Article

STEM and HASS Disciplines in Architectural Education: Readiness of FAD-STU Bachelor Students for Practice

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Abstract: Since the beginning of this century, STEM education has become increasingly important in preserving prosperity and economic competitiveness. Architecture has its own specific attributes. It overarches the STEM and HASS disciplines, and it should be perceived as a cultural phenomenon rather than as a field of study. The main objective of this article is to highlight the methodology based on the statistical method evaluating the correlation rate between the Bachelor’s student performance (SP) in design studio courses and STEM and HASS categories, represented by particular subjects of various areas of study. The relationship between the admission examination procedure and the academic performance of graduates in the DESIGN category was also analyzed. Although the level of knowledge and skills required based on the study results within the curricula was more significant in the HASS category, the direct correlation between subjects in the STEM category, especially engineering, and the quality of the design studio’s outputs as the main and fundamental part of the creative architectural work, was also confirmed. The authors of the article found that STEM knowledge and STEM skills do not reach the required level and, therefore, the emphasis should be placed on changing curricula, balancing the ratio of STEM and HASS categories, adjusting the credits assigned to STEM subjects, or reviewing the classification system.

Keywords: architectural education; STEM and HASS disciplines; bachelor’s study; FAD-STU in Bratislava; student performance; statistical analysis

1. Introduction

Humanity is characterized by the acquaintance of knowledge in various disciplines, to ensure its development, preserve culture, and respond to numerous challenges associated with its activities. It is the basis and assumption for progress, productivity growth, and value/wealth creation. In general, high-quality education allows young people to develop their knowledge, skills, and competencies. It provides them with the system to learn and comprehend the global/local background, as well as the possibility to become creative, active, and responsible citizens fully integrated into society, while meeting its requirements and expectations. In addition, it gives them the option to influence and shape the future and to participate in economic activities.

In the beginning of the 21st century, there emerged a strong need to emphasize the links between prosperity, knowledge-intensive jobs dependent mainly on science and technology (S & T), and continued innovation, especially incremental technological innovation of products and services, to address societal problems and achieve economic competitiveness. Therefore, S & T and its transfer from the education system to the economy play a central role in the modern society based on knowledge and technology [1–3]. In this context, traditional education in science, technology, engineering, and mathematics (also known, colloquially, as STEM education) is an inter-/multi-/transdisciplinary approach to curriculum in many educational systems connecting independent disciplines and represents the primary gateway of higher education to the field of STEM work [4,5]. In fact, the symbiosis...
of design/creative thinking grounded in inspiration, knowledge, and experiences, and the
ability to apply the STEM principles is critical for rational and quantitative designs that
meet performance specifications and requirements [6]. In this regard, there exist several
educational approaches, articulated by numerous authors, for how to synthesize, evaluate,
and formulate solutions to real-world problems such as problem-based, project-based, and
design-centric learning [7–10]. For instance, design-build projects are very popular among
students of the Faculty of Architecture and Design of the Slovak University of Technology
in Bratislava, Slovakia (hereafter referred to as FAD-STU). These projects require/force
students to think broadly. They must respect production proceedings as well as account for
transport and time limitations, but they mainly investigate the features of various materi-
als, deal with many technical issues, propose joints and pipe connections, and so on [11].
Another example of how to incorporate the STEM principles into design considerations of
the problem represents the concept of reverse engineering [12,13].

In contrast to STEM disciplines, there are the so-called HASS disciplines, which are
associated with the humanities, arts, and social sciences. One can argue that their signifi-
cance lies mainly in developing and securing the cultural values of societies. However, the
first group of STEM disciplines existed and succeeded throughout history only because
of the latter. This statement confirms the famous book by Charles Percy Snow, titled “The
Two Cultures and the Scientific Revolution”, and published in 1959. According to them,
the great cultural is divided into two separate considerable areas of human intellectual activity:
science and the arts. To advance human knowledge and benefit society, all practitioners,
’scientistand non-scientists’ in both areas, should build bridges. Snow argues that scientific
culture is really a culture, not only in an intellectual sense but also in an anthropological
sense, with common attitudes, common standards, and patterns of behavior, common
approaches, and assumptions. Apparently, it spreads, surprisingly, more and deeper across
other mental patterns, such as those of religion, politics, or class [14].

The main objective of this study is to examine the correlation between the STEM and
HASS disciplines represented by particular subjects within the Architecture and Urbanism
Bachelor’s study program curriculum at the FAD-STU. Based on student performance
(SP), the authors of the article evaluated their readiness for practice. In general, the SP
usually includes class participation, various types of assignments, individual written work
on papers and exams, or group activities such as projects and presentations. Bachelor’s
graduates were investigated because they represent the first cohort of graduates that
penetrates the architectural labor market. The results of an internal FAD-STU online survey
on alumni in practice, conducted in 2021, revealed that most of the graduates worked in
the field of study as practicing architects [15].

Specifics of Architectural Education

The relevance and importance of the HASS disciplines could be, predominantly,
perceived through architecture, which has its own specific attributes. As one of the most
ancient professions, architecture is a cultural arena based on ideas that jointly produce styles
and individually generate outstanding buildings. It is also a product of the technological
state of its time that is expected to innovate in its forms while ensuring perfect performance
and adaptation to the environment [16]. Using Snow’s words, the authors of the article
are of the opinion that architecture and architectural education deal with the issue of the
bridge effect and are overarching multiple STEM and HASS disciplines. In contrast to
many other built-environment disciplines, architecture is a multidisciplinary field of study
and can be perceived rather as a cultural phenomenon. In essence, it combines artistic
beauty with scientific and engineering precision. It draws on arts, sciences, and social
sciences and, therefore, can be included in a multidisciplinary STEAM group of disciplines
in which the letter A means the extension STEM by the arts and the ability to formulate
ideas and present them convincingly [17,18]. Architectural design involves some concrete
skills, including knowledge of drafting, architectural materials, and structural elements, as
well as other abstract elements such as time, space, environment, and character [19].
The discussion on quality of architectural education and the ratio of STEM and HASS disciplines in curricula has been permanently discussed for ages in the academic sphere. At one pole there are faculties/universities mostly focused on artistic performance. In this case, the role of the architect seems to be reduced to that of a shaper, a form-giver, a designer completely decoupled from the realization of the building, its constructive conception, and with very limited responsibility for the outcome of the entire endeavor. On the other hand, there are institutions that force STEM and technical subjects. Historically, the master builder was a generalist architect who had the competence and capacity to design, construct, and build an edifice. Today, many architecture schools understand their role as a practitioner-generalist in relation to the economic and social impact of projects, the complexity of regulations, the development of building technologies, or the dangers of liability with respect to malpractice. Architecture, in practice, is a participative process that involves communication with many stakeholders such as clients, users, other architects, engineers, specialist consultants, construction managers, statutory authorities, etc. [20]. Stansfield Smith states that the key to a successful architectural profession is not only the ability of that profession to represent quality and deliver high standards, but also its ability to generate the demand for architecture and the qualities it represents [21].

Although the areas in the architecture syllabus and a practical training requirement vary from country to higher institution, in general, the main areas include architectural design, the cultural context of architecture, environmental design, construction and architectural technologies, communication skills, presentation, professional studies, and management [12]. The setup and control of these main areas and standards essential to produce graduates who have a solid educational foundation and are capable of leading the way in innovation, emerging technologies, and in anticipating the health, safety, and welfare needs of the public falls within the accreditation procedure competence of individual professional organizations, institutions, and architectural certification boards around the world. In Europe, architects’ training is subject to the regulation of Directive 2013/55/EU, which specifies a balance between theoretical and practical aspects to ensure the acquisition of specific knowledge, skills, and competencies [22]. Similar documents are in operation in Canada [23], the United Kingdom (UK) [24], and the United States of America (US) [25]. Their comparison according to various Student Performance Criteria (SPC) and specific skills categorized in the STEM and HASS disciplines shows Table 1.

| Student Performance Criteria (SPC) | Specific Skill                                      | Professional Entity | Discipline |
|-----------------------------------|----------------------------------------------------|---------------------|------------|
|                                   |                                                    | EU (CACB) | UK (RIBA) | US (NAAB) | STEM | HASS |
| Design                            | Design Theories, Precedents, and Methods           | x         | x         | x         | -    | -    | x    |
|                                   | Design Skills                                     | x         | x         | x         | -    | x    | -    |
|                                   | Design Tools                                      | -         | x         | -         | -    | x    | -    |
|                                   | Program Analysis                                  | x         | x         | x         | x    | x    | x    |
|                                   | Site Context and Design                           | x         | x         | x         | x    | x    | -    |
|                                   | Urban Design                                      | x         | x         | x         | x    | x    | -    |
|                                   | Detail Design                                     | x         | x         | x         | x    | x    | -    |
|                                   | Design Documentation                              | x         | x         | x         | x    | x    | -    |
|                                   | Aesthetic and Technical Requirements              | x         | -         | x         | x    | x    | x    |

Table 1. Comparison of architectural knowledge and skills required according to various professional entities and their categorization in STEM and HASS disciplines.
### Table 1. Cont.

| Student Performance Criteria (SPC) | Specific Skill                          | Professional Entity | Discipline |
|-----------------------------------|----------------------------------------|---------------------|------------|
| Culture, Communications, and Critical Thinking | Critical Thinking and Communication | x x x - - x |            |
|                                   | Architectural History                  | x x x - - x |            |
|                                   | Architectural Theory                   | x x x - - x |            |
|                                   | Cultural Diversity and Global Perspectives | x x x x - x |            |
|                                   | Ecological Systems and Environment     | x x x x x - |            |
|                                   | Social Factors                         | x x x x x - |            |
| Technical Knowledge               | Regulatory Systems                     | x x x x x - |            |
|                                   | Materials                              | x x x x x - |            |
|                                   | Structural Systems                     | x x x x x - |            |
|                                   | Envelope Systems                       | x x x x x - |            |
|                                   | Environmental Systems                  | x x x x x - |            |
| Comprehensive Design             | Comprehensive Design                   | x x x x x x |            |
| Professional Practice            | Architectural Profession               | x x x - - x |            |
|                                   | Ethical and Legal Responsibilities     | x x x - - x |            |
|                                   | Modes of Practice                      | x x - - x |            |
|                                   | Professional Contracts                 | x x - - x |            |
|                                   | Project Management                     | x x x - - x |            |

Overall ratio of STEM and HASS knowledge \(^1\) 69.23% 53.85%  

\(^1\) This overall ratio is only illustrative, as it varies by country and according to particular areas set by the professional organization/institution. Explanatory note: "x" included/"-" not included.

### 2. Materials and Methods

The main data for this research study were extracted from the university-wide academic information system (AIS), which is used to monitor the course of each student’s achievement across various academic subjects (their academic performance) and makes a lot of information available to the academic community, university staff, and the general public. All data have been processed anonymously, and the authors of the article, as academics, are bound by professional secrecy.

#### 2.1. Characteristics of the Analyzed Data Set

The investigated cohort of Bachelor’s graduates included the students who started their studies in the winter semester of the academic year 2014/2015. In this generation, the total number of students enrolled was 159, of which 110 successfully finished their studies, and 49 were unsuccessful. The analysis also considered those students who have repeated any of the subjects or exceeded the standard length of study. All subjects in the study program were analyzed, except one elective course completed without classified credit. A total of 64 subjects with 235 credits were analyzed out of a maximum of 240 compulsory credits to pass the 4-year Bachelor’s study [26]. Since the study included only successful graduates, the evaluation of their academic performance was classified by grades, from the best to the worst, as follows: A (1.0); B (1.5); C (2.0); D (2.5); and E (3.0). The arithmetic mean (AM) of this classification scale was C (2.0), which corresponded to the intermediate level of knowledge and skills required. The data included the results of the admission examination procedure, as well as the results of particular tasks within it.
2.2. Data Processing Method

The very starting point for the analysis was the creation of individual student profiles. Each profile included their overall academic performance, where their results in individual subjects, as well as the results of the admission examination procedure, were recorded. The student profile analysis enabled to evaluate the relationships between individual subjects or groups of subjects using a comparative method. The data processing method consisted of four stages.

2.2.1. Stage No. 1

In this stage, as presented in Appendix A, the authors of the study established the student profile data sets (Tables A1 and A2) and the data sets of subjects (Table A3), with assigned credits and basic statistical data such as the number of graduates, the numbers and values of the grades, and their (AM). Furthermore, subjects were classified into 3 main categories, DESIGN, STEM, and HASS, including groups of subjects according to their field and the provided knowledge. The first was the DESIGN category, in which the design studio courses were included. Design studio courses colloquially form the backbone of the future architect in practice. In general, the subjects of DESIGN category simulate the real practice of an architect who simultaneously uses knowledge/skills from STEM and HASS subjects. In the second STEM category, the authors involved the MATH—mathematical, TECH—technical, and ENGI—engineering subjects. Since any subjects in the Bachelor study did not meet the characteristics of the Science group, this category was not established. Such subjects are an integral part of Master and Doctoral studies. The third HASS category covered HIST—historical, HUMA—humanities, ART—artistic, and SOCSCI social-sciences subjects. The SOCSCI group was represented only by a single-credit subject. Therefore, this group was evaluated as non-representative and excluded from the next steps of the analysis performed. Since some subjects in their syllabus covered several areas of study, they were classified according to the predominant focus.

2.2.2. Stage No. 2

Based on student profile data sets, student performance (SP) in individual subjects and categories/groups of DESIGN, STEM, MATH, TECH, ENGI, HASS, HIST, HUMA, ART and OVERALL was determined using a weighted arithmetic mean (WAM), weighted by the number of credits of the subject. WAM in the individual subject categories and groups was also converted to normalized values (NV), so that the student with the worst SP acquired a value of 0, while the student with the best SP received a value of 1. The SP between the best and worst was proportionally divided within the interval (0, 1). The NV conversion allowed the authors to compare the SP of classified subjects and tasks of the admission examination procedure (Section 3.10). At the same time, in Section 3.9, it enabled to minimize the differences in the middle level of the required knowledge and skills for a given category/group of subjects. Credits represented a mixed value consisting of learning outcomes that are attributed to individual educational components within the Architecture and Urbanism study program as a whole and the workload, which means that one credit corresponded to 25 to 30 h of work. In the next steps of the analysis, the sum of the credits of the subjects in particular categories and groups was not considered because the authors considered the acquired knowledge and skills important without preference for the architect in practice.

2.2.3. Stage No. 3

The AM of a given category of subjects was determined as the basic parameter characterizing the level of acquired knowledge/skills of the whole analyzed cohort of students. The average value of knowledge/skills in terms of the study program for a given category of subjects was 2.0 (grade C). For the STEM subject category, including the TECH, ENGI, and MATH groups, the AM value was greater than 2.0. This fact confirmed that the stu-
students did not reach the intermediate level of knowledge/skills required on average. The largest difference was recorded in the ENGI group of subjects.

For the HASS subject category and the subjects HUMA, HIST, and ART, the AM was lower than 2.0, which means that students exceeded the intermediate level of knowledge/skills required on average. The largest difference was recorded in the HUMA group of subjects.

From three main categories, the largest difference in AM was found in the DESIGN subject category, which meant that the students significantly exceeded the intermediate level of required knowledge/skills. The AM of the overall SP was below 2.0. The relatively high oscillation of the AM (lowest 1.52/highest 2.28) indicates the disproportion between the intermediate level of knowledge/skills required, the real initial knowledge/skills of the students, and the value of credits for individual subject categories/groups. This oscillation may have been caused by other factors. The reason for this oscillation was not the subject of this analysis. However, the balance between the required level of knowledge/skills and the real initial knowledge/skills of the students is a key to effective education.

Another parameter for evaluating the course of SP in the subject categories/groups was the AM of the best and worst SP in the given subject category or group (AMbw). The AMbw-AM difference determined the degree of proportionality of the achieved SP. If AMbw-AM > 0, then in the given category/group of subjects there was a higher number of worse SP than the better ones. The opposite was true if AMbw-AM < 0. The concrete data show Table 2.

Table 2. Basic statistical data of individual categories and groups of subjects.

| Statistical Data         | Overall | DESIGN | STEM | HASS | TECH | ENGI | MATH | HUMA | HIST | ART |
|--------------------------|---------|--------|------|------|------|------|------|------|------|-----|
| Best SP                  | 1.28    | 1.00   | 1.15 | 1.31 | 1.02 | 1.26 | 1.00 | 1.17 | 1.00 | 1.17 |
| Worst SP                 | 2.44    | 2.42   | 2.72 | 2.28 | 2.79 | 2.93 | 3.00 | 2.26 | 2.50 | 2.44 |
| AM of SP                 | 1.79    | 1.52   | 2.14 | 1.81 | 2.10 | 2.28 | 2.09 | 1.76 | 1.78 | 1.82 |
| AMbw of SP               | 1.86    | 1.71   | 1.94 | 1.80 | 1.91 | 2.10 | 2.00 | 1.71 | 1.75 | 1.80 |
| Credits                  | 235     | 97     | 57   | 80   | 24   | 23   | 10   | 41   | 15   | 24  |
| Difference AMbw-AM       | 0.07    | 0.19   | −0.20| −0.01| −0.19| −0.18| −0.09| −0.04| −0.03| −0.02|
| Standard deviation        | 0.26    | 0.26   | 0.36 | 0.25 | 0.41 | 0.35 | 0.58 | 0.26 | 0.36 | 0.29 |

1 The light gray cells represent the AM of all SP in subjects by category or group that are above the intermediate level of required knowledge and skill, while the dark cells represent those below this level.

2.2.4. Stage No. 4

The SP in the individual subject categories and groups or admission examination procedure results (AR) was ranked from best to worst and compared with the modified Gaussian curve. Modification of the Gaussian curve is based on the probability density of normal distribution of real SP of given category/group of subjects or AR determined by its AM and standard deviation, cumulatively spread to the whole number of the analyzed student cohort. This comparison evaluated the suitability of the proposed assessment. In all categories and groups of subjects or admission examination procedures, the assessment in terms of normal distribution was interpreted as adequate.

The SP or AR was divided into three levels: the first level (best), the second level (moderate), and the third level (worst), which were symmetrically divided around the AM of the SP of the given category/group of subjects or AR. Values outside these three levels were marked as ‘out of range’. The division into three levels resulted from the intention of
the authors of the article to compare the SP of individual categories and groups of subjects at equal levels based on the real SP or AR determined by their AM.

The SP in the STEM and HASS categories were, subsequently, compared with the DESIGN category represented by the design studio courses. The correlation rate (CR) between the number of SP in levels of the STEM and HASS categories or the number of AR in levels of the admission examination procedure and the number of SP in levels of the DESIGN category of subjects was evaluated by geometric mean. Its value demonstrates the following Equation (1):

$$\sqrt{\frac{\text{intersection of number of SP of given level and category/group of SP of given level in DESIGN category and of number of SP of given level and category/group}}{\text{number of SP of given level and category/group}}} \times \sqrt{\frac{\text{intersection of number of SP of given level and category/group of SP of given level in DESIGN category and of number of SP of given level and category/group}}{\text{number of SP of given level in DESIGN category}}} = CR \% \quad (1)$$

The comparative analysis was performed only in one direction, which means that the influence of the SP in the STEM or HASS categories on the SP in DESIGN was examined. The analysis was not performed in the opposite direction and, therefore, it was not evaluated how the SP in the DESIGN category affects the SP in the STEM and HASS categories. The partial findings are shown in Figure 1.

**Figure 1. Cont.**
3. Results

As indicated in Figure 1, all other interrelationships were examined. The final findings on the correlation rate between STEM, HASS categories/groups of subjects, and the DESIGN category calculated according to Equation (1) are shown in the following paragraphs. The correlation rate (CR) is expressed as a percentage. The darker the cell, the higher the degree of correlation rate (Table 3). In Tables 4–11 the integer represents the count of SP of a given level in category/group.

Table 3. The graphical scale of degree of CR according to Equation (1).

| Degree of correlation | Low | 0% | 10% | 20% | 30% | 40% | 50% | 60% | High |
|-----------------------|-----|----|-----|-----|-----|-----|-----|-----|------|

Table 4. The correlation rate of the SP between TECH and DESIGN subjects.

| Group Level | Out of Range | 1st TECH | 2nd TECH | 3rd TECH | Out of Range | Σ |
|-------------|--------------|----------|----------|----------|--------------|---|
| Out of range| 0            | 0%       | 0%       | 0%       | 0%           | 0 |
| 1st DESIGN  | 4            | 24%      | 13%      | 50%      | 12%          | 32|
| 2nd DESIGN  | 4            | 19%      | 6%       | 19%      | 20%          | 49|
| 3rd DESIGN  | 1            | 6%       | 2%       | 8%       | 12%          | 27|
| Out of range| 0            | 0%       | 0%       | 0%       | 2%           | 2 |
| Σ           | 9            | 21       | 44       | 36       | 0            | 110|
Table 5. The correlation rate of the SP between ENGI and DESIGN subjects.

| Group Level | Out of Range | 1st ENGI | 2nd ENGI | 3rd ENGI | Out of Range | Σ |
|-------------|--------------|----------|----------|----------|--------------|---|
| Out of range| 0 0%         | 0 0%     | 0 0%     | 0 0%     | 0 0%         | 0 |
| 1st DESIGN  | 5 36%        | 14 52%   | 11 28%   | 2 6%     | 0 0%         | 32|
| 2nd DESIGN  | 1 6%         | 7 21%    | 26 54%   | 15 37%   | 0 0%         | 49|
| 3rd DESIGN  | 0 0%         | 1 4%     | 10 28%   | 16 53%   | 0 0%         | 27|
| Out of range| 0 0%         | 1 15%    | 0 0%     | 1 12%    | 0 0%         | 2 |
| Σ           | 6 23        | 47 34    | 0 0%     | 110      |              |   |

Table 6. The correlation rate of the SP between MATH and DESIGN subjects.

| Group Level | Out of Range | 1st MATH | 2nd MATH | 3rd MATH | Out of Range | Σ |
|-------------|--------------|----------|----------|----------|--------------|---|
| Out of range| 0 0%         | 0 0%     | 0 0%     | 0 0%     | 0 0%         | 0 |
| 1st DESIGN  | 2 14%        | 3 10%    | 9 30%    | 18 47%   | 0 0%         | 32|
| 2nd DESIGN  | 3 17%        | 17 44%   | 12 32%   | 17 36%   | 0 0%         | 49|
| 3rd DESIGN  | 1 8%         | 10 35%   | 8 29%    | 8 23%    | 0 0%         | 27|
| Out of range| 0 0%         | 0 0%     | 0 0%     | 2 21%    | 0 0%         | 2 |
| Σ           | 6 30        | 29 45    | 0 0%     | 110      |              |   |

Table 7. The correlation rate of the SP between STEM and DESIGN subjects.

| Group Level | Out of Range | 1st STEM | 2nd STEM | 3rd STEM | Out of Range | Σ |
|-------------|--------------|----------|----------|----------|--------------|---|
| Out of range| 0 0%         | 0 0%     | 0 0%     | 0 0%     | 0 0%         | 0 |
| 1st DESIGN  | 6 35%        | 16 54%   | 6 20%    | 4 11%    | 0 0%         | 32|
| 2nd DESIGN  | 3 14%        | 8 22%    | 17 45%   | 21 45%   | 0 0%         | 49|
| 3rd DESIGN  | 0 0%         | 3 11%    | 6 21%    | 18 52%   | 0 0%         | 27|
| Out of range| 0 0%         | 0 0%     | 0 0%     | 2 21%    | 0 0%         | 2 |
| Σ           | 9 27        | 29 45    | 0 0%     | 110      |              |   |

Table 8. The correlation rate of the SP between HUMA and DESIGN subjects.

| Group Level | Out of Range | 1st HUMA | 2nd HUMA | 3rd HUMA | Out of Range | Σ |
|-------------|--------------|----------|----------|----------|--------------|---|
| Out of range| 0 0%         | 0 0%     | 0 0%     | 0 0%     | 0 0%         | 0 |
| 1st DESIGN  | 4 35%        | 16 52%   | 11 31%   | 1 3%     | 0 0%         | 32|
| 2nd DESIGN  | 0 0%         | 14 37%   | 19 43%   | 16 38%   | 0 0%         | 49|
| 3rd DESIGN  | 0 0%         | 0 0%     | 9 28%    | 18 57%   | 0 0%         | 27|
| Out of range| 0 0%         | 0 0%     | 0 0%     | 2 23%    | 0 0%         | 2 |
| Σ           | 4 30        | 39 37    | 0 0%     | 110      |              |   |

Table 9. The correlation rate of the SP between HIST and DESIGN subjects.

| Group Level | Out of Range | 1st HIST | 2nd HIST | 3rd HIST | Out of Range | Σ |
|-------------|--------------|----------|----------|----------|--------------|---|
| Out of range| 0 0%         | 0 0%     | 0 0%     | 0 0%     | 0 0%         | 0 |
| 1st DESIGN  | 1 13%        | 14 45%   | 14 34%   | 3 10%    | 0 0%         | 32|
| 2nd DESIGN  | 1 10%        | 13 34%   | 24 48%   | 11 31%   | 0 0%         | 49|
| 3rd DESIGN  | 0 0%         | 3 11%    | 13 35%   | 11 42%   | 0 0%         | 27|
| Out of range| 0 0%         | 0 0%     | 1 10%    | 1 14%    | 0 0%         | 2 |
| Σ           | 2 30        | 52 26    | 0 0%     | 110      |              |   |
Table 10. The correlation rate of the SP between ART and DESIGN subjects.

| Group Level     | Out of Range | 1st ART | 2nd ART | 3rd ART | Out of Range | Σ |
|-----------------|--------------|---------|---------|---------|--------------|---|
| Out of range    | 0            | 0%      | 0%      | 0%      | 0%           | 0 |
| 1st DESIGN      | 2            | 25%     | 12%     | 17%     | 1%           | 32|
| 2nd DESIGN      | 0            | 0%      | 10%     | 30%     | 9%           | 49|
| 3rd DESIGN      | 0            | 0%      | 2%      | 9%      | 16%          | 27|
| Out of range    | 0            | 0%      | 1%      | 1%      | 0%           | 2 |
| Σ               | 2            | 24%     | 57%     | 27%     | 110          |   |

Table 11. The correlation rate of the SP between HASS and DESIGN subjects.

| Group Level     | Out of Range | 1st HASS | 2nd HASS | 3rd HASS | Out of Range | Σ |
|-----------------|--------------|---------|---------|---------|--------------|---|
| Out of range    | 0            | 0%      | 0%      | 0%      | 0%           | 0 |
| 1st DESIGN      | 4            | 24%     | 20%     | 10%     | 1%           | 32|
| 2nd DESIGN      | 4            | 19%     | 11%     | 27%     | 11%          | 49|
| 3rd DESIGN      | 1            | 6%      | 1%      | 8%      | 18%          | 27|
| Out of range    | 0            | 0%      | 0%      | 1%      | 0%           | 2 |
| Σ               | 9            | 32%     | 46%     | 31%     | 110          |   |

3.1. TECH vs. DESIGN

The correlation rate between the TECH and DESIGN categories was relatively low (Table 4). The most prominent CR was on the first level of acquired knowledge. It was assumed that students with above mean SP (1st level) from TECH subjects can adequately apply these knowledge/skills in design studio work. In general, the design studio work is characterized by an effort to establish the student’s ability to creatively implement the acquired knowledge/skills from theoretical subjects into the process of creation. From the comparison of the relationship between TECH and DESIGN, it is possible to assume that to be able to implement knowledge/skills from theoretical subjects into the creative processes within the design studio, it is necessary to acquire their critical mass.

3.2. ENGI vs. DESIGN

Table 5 confirms that SP in the ENGI and DESIGN categories correlates the most among all groups of subjects within the STEM category. Therefore, it is possible to assume that the level of knowledge acquired in the subjects of the ENGI category is directly related to the quality of design studio outputs that were included in the DESIGN category. At the same time, it is possible to conclude that the mastering of the design studio work from the engineering point of view, such as statics, the quality of project drawings, or building equipment, influences the evaluation of the works on a regular basis.

3.3. MATH vs. DESIGN

Student performance in MATH and DESIGN categories does not highly inter-correlate, respectively, MATH correlates more significantly with random levels as shown in Table 6. For example, the third level of MATH correlates with the first level of the DESIGN category. Based on this result, it can be assumed that MATH knowledge is not directly related to the quality of design studio outcomes. However, it is necessary to highlight the importance of mathematics for the study of subjects included in the TECH and ENGI categories. In this study, the relationship among MATH, TECH, and ENGI is not investigated.

3.4. STEM vs. DESIGN

According to the results shown in Table 7, student performance between STEM and DESIGN categories correlates well but less significantly than in the case between HASS
and DESIGN categories. Based on the findings from the relationship among TECH, ENGI, and MATH groups of subjects and the design studio, it is possible to conclude that design studio work does not require such deep STEM knowledge and skills. However, practice through many shining examples shows that STEM knowledge and skills are irreplaceable, especially if the design is implemented. This difference was probably due to the detail level of the design studio work processing. Except for the Final Bachelor’s Project, in general, the output of the design studio courses is an architectural design, in which the construction and technical solution is documented at the level of a rough concept. Admittedly, another factor that influences the position of STEM in the design studio is the evaluation method. Design studio work is evaluated at FAD-STU using the peer-to-peer review method, where the output includes qualities in the entire spectrum of STEM and HASS subjects and is rated by one grade.

3.5. HUMA vs. DESIGN

Table 8 shows a quite significant correlation between the HUMA group of subjects and the DESIGN category. It is assumed that the knowledge and skills required within the HUMA group of subjects were applied in the creation of the design studio works and their evaluation.

3.6. HIST vs. DESIGN

The correlation between the HIST group of subjects and the DESIGN category was present with greater variance within the evaluation, as shown in Table 9. It is assumed that the knowledge/skills from HIST subjects are a good starting point, but in relation to other evaluation criteria of design studio work, they do not have a distinctly reserved position.

3.7. ART vs. DESIGN

The correlation between ART and DESIGN was most pronounced at the lowest level (Table 10). It is assumed that the aesthetic qualities acquired within the ART group of subjects were the most significant evaluation criteria for lower-quality design studio works. With good quality design studio works, the design was evaluated in a wider range of qualities.

3.8. HASS vs. DESIGN

The correlation between HASS and DESIGN was more significant compared to the STEM and DESIGN categories (Table 11). It is assumed that the degree of correlation reflects the overall better readiness of the students in the theoretical subjects of the HASS category, which corresponds to a lower AM of SP compared to STEM. At the same time, HASS qualities are the predominant assessment criteria in the design studio work evaluation.

3.9. The Relationship Overview of STEM-HASS vs. DESIGN

Using the NV of SP, Figure 2 and Table 12 show that the SP in the design studio (DESIGN) was in direct connection with SP in theoretical subjects, represented by the cumulative value of the STEM and HASS SP (calculated as AM of STEM NV of SP and HASS NV of SP). The ratio between knowledge/skills from the STEM and HASS categories was indirectly related to the SP in the DESIGN category and the cumulative value of the STEM and HASS SP. In the case of students with a worse SP in DESIGN, STEM knowledge/skills prevailed over HASS. On the contrary, for the students with good performance in subjects of DESIGN category, HASS knowledge/skills prevailed over STEM.
Figure 2. The primary vertical axis (left) represents NV of SP (0—worst SP, 1—best SP). The secondary vertical axis (right) shows the ratio of STEM NV of SP vs. HASS NV of SP. The horizontal axis shows the students ranked from the best to the worst according to the NV of SP (0—best NV of SP). The cumulative SP of the STEM and HASS categories was calculated as the AM of NV of SP of STEM and HASS. Trend lines were calculated by linear regression using the least squares method.

Table 12. Overview of the relationship among the parameters in Figure 2 calculated as AM of these parameters for each level of SP in DESIGN category.

|                   | 1st Level DESIGN | 2nd Level DESIGN | 3rd Level DESIGN |
|-------------------|------------------|------------------|------------------|
| AM of NV of DESIGN SP | 0.84             | 0.64             | 0.42             |
| AM of ratio of STEM NV of SP vs. HASS NV of SP | 0.82             | 0.84             | 1.19             |
| AM of STEM and HASS cumulative value of normalized SP | 0.60             | 0.39             | 0.24             |

It is assumed that engineering creativity, which is closely related to STEM, is a natural skill of architecture students and is deepened and supplemented by HASS competencies through the educational process. For the best students characterized with the best cumulative SP values within the STEM and HASS categories, this corresponds to the required learning outcomes of STEM and HASS subjects within the study program curriculum and their AM within the analyzed cohort of students.

3.10. Admission Examination Procedure vs. DESIGN

An integral part of education is the determination of the requirements for applicants and a strategy for the selection of future students. In the European Union, there are no single selection strategies or requirements for applicants in relation to STEM and HASS disciplines in the field of study architecture and urbanism. On one pole, there exist universities with an open or no student admission examination procedure, and the selection process is managed naturally during the studies. The other pole represents universities with selective requirements for admission to study in accredited study programs. The nature of these requirements is diverse and follows the dynamic development of society and the role of the architect within it. Therefore, the intention of the authors of the article was also to confront admission requirements with student performance in the DESIGN category.

Admission examination procedures at the FAD STU are primarily focused on the assessment of applicant’s inborn talent. In the analyzed cohort of students, their STEM or HASS knowledge from secondary school was not identified during the admission procedure. Therefore, on the one hand, it is not possible to recognize a direct link between
the acquired knowledge and skills from the STEM and HASS theoretical subjects and the explicit knowledge acquired from previous studies. On the other hand, it is possible to partially analyze how the degree and character of the applicant’s talent affect their study results. The admission examination procedure of the analyzed cohort of students consisted of four tasks. The first task dealt with composing the volume from geometrical bodies on a specified architectural topic in a spatial perspective. In addition to the ability to capture space with a linear drawing, this task also verified the applicant’s creativity and their perception of 3D space. The maximum value of this assignment was 250 points. The second task tested the ability to realistically display the still-life model with a linear drawing and was assigned 250 points as well. The third task included the test of spatial imagining verifying the spatial sentience, respectively, it solved the intuitive tasks from projective and descriptive geometry. This task was evaluated with a maximum of 200 points. The fourth was the so-called SCIO test, provided by an external institution that assessed the general study prerequisites and the applicant’s abilities to complete university studies. The maximum value of points for this assignment was 300. The maximum point gained from the admission examination procedure was 1000 points, while the threshold to pass this procedure was set at 510 points. The first 200 applicants were given the opportunity to start the study. The fourth task was excluded from the comparison with student performance in the DESIGN category, since it was focused on the ability to complete university studies and the analyzed cohort consisted only of successful graduates. The results of individual tasks (1st task—Composing volume from geometric bodies—COMPO; 2nd task—Still life model drawing—STILL; 3rd task—Test of spatial imagining—SPAT) and the overall results (sum of the first to third task—ADMISS) were converted to NV and examined similarly to Figure 2. The relationship between the admission process and student performance in the DESIGN category of subjects is shown in Tables 13–16 (the integer represents the count of SP of a given level in category/group).

Table 13. The correlation rate between COMPO and DESIGN SP absolute values.

| Group Level | Out of Range | 1st COMPO | 2nd COMPO | 3rd COMPO | Out of Range | Σ |
|-------------|--------------|-----------|-----------|-----------|--------------|---|
| Out of range | 0 0%         | 0 0%      | 0 0%      | 0 0%      | 0 0%         | 0 |
| 1st DESIGN  | 0 0%         | 13 39%    | 9 26%     | 10 30%    | 0 0%         | 32|
| 2nd DESIGN  | 2 20%        | 13 31%    | 19 44%    | 15 36%    | 0 0%         | 49|
| 3rd DESIGN  | 0 0%         | 8 26%     | 9 28%     | 10 33%    | 0 0%         | 27|
| Out of range | 0 0%         | 1 12%     | 1 11%     | 0 0%      | 0 0%         | 2 |
| Σ           | 2 35         | 38 35     | 0 0%      | 110       |

Table 14. The correlation rate between STILL and DESIGN SP absolute values.

| Group Level | Out of Range | 1st STILL | 2nd STILL | 3rd STILL | Out of Range | Σ |
|-------------|--------------|-----------|-----------|-----------|--------------|---|
| Out of range | 0 0%         | 0 0%      | 0 0%      | 0 0%      | 0 0%         | 0 |
| 1st DESIGN  | 1 13%        | 7 24%     | 16 39%    | 8 26%     | 0 0%         | 32|
| 2nd DESIGN  | 1 10%        | 12 34%    | 20 39%    | 16 42%    | 0 0%         | 49|
| 3rd DESIGN  | 0 0%         | 5 19%     | 17 45%    | 5 18%     | 0 0%         | 27|
| Out of range | 0 0%         | 2 28%     | 0 0%      | 0 0%      | 0 0%         | 2 |
| Σ           | 2 26         | 53 29     | 0 0%      | 110       |
The results of the admission examination procedure and student performance in DESIGN category, as shown in Tables 13–16, do not correlate or correlate very slightly in the test of spatial imagining (SPAT) and composing volume from the geometric bodies (COMPO).

In fact, these tasks are inherently creative and directly related to the design studio courses. It is assumed that creativity is a natural competence of an architect. Besides the general and artistic creativity, today’s architect shall dispose with the engineering creativity, which is closely linked to flexibility, understanding of the context, and identification of the problem. The essence of engineering creativity can be perceived on the following three levels: (1) innovation in solving open-ended problems; (2) the ability to cross the boundaries of one’s own field and to expose oneself to the uncertainty of the unknown; and (3) to bring solutions that can be implemented today or in the future [27]. As a result, a more detailed focus on the creativity of the applicants could be a suitable complement to the admission examination procedure.

### 4. Discussion

The total value of the European construction market of 31 European countries (Europe-31) is estimated to be worth EUR 1914 billion in 2020. The sector study conducted by the Architects’ Council of Europe (ACE) on the architectural profession in Europe in 2020 also revealed that in the Europe-31 ACE member countries surveyed, there is an estimated total number of 559,070 architects contributing approximately EUR 17 billion to the economy of Europe. Of these, three-quarters of architects work full-time. As the sole principals working independently and providing a full range of architectural services to clients describe themselves as 33% of architects (more than 50% in Slovakia), making this the largest employment group in the profession. Architects working in private practice as associates or salaried architects comprise 29% of the profession, 7% describe themselves as freelance, 9% are partners and directors, and the public sector employs 13% of European architects. Architectural practices in 2020 remained strongly skewed toward the smallest size groups, as almost two-thirds are one-person practices [28].

This significant rate that reaches almost 80% in Slovakia goes hand in hand with knowledge level and great responsibility to secure the equilibrium/ultimate synthesis of three pillars of architecture introduced by Vitruvius, such as firmitas (commodity), utilitas (firmness), and venustas (delight). In addition, these requirements are nowadays broaden-
ing by highly demanded and forced restituitas (sustainability), to ensure the sustainable
development and mitigate climate change and human activities on the environment.

In general, graduates are able to design simple architectural or urban proposals
and structures under professional supervision, work effectively as team members, and
are competent to independently prepare project documentation for constructions to a
reasonable extent using computer and manual techniques. These graduates have the ability
to independently prepare and evaluate materials for architectural or urban design as well
as present and justify them to a professional audience.

Further investigation in this field could be conducted within the Master’s studies that
enrich the previous studies with extensive professional knowledge, skills, and competences
at the level of evaluation of theory, history of architecture and urban construction, fine arts,
humanities and environmental sciences, construction, or technical problems, equipment,
and technologies. Master’s graduates are versatile, practical, and, theoretically, prepared for
independent architectural and urban planning. The authors are also interested in doctoral
studies, and they consider examining the topics of dissertation theses in accordance with
the STEM and HAAS disciplines. Such research forms the basis for more comprehensive
analyses to properly understand the interrelationships among the subjects of different
disciplines, to improve the education provided by higher education institutions, and to
increase the employment of architecture students in various professional realms.

5. Conclusions

The results of this study authenticated the great importance of knowledge and skills
in STEM disciplines for architects to carry out their practice. Despite the insufficient
intermediate level of STEM knowledge and skills of the FAD STU Bachelor’s students,
the direct relationship between student performance in STEM and DESIGN categories of
subjects was confirmed. There is an assumption that balancing the ratio of the STEM and
HASS categories should contribute, in the end, to higher quality of design studio outputs as
the main and fundamental part of creative architectural work, which is primarily evaluated
during the authorisation—the process of recognition of professional qualification.

Current discussions in the Slovak academic sector aim at the implementation of
a compulsory upper secondary school leaving examination in mathematics, which is
generally considered a starting point and a basic prerequisite for the successful study of
STEM disciplines. In respect to knowledge productivity/creation of knowledge, beyond
its acquisition and application, the STEM disciplines along with the HASS disciplines will
enhance the expertise and will lead to success and maintaining a competitive advantage
not only in architectural practice.

The conducted research by the authors of the article highlights a close link between the
acquired knowledge/skills of the FAD-STU Bachelor’s graduates and the curriculum of the
Architecture and Urbanism field of study, which emphasizes the university’s responsibility
in educating architects. The sustainability of the balance between the competencies of
the applicants entering higher education and the labor market and various social require-
ments is, indeed, a dynamic process. The statistical method applied in the analysis of
the educational process, and using the student performance, proved in this study that
it can be considered a suitable tool to assess the complex of interrelated factors entering
the educational process. Furthermore, this analysis allows one to expand the complex of
monitored parameters by the study results of the candidates before entering the higher
education institution, respectively, the second or third cycle education. At the same time,
the authors see a potential to supplement the student’s profile with the characteristics of
their tacit knowledge, the evaluation of which is not considered in the classification system.
Based on this analysis, the authors are of opinion that the traditional classification system
using five grades (A–E) is insufficient, which is especially relevant for subjects such as
design studio, which penetrate the content of several areas of study. This strictly scaling of
the student performance does not allow to effectively evaluate the synergy of subjects from
related areas. Therefore, it would be appropriate to evaluate such subjects with several
grades, or to introduce a points system to difference student performance in STEM and HASS disciplines.

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### Appendix A

| Course Code | Course Title |
|-------------|--------------|
| 51103_5B | Fundamentals of Architectural Design I |
| 51301_5B | Construction I |
| 51400_5B | Introduction to Architecture and Urbanism |
| 12212_5B | Descriptive Geometry I |
| 51104_5B | Fundamentals of Architectural Design II |
| 51302_5B | Construction II |
| 51403_5B | Drawing II |
| AN1_AU | Design Studio I |
| SF1_AU | Building Physics I |
| TZB1_AU | Technical Equipment of Buildings I |
| AN2_AU | Design Studio II |
| SF2_AU | Building Physics II |
| ST1_AU | Statics I |
| VIS_AU | Manufacturing and Engineering Constructions |
| VYTS_AU | Art Seminar—Plein Air |
| AN3_AU | Design Studio III |
| CJ2_AU | Foreign Language II |
| DAU3_AU | Architecture and Art History III |
| AN4_AU | Design Studio IV |
| DSM_AU | History of Urban Planning |

Table A1. Student profile data set.
Table A1. Cont.

| Student | Admission Examination Procedure Results (Points Obtained) |
|---------|----------------------------------------------------------|
|         | Composing Volume from Geometric Bodies                    |
|         | Still-Life Model Drawing                                   |
|         | Test of Spatial Imagining                                  |
|         | 12212_SB Descriptive Geometry I                           |
|         | 12214_SB Mathematics                                       |
|         | S1015_SB Fundamentals of Architectural Design I            |
|         | S1001_SB Construction I                                    |
|         | S1401_SB Freehand Architectural Drawing                    |
|         | S1400_SB Introduction to Architecture and Urbanism        |
|         | 12215_SB Descriptive Geometry II                           |
|         | S1004_SB Fundamentals of Architectural Design II           |
|         | S1005_SB Residential Buildings                             |
|         | S140 SB Architectural Composition                           |
|         | S1402_SB Construction II                                   |
|         | S1403_SB Drawing II                                        |
|         | 1_AN1_AU Design Studio I                                   |
|         | 1_APR1_AU Architecture and Environment I                   |
|         | 1_DAU1_AU Architecture and Art History I                   |
|         | 1_OBC2_AU Civic Buildings II                               |
|         | 1_PPN_AU Computer Aided Design                             |
|         | 1_STL1_AU Building Physics I                               |
|         | 1_STAV3_AU Construction III                                |
|         | 1_TZB1_AU Technical Equipment of Buildings I               |
|         | 1_AN2_AU Design Studio II                                  |
|         | 1_CFA_AU Foreign Language I                                |
|         | 1_DAU2_AU Architecture and Art History II                  |
|         | 1_KOM2_AU Composition II                                    |
|         | 1_SR2_AU Building Physics II                               |
|         | 1_STL1_AU Statics I                                        |
|         | 1_TZB2_AU Technical Equipment of Buildings II              |
|         | 1_VIS_AU Manufacturing and Engineering Constructions       |
|         | 1_VYTS_AU Art Seminar—Plein Air                            |
|         | 1_AN3_AU Design Studio III                                 |
|         | 1_CJa_AU Foreign Language II                               |
|         | 1_DAU3_AU Architecture and Art History III                 |
|         | 1_MOD_AU Modeling                                           |
|         | 1_NK1_AU Structures I                                      |
|         | 1_OBPA_AU Monuments Restoration                            |
|         | 1_STL2_AU Station II                                       |
|         | 1_STAV4_AU Construction IV                                 |
|         | 1_URB1_AU Urban Typology I                                 |
|         | 1_AN4_AU Design Studio IV                                  |
|         | 1_AN5_AU Design Studio V                                   |
|         | 1_ASM_AU History of Urban Planning                         |
|         | 1_DSM_AU History of Urban Planning                         |
| Table A1. Cont. |
|----------------|
| **Student** | **Admissions Examination Procedure Results (Perkins-Odum)** |
| 86 | 428 |
| 87 | 437 |
| 88 | 299 |
| 89 | 542 |
| 90 | 365 |
| 91 | 297 |
| 92 | 305 |
| 93 | 303 |
| 94 | 410 |
| 95 | 270 |
| 96 | 441 |
| 97 | 320 |
| 98 | 273 |
| 99 | 433 |
| 100 | 544 |
| 101 | 223 |
| 102 | 275 |
| 103 | 540 |
| 104 | 210 |
| 105 | 359 |
| 106 | 355 |
| 107 | 264 |
| 108 | 210 |
| 109 | 256 |
| Time | Course Code | Course Title |
|------|-------------|--------------|
| 0:00 | 20:36       | Table A2. Student profile data set. |
| 0:10 | 20:46       | | |
| 0:20 | 20:56       | | |
| 0:30 | 1:06        | | |
| 0:40 | 1:16        | | |
| 0:50 | 1:26        | | |
| 1:00 | 1:36        | | |
| 1:10 | 1:46        | | |
| 1:20 | 1:56        | | |
| 1:30 | 2:06        | | |
| 1:40 | 2:16        | | |
| 1:50 | 2:26        | | |
| 2:00 | 2:36        | | |
| 2:10 | 2:46        | | |
| 2:20 | 2:56        | | |
| 2:30 | 3:06        | | |
| 2:40 | 3:16        | | |
| 2:50 | 3:26        | | |
| 3:00 | 3:36        | | |
| 3:10 | 3:46        | | |
| 3:20 | 3:56        | | |
| 3:30 | 4:06        | | |
| 3:40 | 4:16        | | |
| 3:50 | 4:26        | | |
Table A2. Cont.
Table A2. Cont.

| Student | 1_INT_AU Interior Design | 1_KPA_AU Landscape Architecture | 1_NK2_AU Structures II | 1_PBB_AU Fire Safety of Buildings | 1_STA V5_AU Construction V | 1_URB2_AU Urban Typology II | 1_AN6_AU Design Studio VI | 1_AN7M1_AU Design Studio VII (module M 1) | 1_AN7M2_AU Design Studio VII (module M 2) | 1_AN7M3_AU Design Studio VII (module M 3) | 1_AN7M4_AU Design Studio VII (module M 4) | 1_AN7M5_AU Design Studio VII (module M 5) | 1_AN7M6_AU Design Studio VII (module M 6) | 1_AN7M7_AU Design Studio VII (module M 7) | 1_AN7M8_AU Design Studio VII (module M 8) | 1_AS1M1_AU Studio Seminar I (module M 1) | 1_AS1M2_AU Studio Seminar I (module M 2) | 1_AS1M3_AU Studio Seminar I (module M 3) | 1_AS1M4_AU Studio Seminar I (module M 4) | 1_AS1M5_AU Studio Seminar I (module M 5) | 1_AS1M6_AU Studio Seminar I (module M 6) | 1_AS1M7_AU Studio Seminar I (module M 7) | 1_AS1M8_AU Studio Seminar I (module M 8) | 1_DAU4_AU Architecture and Art History IV | 1_PS_AU Building Project | 1_UNA_AU Universal Design | 1_VKM1_AU Selected Chapters I (module M1) | 1_VKM2_AU Selected Chapters I (module M2) | 1_VKM3_AU Selected Chapters I (module M3) | 1_VKM4_AU Selected Chapters I (module M4) | 1_VKM5_AU Selected Chapters I (module M5) | 1_VKM6_AU Selected Chapters I (module M6) | 1_VKM7_AU Selected Chapters I (module M7) | 1_VKM8_AU Selected Chapters I (module M8) | 1_AN8_AU Design Studio VIII | 1_ASA2_AU Studio Seminar II—A | 1_ASU2_AU Studio Seminar II—U | 1_ULG_AU Introduction to Legislation in Architecture and Urbanism | 11499_5B Geodesy | B_AU_SS State Exam—Theory and Design of Building Structures | B_AU_SS State Exam—Theory and History of Architecture and Urbanism | 51119_5B Civic Buildings I | 42x302 | 42x296 | 42x290 | 42x284 | 42x278 | 42x272 | 42x266 | 42x260 | 42x254 | 42x248 | 42x242 | 42x236 | 42x230 | 42x224 | 42x218 | 42x212 | 42x206 | 42x200 | 42x195 | 42x189 | 42x183 | 42x177 | 42x171 | 42x165 | 42x159 | 42x153 | 42x147 | 42x141 | 42x135 | 42x129 | 42x123 | 42x117 | 42x111 | 42x105 | 42x100 | 42x95 | 42x90 | 42x85 | 42x80 | 42x75 | 42x70 | 42x65 | 42x60 | 42x55 | 42x50 | 42x45 | 42x40 | 42x35 | 42x30 | 42x25 | 42x20 | 42x15 | 42x10 | 42x5 | 42x0 |
Table A3. Data set of subjects with basic statistical data.

| Subject       | Category                  | Credits | Semester | Year of Study | Total Graduates | A Grade Count | B Grade Count | C Grade Count | D Grade Count | E Grade Count | AM  |
|---------------|---------------------------|---------|----------|---------------|-----------------|---------------|---------------|---------------|---------------|---------------|-----|
| 12212, SB Descriptive Geometry I | MATH 4                  | winter 1 | 110 20  | 25 14 22 21 28 | 2.06            |               |               |               |               |               |     |
| 12214, SB Mathematics      | MATH 4                  | winter 1 | 110 20  | 18 24 16 23 29 | 2.10            |               |               |               |               |               |     |
| 51103, SB Fundamentals of Architectural Design I | DESIGN 8 | winter 1 | 110 20  | 9 26 34 35 6 | 2.01           |               |               |               |               |               |     |
| 51101, SB Construction I | ENGI 5                  | winter 1 | 110 20  | 2 7 23 37 41 | 2.49           |               |               |               |               |               |     |
| 51401, SB Freehand Architectural Drawing | ART 4                  | winter 1 | 110 20  | 11 30 49 18 2 | 1.86           |               |               |               |               |               |     |
| 51403, SB Introduction to Architecture and Urbanism | HUMA 1 | winter 1 | 110 20  | 72 20 15 2 1 | 1.27           |               |               |               |               |               |     |
| 51402, SB Drawing I | ART 4                  | winter 1 | 110 20  | 11 20 44 33 3 | 2.00           |               |               |               |               |               |     |
| 12215, SB Descriptive Geometry II | MATH 2                  | summer 1 | 110 20  | 19 16 21 21 33 | 2.15           |               |               |               |               |               |     |
| 51104, SB Fundamentals of Architectural Design II | DESIGN 8 | summer 1 | 110 20  | 35 47 19 9 0 | 1.51           |               |               |               |               |               |     |
| 51105, SB Residential Buildings | HUMA 4                  | summer 1 | 110 20  | 5 25 35 32 13 | 2.10           |               |               |               |               |               |     |
| 51106, SB Architectural Composition | ART 5                  | summer 1 | 110 20  | 8 25 42 30 5 | 2.00           |               |               |               |               |               |     |
| 51302, SB Construction II | ENGI 4                  | summer 1 | 110 20  | 1 9 29 39 32 | 2.42           |               |               |               |               |               |     |
| 51405, SB Drawing II | ART 5                  | summer 1 | 110 20  | 23 21 41 19 8 | 1.94           |               |               |               |               |               |     |
| 11499, SB Freehand | ART 3                  | summer 1 | 110 20  | 26 40 24 7 13 | 1.75           |               |               |               |               |               |     |
| 51109, SB Civic Buildings I | HUMA 5                  | summer 1 | 110 20  | 6 25 26 18 37 | 2.26           |               |               |               |               |               |     |
| 1_AN11_AU Design Studio I | DESIGN 10 | winter 2 | 110 20  | 43 38 20 7 2 | 1.49           |               |               |               |               |               |     |
| 1_APR1_AU Architecture and Environment I | HUMA 3                  | winter 2 | 110 20  | 42 44 19 4 1 | 1.45           |               |               |               |               |               |     |
| 1_DA11_AU Architecture and Art History I | HBST 3                  | winter 2 | 110 20  | 8 17 35 29 21 | 2.17           |               |               |               |               |               |     |
| 1_DRC2_AU Civic Buildings II | HUMA 3                  | winter 2 | 110 20  | 21 46 33 10 0 | 1.65           |               |               |               |               |               |     |
| 1_FPN_AU Computer Aided Design | TECH 2                  | winter 2 | 110 20  | 63 34 10 3 0 | 1.29           |               |               |               |               |               |     |
| 1_SFI_AU Building Physics I | TECH 2                  | winter 2 | 110 20  | 10 18 27 33 22 | 2.18           |               |               |               |               |               |     |
| 1_STAV3_AU Construction III | ENGI 3                  | winter 2 | 110 20  | 2 12 20 46 30 | 2.41           |               |               |               |               |               |     |
| 1_TZB1_AU Technical Equipment of Buildings I | TECH 5                  | winter 2 | 110 20  | 27 16 26 22 19 | 1.95           |               |               |               |               |               |     |
| 1_AN22_AU Design Studio II | DESIGN 10 | summer 2 | 110 20  | 45 35 19 9 2 | 1.49           |               |               |               |               |               |     |
| 1_C11_AU Foreign Language I | HUMA 1                  | summer 2 | 110 20  | 45 39 27 9 2 | 1.54           |               |               |               |               |               |     |
| 1_DA12_AU Architecture and Art History II | HBST 3                  | summer 2 | 110 20  | 44 35 26 4 3 | 1.50           |               |               |               |               |               |     |
| 1_KOMA_AU Composition II | ART 4                  | summer 2 | 110 20  | 24 42 35 8 1 | 1.64           |               |               |               |               |               |     |
| 1_SFZ_AU Building Physics II | TECH 2                  | summer 2 | 110 20  | 8 13 28 33 28 | 2.27           |               |               |               |               |               |     |
| 1_STI1_AU Statics I | TECH 5                  | summer 2 | 110 20  | 11 23 36 27 13 | 2.04           |               |               |               |               |               |     |
| 1_TZB2_AU Technical Equipment of Buildings II | TECH 5                  | summer 2 | 110 20  | 27 10 22 23 28 | 2.07           |               |               |               |               |               |     |
| 1_VBA_AU Manufacturing and Engineering Constructions | HUMA 3                  | summer 2 | 110 20  | 0 17 14 38 41 | 2.47           |               |               |               |               |               |     |
Table A3. Cont.

| Subject | Category | Credits | Semester | Year of Study | Total Graduates | A Grade Count | B Grade Count | C Grade Count | D Grade Count | E Grade Count | AM |
|---------|----------|---------|----------|--------------|-----------------|---------------|---------------|---------------|---------------|---------------|----|
| 1_VTS_AU Art seminar-plein air | ART | 1 | summer | 2 | 110 | 35 | 40 | 30 | 5 | 0 | 1.52 |
| 1_AN3_AU Design Studio III | DESIGN | 10 | winter | 3 | 110 | 43 | 41 | 21 | 5 | 0 | 1.45 |
| 1_C2D_AU Foreign Language II | HUMA | 1 | winter | 3 | 110 | 52 | 34 | 11 | 6 | 7 | 1.46 |
| 1_DA3_AU Architecture and Art History III | HIST | 3 | winter | 3 | 110 | 41 | 16 | 21 | 24 | 6 | 1.71 |
| 1_MOD_AU Modeling | ART | 3 | winter | 3 | 110 | 23 | 54 | 26 | 7 | 0 | 1.98 |
| 1_NKI_AU Structures I | TECH | 2 | winter | 3 | 110 | 5 | 10 | 26 | 36 | 33 | 2.37 |
| 1_ORPA_AU Monumentic Restoration | HUMA | 3 | winter | 3 | 110 | 37 | 21 | 26 | 21 | 5 | 1.71 |
| 1_S2L_AU Statics II | TECH | 2 | winter | 3 | 110 | 8 | 21 | 18 | 32 | 31 | 2.26 |
| 1_STAV_AU Construction IV | ENGI | 3 | winter | 3 | 110 | 4 | 12 | 25 | 28 | 41 | 2.41 |
| 1_LURB_AU Urban Typology I | HUMA | 3 | winter | 3 | 110 | 27 | 56 | 20 | 4 | 1 | 1.52 |
| 1_AN4_AU Design Studio IV | DESIGN | 5 | summer | 3 | 110 | 62 | 35 | 13 | 0 | 0 | 1.28 |
| 1_AN5_AU Design Studio V | DESIGN | 5 | summer | 3 | 110 | 38 | 34 | 25 | 11 | 2 | 1.57 |
| 1_DSM_AU History of Urban Planning | HIST | 3 | summer | 3 | 110 | 13 | 25 | 47 | 23 | 2 | 1.89 |
| 1_INT_AU Interior Design | HUMA | 3 | summer | 3 | 110 | 49 | 45 | 13 | 5 | 0 | 1.36 |
| 1_KPA_AU Landscape Architecture | HUMA | 3 | summer | 3 | 110 | 12 | 28 | 31 | 23 | 16 | 2.01 |
| 1_NKI_AU Structures II | TECH | 4 | summer | 3 | 110 | 7 | 13 | 21 | 23 | 46 | 2.40 |
| 1_FBB_AU Fire Safety of Buildings | TECH | 1 | summer | 3 | 110 | 7 | 29 | 46 | 14 | 4 | 1.96 |
| 1_STAV_AU Construction V | ENGI | 3 | summer | 3 | 110 | 6 | 13 | 39 | 31 | 21 | 2.22 |
| 1_LUR2_AU Urban Typology II | HUMA | 3 | summer | 3 | 110 | 44 | 37 | 21 | 4 | 4 | 1.49 |
| 1_AN6_AU Design Studio VI | DESIGN | 4 | winter | 4 | 110 | 36 | 58 | 15 | 1 | 0 | 1.41 |
| 1_AN7M1_AU Design Studio VII (module M 1-8) | DESIGN | 13 | winter | 4 | 110 | 59 | 32 | 15 | 3 | 1 | 1.34 |
| 1_AN7M1_AU Design Studio VII (module M 1) | DESIGN | 13 | winter | 4 | 22 | 12 | 5 | 5 | 0 | 0 | 1.34 |
| 1_AN7M1_AU Design Studio VII (module M 2) | DESIGN | 13 | winter | 4 | 24 | 15 | 7 | 2 | 0 | 0 | 1.23 |
| 1_AN7M1_AU Design Studio VII (module M 3) | DESIGN | 13 | winter | 4 | 3 | 2 | 0 | 1 | 0 | 0 | 1.33 |
| 1_AN7M1_AU Design Studio VII (module M 4) | DESIGN | 13 | winter | 4 | 19 | 9 | 6 | 3 | 1 | 0 | 1.39 |
| 1_AN7M1_AU Design Studio VII (module M 5) | DESIGN | 13 | winter | 4 | 10 | 4 | 5 | 1 | 0 | 0 | 1.35 |
| 1_AN7M1_AU Design Studio VII (module M 6) | DESIGN | 13 | winter | 4 | 19 | 11 | 4 | 2 | 1 | 1 | 1.39 |
| 1_AN7M1_AU Design Studio VII (module M 7) | DESIGN | 13 | winter | 4 | 6 | 2 | 1 | 0 | 1 | 0 | 1.30 |
| 1_AN7M1_AU Design Studio VII (module M 8) | DESIGN | 13 | winter | 4 | 9 | 4 | 4 | 1 | 0 | 0 | 1.33 |
| 1_AN7M1_AU Design Studio VII (module M 9) | DESIGN | 2 | winter | 4 | 110 | 68 | 32 | 9 | 1 | 0 | 1.24 |
| 1_AN7M1_AU Design Studio VII (module M 10) | DESIGN | 2 | winter | 4 | 22 | 16 | 3 | 1 | 0 | 0 | 1.11 |
| 1_AN7M1_AU Design Studio VII (module M 11) | DESIGN | 2 | winter | 4 | 24 | 11 | 9 | 4 | 0 | 0 | 1.35 |
| 1_AN7M1_AU Design Studio VII (module M 12) | DESIGN | 2 | winter | 4 | 3 | 3 | 0 | 0 | 0 | 0 | 1.00 |
Table A3. Cont.

| Subject | Category | Credits | Semester | Year of Study | Total Graduates | A Grade Count | B Grade Count | C Grade Count | D Grade Count | E Grade Count | AM |
|---------|----------|---------|----------|--------------|-----------------|---------------|---------------|---------------|---------------|---------------|----|
| 1_AS1M4_AU Studio Seminar I (module M 4) | 2 | winter | 4 | 19 | 11 | 8 | 0 | 0 | 0 | 1.21 |
| 1_AS1M5_AU Studio Seminar I (module M 5) | 2 | winter | 4 | 9 | 5 | 2 | 2 | 0 | 0 | 1.33 |
| 1_AS1M6_AU Studio Seminar I (module M 6) | 2 | winter | 4 | 19 | 10 | 7 | 1 | 1 | 0 | 1.32 |
| 1_AS1M7_AU Studio Seminar I (module M 7) | 2 | winter | 4 | 4 | 3 | 1 | 0 | 0 | 0 | 1.13 |
| 1_AS1M8_AU Studio Seminar I (module M 8) | 2 | winter | 4 | 10 | 7 | 2 | 1 | 0 | 0 | 1.20 |
| 1_EAU4_AU Architecture and Art History IV | 2 | winter | 4 | 110 | 36 | 23 | 38 | 10 | 3 | 1.64 |
| 1_PS_AU Building Project | 2 | winter | 4 | 110 | 36 | 26 | 29 | 10 | 7 | 1.65 |
| 1_UNA_AU Universal Design | 2 | winter | 4 | 110 | 35 | 22 | 23 | 20 | 12 | 1.80 |
| 1_VKM1_AU Selected Chapters I (module M1-8) | 2 | winter | 4 | 110 | 51 | 29 | 22 | 5 | 3 | 1.45 |
| 1_VKM1_AU Selected Chapters I (module M1) | 2 | winter | 4 | 21 | 16 | 3 | 2 | 0 | 0 | 1.17 |
| 1_VKM2_AU Selected Chapters I (module M2) | 2 | winter | 4 | 24 | 9 | 11 | 4 | 0 | 0 | 1.40 |
| 1_VKM3_AU Selected Chapters I (module M3) | 2 | winter | 4 | 18 | 5 | 8 | 4 | 1 | 0 | 1.53 |
| 1_VKM4_AU Selected Chapters I (module M4) | 2 | winter | 4 | 9 | 1 | 0 | 3 | 2 | 3 | 2.33 |
| 1_VKM5_AU Selected Chapters I (module M5) | 2 | winter | 4 | 18 | 6 | 2 | 8 | 2 | 0 | 1.67 |
| 1_VKM6_AU Selected Chapters I (module M6) | 2 | winter | 4 | 10 | 7 | 2 | 1 | 0 | 0 | 1.20 |
| 1_ANG_AU Design Studio VIII | 2 | summer | 4 | 110 | 62 | 31 | 9 | 4 | 4 | 1.35 |
| 1_AS2_AU Studio Seminar II-A | 2 | summer | 4 | 94 | 72 | 15 | 6 | 1 | 0 | 1.16 |
| 1_ANA_AU Studio Seminar II-U | 2 | summer | 4 | 110 | 62 | 31 | 9 | 4 | 4 | 1.35 |
| 1_LEG_AU Introduction to Legislation in Architecture and Urbanism | 2 | summer | 4 | 110 | 32 | 46 | 29 | 1 | 0 | 1.50 |
| 1_ENG_AU State Exam-Theory and Design of Building Structures | 2 | summer | 4 | 110 | 32 | 46 | 29 | 1 | 0 | 1.50 |
| 1_HUM_AU State Exam-Theory and History of Architecture and Urbanism | 2 | summer | 4 | 110 | 27 | 37 | 28 | 11 | 7 | 1.70 |

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