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Academic Teaching of BIM in Germany
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Abstract:
Building Information Modeling (BIM) becomes increasingly established in the construction industry. Accordingly higher education institutions (providing architecture, civil engineering and related degree programs) have to adapt adequate BIM modules to their curriculum so that future young professionals learn not only how to use but also how to implement, shape and control BIM processes in professional life.

In the first part of the paper “Academic teaching of BIM in Germany” the state of BIM in 2017 and the development of BIM in academic teaching in Germany within the last two years is presented. In 2015 only 28 out of 69 investigated institutions (about 40\%) provided BIM modules, since then the number has risen up to 41 institutions (about 60\%). In addition to that further topics for instance the distinctions between universities and universities of applied sciences as well as architecture and civil engineering degree programs are examined.

In the second part of the paper a target state of BIM learning contents at higher education institutions is defined. An examination reveals the current state at German higher education institutions so that the gap between the target and current state is unveiled. One of the main results is, even if multiple involved parties require practicing of new work and communication processes while working on BIM projects in interdisciplinary teams, it is still underrepresented in academic teaching of BIM.

Keywords: BIM; Academic teaching; Curriculum; Learning contents; Universities in Germany

1. Introduction
“Even though BIM is becoming widely adopted in the construction industry, the lack of individuals with BIM skills and knowledge is a key issue in effectively utilizing BIM” (Lee and Hollar, 2013). The implementation of BIM changes not only the requirements on technical skills but also the whole work and communication processes as well as the understanding of job profiles (Liebchen, 2014). As a connector between students and the construction industry, higher education institutions need to implement BIM in their curriculum to support their students to meet the new requirements (Khorrami and Heins, 2015; Lee and Hollar, 2013).

The aim of the research is to present the state of the quantitative spread of academic teaching of BIM in Germany. Furthermore disparities between the current and target state of BIM

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learning contents and consequently the action required at higher education institutions are shown.

2. Research process and methods

The research process is divided into two work packages. In **Work package I** general information and figures about the quantitative spread of BIM in academic teaching in Germany are examined. Therefor figures of 2015 to 2017 are compared concerning the number of institutions offering BIM, the differences between universities and universities of applied sciences, the number of compulsory and elective modules and the differences between architecture and civil engineering degree programs.

In **Work package II** the actual learning contents of BIM are shown. The goal is to examine the focus of offered BIM modules and point out, in what extend German higher education institutions meet the requirements. First the target state of BIM learning contents in academic teaching needs to be defined. Afterwards an examination of the current state of existing learning contents in different higher education institutions needs to be accomplished. On this basis the gap between the target and current state can be shown, to highlight the fields where action is required. Finally recommendations for higher education institutions are given (see figure 1).

Following the research method of both work packages is presented. To depict not only the state of academic teaching of BIM but also the development, a **longitudinal research design** is chosen. This permits to study the changes and progress in academic teaching of BIM (Baur and Blasins, 2014). Therefor the first research was accomplished in 2015 while the second research was finished in 2017. The selected research method is a **nonreactive quantitative method**, which implies no interference with those being studied. The nonreactive quantitative method for this research is a **content analysis of process-produced data**. This involves all data which are produced by public and private organizations within the scope of their duties and not only for academic usage (Diaz-Bone and Weischer, 2015).
The process-produced data which are examined for this paper include the websites of the 69 higher education institutions in Germany which offer architecture and civil engineering degree programs. Especially the curriculums, module descriptions of offered degree programs and additional information about the modules, provided by the higher education institutions on their websites, are investigated.

To accomplish a systematic and replicable content analysis a **coding scheme** (Diaz-Bone and Weischer, 2015), on the basis of the research questions, needs to be developed for each work package. The coding scheme (keywords) for work package I is based on the subdivision of universities and universities of applied sciences, compulsory or elective modules as well as architecture and civil engineering degree programs.

The coding scheme (keywords) for work package II is based on the target state of BIM learning contents (developed in chapter 4.1, figure 7). For each subdivision a list of keywords is created to scan the process-produced data. Afterwards the data are collected and analyzed.

### 3. Work package I – General data of BIM in academic teaching (2015 to 2017)

#### 3.1 The higher education system in Germany

In Germany exist 427 state accredited higher education institutions which can be divided into three types: universities, universities of applied sciences and colleges of art, film and music (Deutscher Akademischer Austauschdienst e. V.). In this paper only the first two types of institutions are considered. While “universities offer strong theoretical and academically-oriented degree programs” (Deutscher Akademischer Austauschdienst e. V.), universities of applied sciences are practice-oriented and impart the skills for “real-world requirements of professional life” (Deutscher Akademischer Austauschdienst e. V.).

Out of the 427 higher education institutions in Germany, 69 provide architecture and/or civil engineering degree programs. Among these 69 institutions 21 are defined as universities and 48 as universities of applied sciences.

#### 3.2 BIM at higher education institutions

In 2015 BIM is implemented in the curriculum of 28 higher education institutions (about 40 %). The learning contents of the offered modules is fluctuating (see chapter 4). Out of these 28 higher education institutions 11 are defined as universities and 17 as universities of applied sciences (cf. Khorrami, 2015, University of Wuppertal, comparable results). The development over the last two years shows that BIM becomes more and more implemented in academic teaching. In 2017 already 41 higher education institutions (about 60 %) provide one or more BIM modules for their students, whereby 15 are defined as universities and 26 as universities of applied sciences (see figure 2).
The total number of offered BIM modules depends on the respective institution. While most institutions just offer one to two BIM modules, some provide several modules with different focuses (Khorrami, 2015). While the number of institutions offering BIM has risen from 28 to 41 from 2015 to 2017, the number of offered BIM modules has almost doubled (36 to 67). On average the intensity (BIM modules per institution) increased from 1.3 (36/28) to 1.6 (67/41) modules per institution (see figure 3).
3.3 Universities and universities of applied sciences

While in 2015 only 11 out of 21 (52%) universities offer BIM to their students, in 2017 already 15 out of 21 (71%) universities provide BIM modules. At universities of applied sciences the spread is significantly lower. While in 2015 only 17 out of 48 (35%) universities of applied sciences offer BIM modules, in 2017 at least 26 out of 48 (54%) provide BIM in different intensities (see figure 4).

![Figure 4](image)

Figure 4. Development of BIM at universities and universities of applied sciences (2015 to 2017)

3.4 Compulsory and elective modules

The required information for the following analysis is not offered by all institutions so that only 33 out of 67 BIM modules are evaluated. Out of these modules only 27% are compulsory modules while 73% are elective modules, which students can choose on their own interests (see figure 5).

![Figure 5](image)

Figure 5. Compulsory and elective BIM modules (2017)
One of the reasons that higher education institutions mostly just offer elective modules might be the effort it takes to introduce a new compulsory module in an existing degree program. Depending on the higher education institution and their respective regulations the establishment of a new module may lead to a change of the examination regulations, which may be fairly time consuming. Because of that it is often easier to introduce an elective module, even if this means that not all students obtain necessary BIM learning contents.

3.5 Architecture and civil engineering degree programs

Furthermore the discrepancy between architecture and civil engineering degree programs is remarkable. In 2017 only one third (22 out of 67) of the offered BIM modules is for architects and about two thirds (45 out of 67) are offered within the scope of civil engineering degree programs (see figure 6). This reflects the situation in the construction industry. Although architects have a large impact on implementing BIM, they are sceptical, partly even refusing towards BIM. One of the reasons, which is frequently stated by architects is that BIM threatens the process of creative planning (Pilling, 2015). In addition to that questions as authorship, liability and insurance are discussed critically and hamper the development of BIM (Ettinger-Brinckmann, 2016).

3.6 Results – work package I

As BIM is becoming increasingly important to the construction industry, over the last two years (2015 to 2017) a huge development regarding academic teaching of BIM took place at higher education institutions (figure 1).

Nevertheless, in figure 2 it is shown that universities of applied sciences need to increase the number of BIM offers to justify their reputation as practice-oriented institutions. But also universities may have to enhance the number of BIM offering institutions to enable future young professionals to implement BIM in the construction industry.

For this it also is decisive that all students get the BIM training they need for their future career. It is most likely that “students with relevant BIM knowledge and skills will have a competitive edge in the current job market” (Lee and Hollar, 2013). To ensure that all students have
the best chances on the job market it could be reasonable to offer at least one compulsory BIM module at each higher education institution (figure 3).

In figure 4 it is depicted that especially architecture degree programs need to increase their number of adequate BIM lectures for their students, particularly as they have a key role in BIM processes.

4. Work package II – BIM learning contents

4.1 Target state of BIM learning contents

To analyze in what extend German higher education institutions meet the set requirements, regarding BIM learning contents, the target state needs to be defined. Therefore three sources are considered:

- BIM organizations,
- literature and
- the construction industry.

In Germany multiple organizations, like BuildingSMART e.V., Planen-Bauen 4.0 and the 5D Initiative, are working on the implementation of BIM in the construction industry. In addition to that especially the German Association of Computing in Civil Engineering (GACCE) defined recommendations on which learning contents should be provided at higher education institutions (GACCE, 2015).

In the literature the most discussed problem concerning BIM learning contents is that BIM modules, provided so far, mainly focus on using BIM capable software. In contrast the imparting of new work and communication processes, which are vital for working as a part of a BIM project, is being neglected (Khorrami, 2015; Khorrami and Heins, 2015; Maaß, 2016; Pilling, 2016).

This allegation is being supported by requirements set by the construction industry. A study of the Karlsruhe Institute of Technology (KIT) encompasses how the construction industry rates the BIM qualification of young professionals. Surveyed were the following parties of the construction process: public and private clients, planning teams (e.g. architects, engineers), construction teams (e.g. building contractors) and facility managers. In the results it is shown that the work and communication process skills of young professionals are rated poor compared to their IT-skills (Both et al., 2013).

The gathered learning contents can be divided into theoretical and practical lectures. The theoretical lectures contain basics, e.g. fundamental knowledge about the topic as well as the introduction of job profiles which emerge out of using BIM. In addition to that technological knowledge needs to be imparted. This includes object-based parametric modeling, data exchange and management and the scope of various BIM tools. The third part are processes which change while working on a BIM project. This encompasses changing work and communication processes and modified responsibilities of the involved project parties. Moreover it includes difficulties regarding the construction law and contractual characteristics. At last the fields of application, which can be improved by using BIM, need to be demonstrated e.g. calculation, tendering or scheduling.
The practical lectures can be divided in two parts. First the technological part where the application of BIM capable software is taught. The second part includes participation in an interdisciplinary team were students can experience the changed work and communication processes during their own project. An overview of these learning contents is given in figure 7.

![BIM learning contents](image)

**Figure 7. Target state of BIM learning contents**

### 4.2 Current state of BIM learning contents

Based on the learning contents the coding scheme of the content analysis for work package II is developed. For each subdivision a list of keywords is gathered. On the basis of this coding scheme the process-produced data (websites of higher education institutions) are scanned. The examination reveals the current state where higher education institutions focus on while teaching BIM. The percent values refer to the number of BIM offering institutions and not to the total number of offered BIM modules (figure 8).

It has to be taken into account that on the one hand the chosen coding scheme and on the other hand the provided information by the higher education institutions (process-produced data) have an essential impact on the results of the examination. It can be expected that the learning contents, which are presented on the websites, may differ from the actual teaching contents. This may lead to a slight variation of the results. Nevertheless, it can be assumed that the overall trend is depicted by the results.
The topics, which higher education institution focus on, are divided into three groups depending on how many higher education institutions offer the respective content. Topics are rated as good if at least 70% of the examined higher education institutions offer the particular topic, with 30 to 69% the topics are rated mediocre, with less than 30% they are rated as poor.

### 4.3 Gap between current and target state

In this paper only the results for BIM learning contents in 2017 are shown. Additional results for 2015 point out that the focus of the higher education institutions did not change considerably during the last two years.

While only one topic, introduction and fundamentals, is rated as good, five topics are classified as mediocre:

- Digital building models,
- Application of BIM capable software,
- Fields of application,
- Data exchange and management and
- BIM Tools.

Topics which are treated poor at higher education institutions are:

- Process modeling and responsibilities,
- Work and communication processes,
- Job profiles and
- Construction law.

Remarkable is that especially modules, where the work and communication processes are taught in interdisciplinary working groups, are not very common at German higher education institutions.
Since BIM has been longer practiced and taught in other countries, it is highly recommended to consider international education concepts as well (Pilling, 2016). In the USA higher education institutions started to implement BIM concepts in 2002. Now there can be found three teaching concepts: single-course concepts where they provide modules for just one discipline, interdisciplinary concepts where they offer modules for two or more disciplines, and distance collaboration where they cooperate with distance schools to offer modules for two or more disciplines (Barison and Santos, 2010).

A possible reason, why German higher education institutions usually just offer single-course concepts, is the high competitive pressure between higher education institutions or departments of one institution which may prevent interdisciplinary concepts and distance collaboration (Khorrami and Heins, 2015).

4.4 Results – work package II

The gap between the target and current state regarding BIM learning contents at higher education institutions reveals that there is a demand for action. Not only topics which are treated poor, for instance process modeling and responsibilities as well as work and communication processes but also topics which are classified as mediocre, e.g. BIM tools as well as data exchange and management, need to be adapted into the curriculum of more institutions.

Especially the academic teaching of work and communication processes in interdisciplinary groups, which is not only discussed in literature but also required by the construction industry, should be provided by higher education institution. As the competitive pressure between higher education institutions seems to prevent distance collaboration, particularly higher education institutions, which already have corporate academic training of architects and civil engineers and related degree programs, should take advantage of this benefit and provide interdisciplinary modules (Liebchen, 2014).

5. Summary

In the first part of the paper it is depicted that academic teaching of BIM in Germany had a remarkable development between 2015 and 2017. The number of higher education institutions offering BIM modules has risen from about 40 % up to almost 60 %. The intensity at this period has risen from 1.3 to 1.6 offered modules per institution. The distinction between universities and universities of applied sciences shows that in 2017 already 71 % of the universities and only 54 % of the universities of applied sciences provide BIM modules to their students. In addition to that it is noticeable that two thirds of the offered BIM modules are embedded in civil engineering degree programs and only one third are offered to architects.

The examination shows that the total number of BIM offering institutions, especially with reference to universities of applied sciences, needs to be increased. In addition to that each institution should offer at least one compulsory module instead of offering elective modules to prepare all students for changing processes in the construction industry. Further the higher education institutions need to ensure that future young professional are able to implement, shape and control BIM processes and as a consequence can contribute to the development of the construction industry. Moreover particularly architects who hold a key role in BIM processes need to increase offered BIM modules to their students.
In the second part of the paper the gap between the target and current state regarding the learning contents of provided BIM modules is presented. The focus differs from institution to institution and also from module to module. Most of the time the modules focus on fundamental knowledge, digital building models, fields of BIM application and the use of BIM capable software.

Nevertheless, working within a BIM project involves interdisciplinary team work and new working and communication processes. These changes in the construction industry are preferably taught in interdisciplinary groups were students experience the new processes during their own project. This learning concept is frequently discussed but still relatively rare spread at German higher education institutions. Only 12 % of the higher education institutions offer this kind of module to their students. This shows that there is still a high potential of development in academic teaching of BIM at higher education institutions in Germany.

References


