Methods of teaching students versus their preparedness for work as architect engineers

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ABSTRACT: In this article, the authors present the findings of an assessment of the effectiveness of curricula in the faculties of architecture at Cracow University of Technology, Kraków, Poland; the Kyiv National University of Construction and Architecture; and the University of Aviation in Kyiv, Ukraine, in preparing students for work in the profession. A survey was conducted among fourth-year students. The students were asked to list the modules that significantly affect their preparedness for work. The students were also asked about the importance of the manner of teaching and about the activities during classes. The answers obtained at the three universities were not uniform, however the *design* module was rated the highest by respondents. Some responses indicate that it is important to employ different forms of classes - group discussions, individual critiques and workshops. The findings could prove useful in preparing curricula for each year of study.

INTRODUCTION

The focus of the university teaching process is on preparing students for work in their chosen profession. In the case of technical courses, a two-cycle system operates. First-cycle courses in toto typically last no less than seven semesters. At least 50% of the classes are seminars, laboratory and design classes. The remaining classes - up to 50% - are lectures. Various forms of class develop a student's creativity and analytical thinking for developing designs required to meet aesthetic, utilitarian and technical standards [1-3]. The modules in the curriculum of architectural studies in the Faculty of Architecture at Cracow University of Technology (FA-CUT), Kraków, Poland, include: introduction to architectural and urban design; general building construction; building materials; building mechanics; building physics; building structure; construction internship; computer-aided design; freehand drawing; the history of architecture; the history of urban design; contemporary architecture and descriptive geometry.

The second-cycle modules include: principles of urban planning; design for conservation; negotiations - practical aspects of the architectural profession; urban design survey internship; and design internship. Second-cycle courses last at least three semesters. Upon graduating from a second-cycle course, graduates should be prepared to engage in creative work in architectural and urban design, obtain a professional design licence and perform independent technical functions in construction and architecture [4].

Design and general construction are important modules included in the curriculum of architectural studies. They aim to improve students' creative thinking by implementing various project tasks. Their effectiveness can be evidenced, *inter alia*, by the degree of student preparation for work in the profession. To achieve this desired outcome, appropriate teaching tools and techniques are applied, as well as covering a variety of design topics.

The problem with the curriculum was described by Wesołowski, who characterised the tasks undertaken by students during the general construction module [5]. He decided that the building information modelling (BIM) systems, already used in many architectural offices, is an important design tool to be included in the didactic programme. Therefore, it can be considered that learning its principles and application will be useful for students in their professional work. Radziszewski and Cudzik also wrote about parametric design implemented in the Faculty of Architecture at Gdańsk University of Technology [6]. In their opinion, design tools change contemporary architecture, which makes it necessary to master digital tools for 3D modelling. Kobylarczyk elaborated on other activities of students at the FA-CUT and described the process and purposefulness of developing investment offers commissioned by local government [7].

The leading module of *architectural studies* is a design studio. It is intended to enhance students' creative thinking through various design assignments based on proven teaching methods. Their effectiveness is attested to by the degree

to which a student is prepared for work in the profession. To achieve this effectiveness, it is important to apply proper teaching tools and techniques, as well as to cover a diverse range of design subjects.

ASPECTS OF TEACHING DESIGN STUDIO MODULES

The verbal report technique is the best preparation for work in the students' profession [8]. Protocol formulation was applied by many scholars. Von der Weth and Frankenberg used this method in combination with digital simulation, to study the work of engineers [9]. They were able to explore their manner of working on design concepts. Eisentraut and Günter conducted observations of the time designers devoted to each stage of preparing a design and the sequence of actions [10].

Reports are employed during different stages of preparing a design. As observed by Dorst, they are significant both during the initial phase, the approval and the conclusion of work on a project [11]. Ericsson and Simon conducted analyses on the method of *thinking aloud* [12]. Its use by the authors allowed thoughts to be captured concerning the preparation of a conceptual proposal, without assessing creative thinking. This form of conducting design assignments allows for collecting behavioural data, studying a mode of thinking and creative preferences. Bujacz opined that the value of this method lies in the possibility of recording the sequence of the actions and thoughts that form an entire process and not merely isolated observations [13].

Nizbett and Wilson observed that structured protocols provide an objective image of the design process [14]. A short statement by the author of a design can summarise thinking and be significant in determining the final form of a conceptual proposal. Tracing thought processes prepares students for creative work in the profession. This facilitates students in making proper decisions during the initial and later stages of formulating conceptual proposals.

The protocol method can be applied during design tasks, including exercises that require students to work individually and in groups. The choice of design subjects - assignments worked on during various modules as a part of module integration - is also key. The thematic variety of the assignments allows students to come into contact with diverse problems during their professional careers. The thematic variety requires teachers to implement many forms of class - individual critiques, workshops and group discussions. These were rated by students in a survey.

The rating of student work is based on project coding and assignment guidelines. These provide information on:

- assignment content (is the assignment rooted in the real-world?);
- design guidelines (including the size of the building/space);
- the character of the task (whether the building or space will be used in the future);
- assignment conditions (whether they can be compared to actual work at a design practice and whether they are similar in terms of required time) [13].

OVERVIEW OF THE DESIGN STUDIO CURRICULUM

Design classes are conducted using the AP-P method (analiza protokołu-projektowanie) (protocol analysis-design in English)), described by Bujacz [13]. The justification for it was based on data about assignment preparation by students. The authors employ joint discussions and individual critiques. Bujacz avers AP-P is useful for analysing content [13]. It was key to defining the thematic scope of an assignment and the result of design assignment selection criteria [11]. The AP-P was applied by the authors to both individual and group assignments. As previous scholars have indicated, the difference between assessing a design to account for a student's individual work, and group design work requires data analysis. Solving design problems should be considered key. The ability to analyse and solve design problems involve constant monitoring, which is also important during work in the profession [13]. The method is an introduction to teaching both architectural and urban design. It supports different design subjects and forms of class to facilitate independence in making design decisions, while teaching how to work in groups.

Among the group design assignments is site analysis and site planning. Individual student assignments include the sustainable design of a pavilion and a competition for the plan of the interior of a residential or commercial space. Work on the assignments is supported by additional forms of class; for example, joint discussions, workshops, project defences and seminars. They allow students to understand design problems, discuss them and defend their ideas as expressed in conceptual design proposals. Verbal data are collected during the preparation of assignments using the *thinking aloud* method. Visual data are collected via conceptual sketches and the final assignment. The students record their design ideas via handmade drawings. They similarly present the process of arriving at the final proposal.

During work on their assignments, the students visualise scenarios to find optimal solutions. Adopting several scenarios for the use of a given building or space enables the most beneficial choice, which results in project execution under conditions that simulate professional work. When combined with protocol analysis, formulating scenarios allows for the tracing of a design over different stages of the preparation of a design proposal. The first stage is understanding

the subject via analysis, followed by solving problems with the *thinking aloud* method, explaining problems through scenarios, generating solutions through sketch presentations and the final solution via participation in a public discussion.

During the first semester, students in the Introduction to Architecture and Urban Design course are tasked to design an abstract form based on the precepts of composition. Sometimes, this task is based on transforming the work of a selected artist into an original spatial composition. The sensitivity of each student to the aesthetic value of works of art is key here. The necessity to transform provides freedom to interpret the composition. Reporting thoughts over the course of the assignment provides a full picture of how a student utilises their spatial imagination. The assignment requires individual work. The tutor can study a given student's sensitivity, their pace of work and the preferred techniques of preparing the concept. This provides an opportunity for students to come into contact with art and link it to architecture, which can affect how they work on other proposals and other subjects.

The second assignment involves the arrangement of a public space. Before the design work, students perform urban analyses of areas that allow them to formulate conclusions and point to the strong and weak sides of a given area, its development potential or barriers to development. Reporting thoughts associated with formulating the spatio-functional programme after an assessment of the site allows for its rational planning.

Assessment of the designs is through a coded key, following Bujacz [13]. It includes:

- problem verbalisation (what the student worked on, what constrained the layout, how they dealt with the design problem);
- visualisation of the main ideas, assumptions;
- meeting expectations within guidelines (scenarios), generating ideas;
- sketches, idea verification;
- joint discussion, approval, public defence.

In addition, the following is assessed:

- thematic compliance of the project;
- composition of project sheets;
- correctness of the solution, functionality, aesthetics, idea.

RESEARCH METHOD

To investigate to what degree the modules impact the preparedness of students for their professional careers, the authors used questionnaire surveys. Surveys have been used by the authors numerous times when conducting studies of the quality of the housing environment [15]. Surveys are often employed in various fields of knowledge and learning. The surveys used by the authors are original and not published. The questionnaires were handed out to students during design studio classes. The study purpose, scope and the way of using the results were explained, as well as their importance in modifying the curriculum and improving the quality of classes. The time provided for the completion of the survey was not limited, but usually did not exceed 20 minutes.

The study was performed in 2020 at the faculties of architecture of three universities: Cracow University of Technology (CUT), Kiev National University of Construction and Architecture (KNUCA) and the National Aviation University (NAU) in Kiev, Ukraine. Performing the study at three different academic facilities made it possible to compare the three universities and formulate conclusions that can prove useful in improving curricula.

The choice of the research method was driven by the desire to consult the most interested party, the students, to gain their assessment of the effectiveness and quality of teaching. This approach supported the statutory empowerment of students for curricula assessment.

Students are required to assess academic teachers, including the manner and quality of knowledge transfer and teaching content. Such assessment is made by students after the end of each semester. Fourth-year students could assess the usefulness of subjects as well as the content. Workshops enable students to solve practical tasks.

Some students had carried out and defended engineering works related to problems reported by local government. The results are evaluated not only by the examination board but also by the originators of the topics. The survey subject and the scope of the questions resulted from the authors' co-operation with professional environments, including associations of architects and urban planners, as well as representatives of administrative units, design offices and contractors. Students were asked to answer basic questions on their gender and age. Afterwards, they provided descriptive answers that required them to list all classes that, in their opinion, had a particularly strong impact on their preparedness for future professional careers.

The questions that followed concerned the effectiveness of teaching the *design* module and whether the students thought that this module played a significant role in preparing them for their future careers. The students were asked to make a similar assessment for the modules *building construction*, *materials science*, *computer-aided design* and *structural systems*.

The final question of the first part of the survey assigned weights to each activity in preparing students for work in the profession (group discussion, individual critiques and workshop). In the second part of the survey, the students assessed the curriculum for each module taught during the course that had an impact on their preparedness for their future work. The students rated each element on a ten-point scale. The students assessed the modules *design, building construction, materials science, structural systems* and *computer-aided design*.

These ratings showed variations in student opinions concerning the modules at the three universities. The authors used statistics for the average rating value *m*, standard deviation *s* and the coefficient of variation *n*. It can be concluded that the method and sample size were sufficient to consider the findings objective concerning *m* and in comparative terms in respect to *s* and *n*. The most reliable value is the average rating value *m*. The standard deviation *s* and the coefficient of variance *n* should be approached with caution. They can be treated as given for presentation purposes and used only for comparison.

RESULTS AND ANALYSIS

The first part of the survey indicated that the *design* module played a significant role in preparing students for work in the profession. This was expressed by a majority of students of the CUT (24 out of 25 respondents). Of the 23 respondents from the KNUCA, nine reported that *design* module classes played a major role, two disagreed and 12 provided no answer. Of the 66 respondents from the NAU, 30 appreciated the significance of the *design* module in preparing students for work in the profession. Only one respondent disagreed and 35 respondents did not answer.

Similar results were obtained concerning the *building construction* module. Of the CUT-based respondents, 23 acknowledged *building construction* as significant in preparing them for their professional career, while two respondents disagreed. Of the KNUCA-based respondents, nine appreciated the significance of this module, two respondents disagreed and 12 provided no answer. Of the NAU-based respondents, 30 acknowledged the significance of this module in preparing students for work in the profession, one respondent disagreed, while 35 respondents gave no answer.

The module reported by the students of the CUT to have the least significance in preparing them for work was *computer-aided design*. Just 15 respondents acknowledged the significance of it. The *materials science* module was rated only slightly more significant (17 respondents acknowledged its significance), followed by *structural systems* (19 respondents). Of the KNUCA-based respondents, the significance of the *structural systems* and *computer-aided design* modules were rated the same (eight students rated positively the significance of these modules). The vote in favour of the significance of the *materials science* module was higher by only one. Students of the NAU rated the *structural systems* module the highest (22), followed by *materials science* (19) and *computer-aided design* (15).

The results concerning individual forms of activity - group discussions, individual critiques and workshops - were much more varied. The CUT-based respondents rated individual critiques the highest (19 respondents), followed by workshops (four respondents), with group discussions rated the lowest (two respondents). The form of teaching class appreciated most by the KNUCA respondents was the workshop (six respondents). The two other forms of teaching class - individual critiques and group discussions - were each rated positively by two respondents. Similarly, the workshop was rated the highest by the students of the NAU (12 persons). Individual critiques received a slightly lower rating (nine respondents in favour), while group discussions were rated the lowest (four votes).

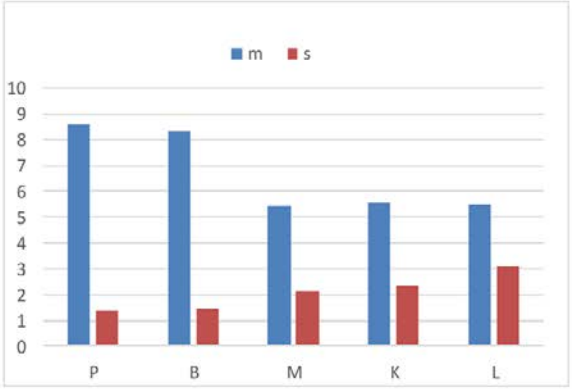

Figure 1: Average value *m* and standard deviation *s* for module ratings by CUT-based respondents.

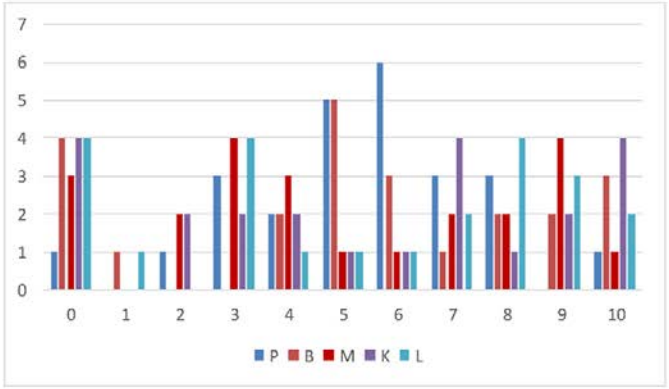

Figure 2: Summary chart for modules, for KNUCA-based respondents.

The second part of the survey concerned assessing each module. The results have been presented in the form of bar charts. The legend is: I - KNUCA; II - NAU; III - CUT; P - design; B - building construction; M - materials science; K - structural systems; L - computer-aided design; *m* - average value; *s* - standard deviation; and *n* - coefficient of variance.

Presented in Figure 1 are the analyses for each module and standard deviation for the CUT. Similar results were obtained at other universities. Certain patterns can be observed. The difference in the usefulness rating of a given module in future professional work does not differ significantly for each module, except for *design*, which was rated the highest at all the universities. The ratings of other modules were comparable with each other. There were small differences between the universities. The exception was the *building construction* module, which received much higher ratings at the CUT. Much greater differences were observed in the ratings given to each module. One distinct feature was the high number of zero-point ratings. The exception here was the *design* module. This is a tendency observed among all the universities.

The standard deviation *s* is listed in Figure 1. These values are similar for the KNUCA and the NAU. They are high when compared to the average *m* values. Much smaller *s* values were obtained for CUT-based respondents. The only exception was the standard deviation for the module *computer-aided design*, which was similar for all the universities. In Figure 2 is the summary chart for modules, for KNUCA-based respondents.

The distribution of ratings by module at each university reveals the diversity both among the modules and universities. It can be assumed that the ratings were independent, without contact between the students, either within or between the universities.

The coefficient of variance *n* results are shown in Figure 3 and, of course, directly relate to the s values. They are considerably higher than in classical studies (more than twice as high). Due to the character of this study, this is to be expected. Hence, the *s* and *n* results should be used solely for comparative purposes. They cannot be used to assess the uniformity of the findings.

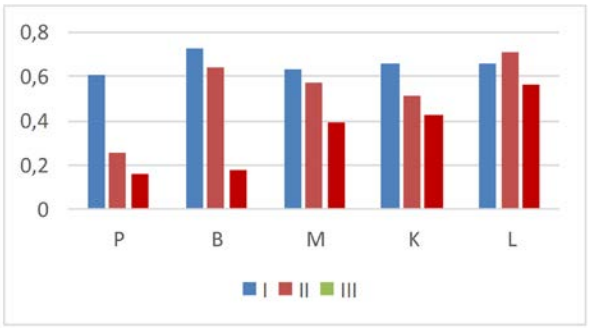

Figure 3: Coefficient of variance value *n* for the rating of the modules by students from each university.

DISCUSSION

Teaching intended to prepare students for work requires constant improvement, including using new teaching techniques distinct for architecture, structural engineering and technology. One limitation that is pointed to by scholars is the necessity to define and impose a mode of thinking for preparing a design. The manner of analysing a design is imposed at the formulation phase in teaching - *say/write/draw what you think*. Verbalisation is not a complete method of analysing modes of thinking - unfortunately there are no means to study its completeness, hence it appears justified to support the method of *thinking aloud* along with other techniques, such as group discussions and sketching. Minimising the problem can involve leaving the students to work by themselves so that they can focus on their own ideas.

The methods presented here are used to support the teaching, primarily of the *design* module, which was highly rated by students. The following modules were also rated: *building construction*, *materials science*, *computer-aided design* and *structural systems*. These modules were identified by students as important before the study. The study confirmed the purposefulness of conducting various forms of classes.

The method of *thinking aloud*, the purposefulness and significance of which was highlighted by students during classes, was not subjected to assessment.

CONCLUSIONS

The results of the analysis were presented in descriptive form for the first part of the survey and then in Figures 1, Figure 2 and Figure 3. Similarities and differences in the ratings of modules at each university and between the universities were analysed. The question concerning how the quality of teaching impacted the survey was left

without a clear answer. However, when the similarity of tendencies is accounted for, it can be concluded that this impact is not significant enough to undermine the credibility of the study and its results.

The *design* module was rated the highest by respondents from all universities. This is understandable since design is the major activity of architects and urban planners. Young people, when making the decision to enrol in the Architecture and Urban Design course, dream of designing works. It is also a module that requires creativity to a greater degree than other modules. Being creative is the pursuit of young people. The AP-P, i.e. the use of appropriate coding of assignment assessments, is a method appropriate for creative design classes. Scenarios that enable the analysis of conceptual proposals and the selection of a final solution are another such tool.

When applying different teaching techniques, it is important to employ different forms of class - group discussions, individual critiques and workshops. Individual critiques proved to be the highest-rated form of class in the Faculty of Architecture at Cracow University of Technology. This implies that the teachers are well-prepared and speaks in favour of their competence and experience.

At the University of Aviation in Kiev and Kiev National University of Construction and Architecture, the form of class rated the highest was the workshop. The answers obtained at the different universities were not uniform, which proves that student preferences differ, but that it is necessary to engage in both discussions, as well as individual and group work.

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