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Project realisation for teaching building materials - a case study

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ABSTRACT: The author has described in this article a modification of the building materials module of the Landscape Architecture course, taught in the Faculty of Architecture at Cracow University of Technology (FA-CUT), Kraków, Poland. The primary motivation behind the changes was the decline in the quality of student projects. Students repeated the solutions from books and projects prepared by older students. There was a lack of creativity in design and a lack of understanding of the technologies. The change described in this article was based on introducing project realisation as a stage in the teaching. Students were obligated to build the structures they had designed, to a scale of 1:1. The objective was to move from theoretical to practical teaching. The change provoked students to a more creative approach to designing structures and new means of expression. It also allowed them to develop skills other than those gained by working with a computer.

INTRODUCTION

As the saying goes, *carta non erubescit* (*paper does not blush*). Student projects, even if made using modern software, consulted about and corrected by instructors, may contain errors. One way to present errors in a project is to build the designed object. Sometimes the realisation of the object may cause blushes.

MODULE OBJECTIVES

Building materials is a module taught in the second and third semester of the first tier of studies of the Landscape Architecture course, in the Faculty of Architecture at Cracow University of Technology (FA-CUT), Kraków, Poland. The primary objective of the module is to familiarise students with the properties of construction materials that are applied widely in landscape design and to encourage students to use creatively diverse materials and products. Students should become familiar with standards concerning material quality and application, as well as basic symbols on architectural and construction drawings [1]. The following problems are discussed during lectures:

- Basic physical and mechanical properties of construction materials.
- Problems associated with manufacturing ceramics and ceramic materials; their application in street furniture design.
- Stone as a material for building and architectural interior design; the advantages and disadvantages of various types of stone and their origin.
- Application of reinforced and non-reinforced concrete; the prefabrication of construction materials.
- Timber and wood as a material in landscape architects' design of interiors.
- Metals and metal alloys as an architectural material; metal joints and corrosion protection.
- Cables and membrane covers applied in the design of small entertainment arenas, observation points and open-air gathering sites.
- Typical roofing materials (tiles, slate, metal sheets) and their natural counterparts.
- Glass, its advantages and disadvantages as factors that determine its application in the design of garden interiors.
- Paints and impregnates as elements that bind and proof works of architecture at the construction stage.

The above is intended to be applied in student street furniture design projects. Each semester ends with a knowledge test and the submission of an end-term project.

CHANGES TO TEACHING

Reasons for the Changes

Before 2018, the object of the term project of the building materials module were structures, such as park benches, gazebos, field altars or fences. These exercises were interlaced with lectures. The lectures sometimes featured on-site studies based on visiting neighbouring parks to investigate the material and technology. The elements that were analysed included the causes of structural degradation and preventive measures. Previously, the teaching was over one semester, as shown in Figure 1:

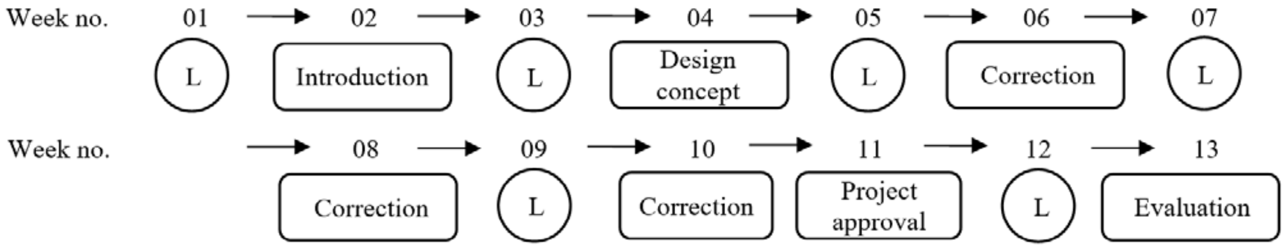

Figure 1: Original teaching: *L* signifies lecture, rectangles signify exercises.

Many students were inspired by what they had seen during visits, copying the viewed solutions. Some students did not pay much attention to construction details, instead focusing only on the general appearance of the structures - on aesthetics. They did not put much thought into the construction or cost, which is one of the major factors in architecture. Furthermore, many projects featured solutions that had been copied directly from the literature or from projects prepared by students during preceding years. This copying was performed without analysis of the copied solutions.

To address this, the teaching was altered to add a practical aspect to verify student projects. The model selected is widely used in teaching modules at the FA-CUT, with good results. As Kusionowicz argues:

> *Making preliminary models for individual structural parts of the whole building structure is a valuable complement to the process of teaching* General Building Engineering *to architects. In the absence of opportunities to participate in the construction of buildings directly, it remains the only way to illustrate the physical principles of solving and constructing various elements, which form the material structure of the building* [2].

However, for small-sized structures, the full design would not be markedly more expensive and time-consuming than a model and would better reveal mistakes and inaccuracies to students.

Modifications to Teaching and their Rationale

In 2017, the teaching was changed to add the realisation of the project. The initiator was Dr Bogdan Dziedzic. To reduce the work and costs, students were divided into seven small groups.

The object of the project was a nesting box for birds. Hanging such objects on trees is the most popular method of protecting birds in Poland [3]. Due to the variety of their construction, they can provide safe places for the nesting of species with different environmental preferences [4]. The nesting box imitates a hollow in a tree and provides protection from rain, wind, cold and predators. Birds build their nests, lay eggs and raise their young inside them. Each student group was to design and build a nesting box. The following guided the project:

- A direct link with the subject of the classes taught in the Landscape Architecture course. Such structures are placed in forests, parks or green squares and are seen increasingly in city centres, even on building façades.
- Small size and weight of the structure makes it movable, which means it can be physically brought to class for review. There is a reduction in construction costs by reducing material use, e.g. it is possible to use, among other things, refused from a carpentry shop.
- Design on the most precise of scales, with drawings on a scale of 1:5, 1:2 and even 1:1. No other module allows drawings to this scale.
- Requirements that place constraints on form and function. They depend on the species of bird that are to nest in the box (the size of the entry opening, the depth of the box) or the place where the box is located (roof shape, the design of the inclines, extending the eave above the entry opening).
- Design freedom: apart from the constraints mentioned above, students are left with considerable freedom in terms of shaping the form of the object, materials, colour or texture.
- The necessity to adapt the form to the function and the function to the form, which is the fundamental objective of architectural design,
- Sensitising students to problems associated with environmental protection and the ecological aspects of landscape design.

Modified Course Outcomes

It was assumed that the existing educational outcomes would be achieved, i.e. familiarity with construction materials deployed in landscape architecture, construction material selection and pairing [1].

The outcomes were to be enhanced by design realisation. Students were to approach the design in a more pragmatic way. It was assumed that new outcomes would be achieved: methods of joining materials; surface finishes; proofing materials against physical, chemical, mechanical and biological factors; working within a team; co-ordinating with specialists; negotiating with a contractor; formulating alternative proposals (often associated with costs); project budget control.

PRAGMATIC TEACHING

The proposed changes were to affect a transition from theoretical teaching to a pragmatic model.

> *Pragmatism is particularly focused on the theory of truth, (...) it postulates a practical mode of thinking and acting (action, particularly practical action, as a fundamental philosophical category) and favours critical thinking and the experimental sciences; experience is understood as a process of the adaptive interaction between an organism and reality (activism in cognition theory); it assumes utility as a criterion of truth, conditioning the truth of statements on their practical outcomes* [5].

The teaching was intended to be similar to the tasks future architects must face in practice, and hence better prepare students for work. The decision to introduce group-based learning was dictated by pragmatism. A designer must work with a team, including representatives of other branches of engineering [6]. For example, this could include work on a conceptual proposal, a design and its realisation in co-operation with a carpenter or ironworker.

> *Interest in group-based learning is being driven by three major factors. First, there is a growing awareness, fuelled by criticisms from employers that students need to be better equipped to work in teams and to be able to collaborate and communicate with people with specialisms other than their own. Second, pressures on staff resources are encouraging academics to explore ways in which students can work effectively in groups, perhaps without supervision. Third, academics and employers are becoming increasingly aware that collaborative learning can raise the quality of the learning experience by developing a range of personal skills and qualities, enhancing understanding of key concepts and giving exposure to a greater variety of perspectives and materials* [7].

MODIFIED TEACHING

During the second semester of the first tier of studies, 30 students were enrolled. They were divided into seven groups. Each group was composed of three or four students. The students formed the groups by themselves. Due to the addition of a new stage - realisation - the course took the form shown in Figure 2.

Introduction to the Project: Week 02 (Figure 2)

The first class is a lecture on the properties of wood. It also features a presentation of the project schedule and subject. As their first assignment students discuss examples of built bird nesting boxes. The analysis is to focus on form, function, material solutions and the manner of construction, possibly adding construction cost. This stage looks for inspiration from existing works that could be useful in the design stage.

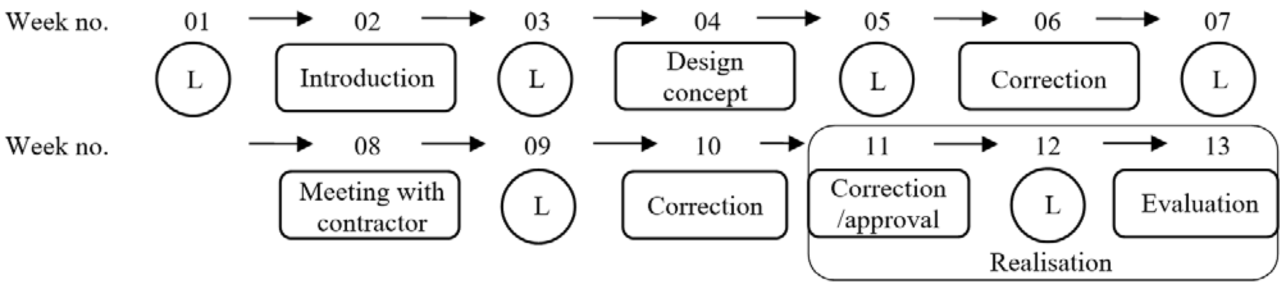

Figure 2: Scheme of the modified course. Circles labelled with the letter *L* signify lectures, while rectangles signify exercises.

Initial Conceptual Proposals: Week 04 (Figure 2)

The next stage involved conceptual proposals. The students were to present working sketches and models and could use 3D modelling software. They were encouraged to find material samples, joints and methods of applying external finishes. They were to pay particular attention to the building of the structure (which would significantly lower its cost) and to limit the environmental impact. Conceptual sketches are always the first *clash* with a new subject. The greatest architects, the likes of Le Corbusier, Renzo Piano or Norman Foster, considered the sketch to be the most important tool of their work [8].

Corrections/reviews: Weeks 06, 10, 11 (Figure 2)

Student groups talk with their instructors, discussing the proposed formal, aesthetic, technological and functional solutions. Apart from sketches and models, the following drawings were required: façade views, plan views, one horizontal cross-section and two vertical cross-sections. The drawings were to be drawn to a scale of 1:2. Over the course of the semester, three classes were assigned for corrections/reviews. Consultations were also provided enabling additional contact with the instructors.

Contractor Meeting: Week 08 (Figure 2)

Some of the groups commissioned contractors to build their nesting boxes or some of its elements. This was often motivated by the degree of complexity of the project (e.g. welded joints, cutting complicated shapes). The teaching did not rule this out. Students learn to talk with contractors, present their ideas and convince them to accept their point of view. They also learn to listen to and employ the experience of specialists. They communicate verified, substantive information with greater confidence. The ability to present ideas is a valuable asset prized by employers [9].

Project Approval: Week 11 (Figure 2)

After corrections/reviews the students made the final tweaks to their projects. The students then commenced the realisation of the project or commissioned it. It was essential to highlight the availability of materials and the possibility of processing them over the course of two weeks, so that the finished projects could be completed before the end of the semester.

Project Submission and Grading: Week 13 (Figure 2)

The students brought their completed bird nesting boxes to the final class of the semester, along with the required set of drawings. The instructors inspected the quality of workmanship and discussed with the students construction methods, as well as any problems or errors, their causes and ways of avoiding them in the future. Also verified was compliance of the structures with the design drawings.

RESULTS OF THE MODIFICATIONS

After the changes introduced to the teaching of the building materials module, seven projects of bird nesting boxes were completed (Figure 4). All were delivered on time. Persons from outside the university, who worked with the materials in the projects either professionally or as a hobby, took part in constructing the nesting boxes. In four out of seven projects, the teaching process went as planned. The three remaining groups, after approval of the initial conceptual design (week 04), handed their initial sketches to contractors. As a result, it was the contractors who made decisions that affected, among other things, the aesthetic quality of the structure (Figure 3). These decisions included surface finishes, the joints between elements and the materials used. The students then prepared technical drawings with the completed structures as a reference. In the case of these three groups, the teaching took the following form:

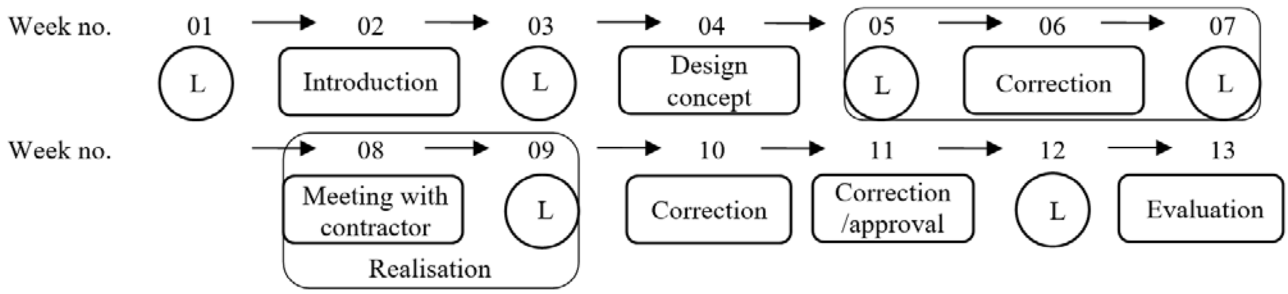

Figure 3: Course involving contractor realisation (second semester). *L* signifies lecture, rectangles signify exercises.

ASSESSMENT

The following criteria were taken into account in the project assessment: compliance with functional requirements; completeness of the project; participation in classes; application of graphic standards; correctness of the materials and construction. The quality of the nesting box realisation and its aesthetics were not important criteria. Although the projects were carried out as part of the building materials module, these criteria do not exist in the educational outcomes. The task of an architect is to design, not build. The exercise goal was to illustrate realisation to verify if the solutions were correct. Training craftsmen is not a goal of the building materials module which, perhaps, should be emphasised when informing students about the assessment criteria [10]. They should attach more importance to the design and less to the realisation.

Effectiveness of the change was assessed by comparing the projects from the previous two years with the new projects. However, it should be noted that previously the students worked independently and 56 projects were completed over those two years. They were compared with the seven new projects. Progress was most apparent in the accuracy of drawings. The difference was because students drew items they had realised. The drawings were preceded by research, the search for the most rational solution and construction. They knew the components of the structure physically, observed the process of creation and the end result. Also, there was a change in the detail of the descriptions. For example, an element description in 2016 was *wooden wall, 2 cm, impregnated, white*. In a new project, a similar element was described as *wall, oak wood, 2 cm, stain-varnish Vidaron Anthracite, grey L16*.

The author approached the results of this comparison with some reserve. Although the assumed goals had been achieved, it should be noted that the *individual* work was compared to the *group* work. A feature of group work is that the talented and hardworking students raise the level of the entire project. In addition, drawing conclusions based on such a small sample is not reliable.

DISCUSSION

The teaching in previous years dedicated much more time to fine-tuning student projects. The corrections/reviews primarily concerned the aesthetic layer of the structures (e.g. gazebos, pergolas and benches), followed by their ergonomics and functionality. Decisions concerning material were made at the end. It appeared appropriate that students quickly shifted to material-related subjects. The choice of the bird nesting box, a small and simply built structure achieved this goal. Four weeks (two exercises and two lectures) were adequate to develop an initial design proposal. The six following weeks (three exercises and three lectures) also proved sufficient to complete the technical design stage.

A problem was the deliberate avoidance of the technical design stage by three design groups. By delegating some of the design decisions to a contractor, they wasted an opportunity to learn many skills key to architects. These skills include making decisions that are key to a project and the ability to analyse technical solutions in terms of feasibility and buildability. They also could not discuss changes with their instructors.

The role of the instructor during corrections/reviews is to not only correct mistakes, but also to motivate further pursuit in the design [11]. Some corrections noted on drawings prepared would have been pointless, being too costly and necessitating a reconstruction from scratch. Such corrections had a theoretical character, contrary to the teaching.

For next year's classes, it is planned to introduce a separate grade given at the end of the corrections/reviews period (Figure 2, step 11), before realisation, to allow better enforcement of the teaching.

Figure 4: Examples of nesting boxes designed and built by students, during the modified teaching.

CONCLUSIONS

Changes to the teaching process produced the expected results. Transitioning from theoretical to pragmatic teaching provoked students into a more creative, individual approach to designing the project structure and its aesthetics. The finishing of surfaces and the choice of colour were given much more attention. The appearance of the object on a computer monitor is not sufficient when preparing a design.

Modification of the teaching also enabled the development of skills that cannot be obtained by working alone with a computer. By working in a team, students experienced first-hand how difficult it is to delegate and assign tasks. It is important to define clearly the scope of responsibility, to avoid misunderstandings and conflicts. They also gained experience in exchanging ideas to improve their designs. Work with an actual material allows students to better understand its physical and mechanical properties. Instructors at present are discussing the possibility of adding changes, involving the realisation of much bigger structures, such as information boards or benches, by larger design groups.

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