted questionnaires recommended by following institutes. Firstly, KOAB which is a project coordinated by the International Centre for Higher Education Research (INCHER-Kassel). For that project university alumni participate in surveys. The surveys are run 1.5 years after the students' degree and are repeated four to five years after the degree, secondly, HIS which is a publication series of survey results conducted by the German Centre for Higher Education Research and Science Studies (DZHW) and as third source the Hagener Online Panel (HOP) which is a virtual lab for online surveys of the institute of psychology of the FernUniversity in Hagen. Students can participate in different surveys of the institute but also in surveys developed by students for their bachelor or master theses. Secondly, the surveys were based on scientific standards by survey literature [**32**,**33**,**34**]. In a first step we identified nine classes by the evaluation of the literature listed above and assigned the metadata to the thematic related classes (see Figure 2).

The questions of the survey are mainly derived from the literature mentioned above, but were adapted to the specific situation of universities. For example, metadata representing the compatibility of study and profession are added to surveys. The class *health* was derived from the Social Survey and the German Federal Statistical Office [**32**].

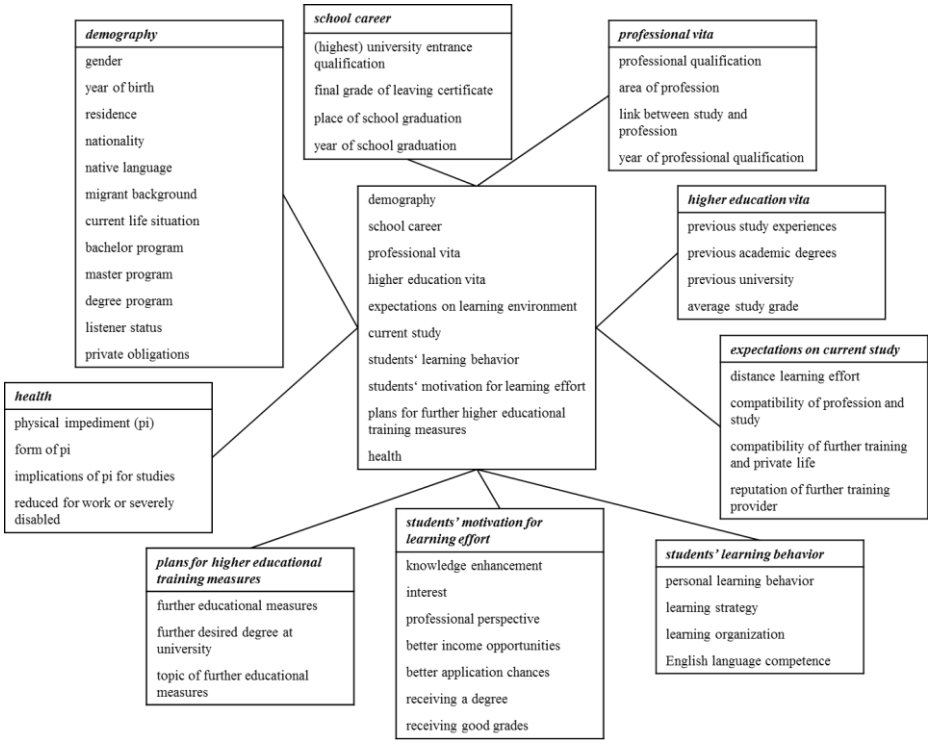

Figure 2. Star schema of student profiles

As explained above it is necessary to use a comprehensive student definition as digital learning environments are designed for a broader public than only the "typical" university students directly graduating from school. Therefore, the profile was complemented by characteristics which are relevant in addition to the student metadata profile. For example the class *plans for further educational training measures* and the appropriate properties. The resulting profile (Figure 2) is describing the metadata characteristics of the student of digital learning environments.

In the center of Figure 2 the fact table presents the classes of the metadata profile for students of digital learning environments. We identified nine classes for the profile from the surveys. In the star schema each class is supplemented by one corresponding dimension table, demonstrating the properties of each class. The star schema in Figure 2 only presents the classes and the corresponding properties, but behind each property there is another table showing the associated encoding scheme which could not be shown in the figure. As explained above the encoding scheme represents all

possible assorted manifestations of the property. After the analysis and illustration of the meta-model for student profiles which depicts the requirements of the demand side, in the following section the AMA is derived as part of the supply side of higher education.

4 Architecture for Academic Media Use

In order to derive a first idea for the design of an architecture for the use of media in an academic context three dimension tables from Figure 2 are exemplarily analyzed: "students' motivation for learning effort", "students' learning behavior" and "expectations on learning environment." These dimension tables are selected as they are not merely demographic but present classes that can be addressed and to a certain extend be controlled by adapting the academic media architecture. Implications for the architecture and thereby structure and use of technology in academic teaching will be derived from these classes. As illustrated in Figure 1, the AMA consists of four components, whose bases are described in the following.

The first component is the *media* itself. Therefore, [**11**] points out that digital technologies offer prospects for modifying education so that students learn in various ways and explore through different electronic and dynamic media. Students are motivated by autonomously choosing different learning media from different educational providers to suit their own learning requirements [**35**]. Students can use the public presentation of their arguments supported by media to defend their position and to learn to express their way of thinking [**36**,**37**]. The use of media in a learning environment enables students to combine their work and daily endeavors with their studying (see Figure 2). The expectations concerning the autonomy should be balanced with supporting students with regards to collaboration, media literacy and assessment. A high degree of structure provided and a low degree of dialogue lead to a high transactional distance (TD). The autonomy of a learner increases with growing transactional distance [**38**]. [**38**] recommends a low TD for students with low self-management skills, while high TD supports the self-regulated learning for learners with better self-control or motivation. Since digital literacy is seen as a core competence (see section 2.1), students need to be enabled to work with digital technologies. Furthermore, media supports the lecturers to concentrate on their unique contribution for learning processes by providing context, acting as mentors, fostering reflection, and creative thinking.

Interfaces to different media which enable the communication between students and lecturers are the second component of an AMA. In an authentic context different learning tasks have to reflect the way knowledge is used in real life. In order to deepen the understanding, access to expert thinking needs to be provided. By using social media tools, students are able to directly interact with experts [**36**]. The sharing of knowledge is connected to the institutional knowledge sharing culture [**40**,**41**].

The third component covers *functionalities* which fulfil the requirements of students and lecturers concerning media in the digital learning environment. It encourages authentic learning tasks supporting transfer of knowledge. These are

authentic "macrocontexts" for learning discussion and problem solving and were proven useful as instructional strategies [**13**]. According to [**26**] students use the competence, or a combination of knowledge, skills and behaviors that should be applied in their professional life situations. Students are using simulations and game-based learning for information skills training [**42**]. With digital technologies students can inquire and research topics for themselves [**43**]. To address flexibility in thinking as well as transfer of skills, a learning environment should offer multiple roles and perspectives to the students and work with tasks that allow competing solutions and a diversity of outcomes. It should also offer articulation and collaboration, as these deepen the understanding and reasoning and identifies the gaps in lines of thought [**35**]. By supporting students to collaborate within their learning processes, they get prepared for the digital working life. The use of digital technology allows flexibility and efficient delivery of learning. One solution is blended learning with a "dynamic digital scaffold" for media use in learning environments [**11**] for emphasizing the facilitation for the lecturers to address the student's learning behavior (see Figure 2) and their need for flexibility. This hybridization enables lecturers to "improve instruction at scale by personalizing the students' learning experiences" [**11**]. Technical devices may influence this structure via automatic feedback, given in, e.g., learning tasks, opposed and/or contributed to interpersonal dialogue [**44**].

The last component focuses on *communication relationships*. [**45**] note that digital technologies offer ways to help students develop and maintain various types of communication. Technological advances have the potential to strengthen and restructure teaching and learning in higher education. Digital technologies promote a learner-centered environment, "when implemented through active inquiry-based learning pedagogies, online learning can stimulate students to use higher order skills such as problem solving, collaboration, and stimulation" [**45**].

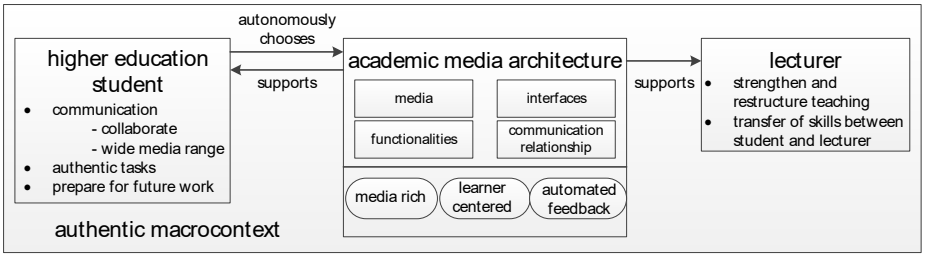

Figure 3: Context and design principles of an AMA

The concept of and relations within the proposed AMA are shown in Figure 3. The authentic macrocontext is the framework for the AMA. Furthermore, the figure is divided into three parts: On the left the higher education students with their characteristics and requirements on the AMA is presented. The lecturers are positioned on the right. The AMA supports both. It is on the one hand illustrated with its four components, and on the other hand the important design measures below.

5 Conclusion and Further Research

The paper has shown that universities face changes in students' behavior and their requirements, as well as new requirements by companies, institutions and politics. It is important to follow a structured procedure when introducing changes in order to fulfil these needs. In a first step, it was crucial to design a meta-model for student profiles to understand the demand side and based on that to derive design principles for an AMA as shown above. Our paper elucidates how an efficient design of an AMA can be derived based on requirements of different interest groups of society. To validate these findings different methodical approaches should also be applied and tested to identify additional aspects for the application of the architecture in higher education. As the developed AMA can be used for higher education in general, it is important to analyze and validate the specific needs that manifest in the respective instantiation of the meta-model for each university.

Further research should dive into the systematic process of creating suitable instantiations of student profiles and deriving respective manifestations of the AMA to provide an individualized learning environment. An interdisciplinary approach could be pursued by looking into adaptive learning environments coming from the field of educational media research and secondly, by integrating the knowledge on learner profiles from psychology. Moreover, it would be necessary to create an approach for measuring the "success" of the mapping process of student profiles and their learning environment, including metrics to measure learning progress and the success of interventions by lecturers. In order to support the validity of the AMA an exemplary case study could be performed by instantiating the model. Finally, questions of data ownership and security arise which need to be addressed regarding legal implications. Therefore, our paper provides a basis for different research ideas.

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