A Design Studio Pedagogy for Experiments with Unusual Material, Collaboration and Web Communication

Kateřiná Nováková, Henri Achten and Dana Matějovská
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Abstract

In this paper we describe an experimental CAD design studio, where we study the influence of CAD tools and special materials on the process of designing. The studio has the following aims: teaching how to collaborate using an Internet facility, and exploring the relationship between computation, sketching and physical models. Interaction and sustainability are major themes in the design studio. We present the pedagogical approach and results of the design studio, followed by observations and conclusions.
1. Introduction

In order to teach students different working methods with the computer and in design teams, an experimental CAD design studio was created. The studio takes place in the Master programme of the faculty and is a voluntary course for 4 credits (ECTS). The pedagogical aims for the studio are learning to collaborate, how to use an Internet facility to communicate between design team members, and explore the relationship between computational and physical models. Up to now, three themes have been realized within the design studio: “interactive playground” (one semester), “responsive exhibition stand” (one semester), and “garbage architecture” (three semesters). The themes are small enough so that they can be realized within the semester, and different enough from regular design studio assignments to stimulate curiosity. Also the theme of interactivity allowed discussion about various existing and novel technologies that are currently being explored within the field of architecture (see for example [1], [2], and [3]). Twenty-nine students and three teachers took part in the experimental design studio till today.

2. Untraditional Materials and Cad

For a long time, traditional CAD support has focused on the formal side of architecture—that is the geometric description of the design in 2D and 3D documentation. As geometry is relatively straightforward to describe digitally, this did not pose too many problems. In fact, because of its fairly neutral character (the geometrical description by itself does not presuppose particular ideas, concepts, and annotations by the architect) geometry has been a very productive basis for CAD systems. Things become more difficult however, when we want to incorporate notions such as material properties. In Machine Engineering for example this is developed quite far, but in architectural design this is not so much the case. Recent developments in architecture—the area of fabrication most notably—is exploiting this relationship as well (see for example [4], [5]). In fabrication the relationship between material and what kinds of designs are possible is explored. When we are working with traditional materials, such as concrete, bricks, and steel, then the properties are well known, and we know what to expect in terms of what shapes and dimensions we can afford, what it will look like, and so on. These materials are easy to parameterize since we know their properties.

What happens however, when we want to use alternative materials (for example strawbricks, mud, earth)? Of such alternative materials not a lot is known, and therefore they are difficult to parameterize let alone design with. The only way how to get some working experience with such materials is by experience, and thus experimentation. When such experimentation takes place in a design context—for example a design studio—then there is a very tight relationship between the experimentation and the design result. If we
move to even more untraditional materials such as garbage, then our knowledge of the material really falls short. There is for example some testing going on at the Faculty of Civil Engineering VUT, where they construct flood protecting walls of concrete mixed with cut PET bottles. Working with such untraditional materials in a design studio setting works in a continuously cyclic process of material experimentation, trying to capture some properties of the material, proposing designs based on this knowledge, and further experimentation with slightly more advanced designs and insight.

2.1. Virtual Environment

From the argument outlined above, we believe that working with untraditional materials requires a different approach in the design studio. The focus is much more on the material exploration and getting to understand the characteristics of the material than on the parameterization as such and generating form on that basis. In such a setting, there simply is no knowledge which enables a student to start a parametric or performative design right away with a CAD tool, generate shapes, and create these shapes by means of fabrication. Rather, the studio operates in much the same way as the “Active Studio” explored by [6]. In the Active Studio students were offered a set of tools and the teachers were rather learning along and guiding the students instead of instructed one ideal or best working process. The “learning-by-doing” approach of Active Studio we extend by embedding the design studio in a virtual learning environment which the students use to record their work. In this sense, the studio supports a more constructivist approach [7]. Additionally, we are aiming for a Lo-Tech approach as we have limited means in our institution on the one hand, and as the use of easily available untraditional materials such as waste are readily available for students.

The experimental design studio took place within the facilities of MOLAB. The students had at their disposal a computer lab and the workshop. In order to support the collaborative design process, we used the Moodle system which is available at the university [8]. Moodle (an acronym for ‘Modular Object-Oriented Dynamic Learning Environment’) is an open source educational system. It allows a variety of teaching approaches, such as courses with weekly, thematic, or open structure and allows all kinds of interactions between students (groups) and teachers. In a traditional way, the teacher is the information provider who prestructures a course or design design, and the students are more or less the consumers with limited ability to add or change the content. Within predefined sub-wiki’s by the teachers students can create their own workspaces. Guests can see accessible courses but are not allowed to upload work or edit the pages. Moodle is predominantly used for regular course teaching. In case where it is used for design studio teaching, its typical application is as a datastore for information to students, messages from the teachers to the students, and to present the program of the studio. In our case we changed the traditional approach by giving all students the teacher status, meaning they could change the design studio pages by themselves as
they saw fit. In the beginning of the design studio, Moodle was presented and demonstrated how it worked. After that the students could take things into their own hands. Similar approaches are for example [9], by means of the Phase(X) system. In this system students would upload their work, and select and continue with the work of someone else.

Although Moodle can be used in a collaborative manner, it does not strongly promote the awareness of the co-presence of fellow users. Other kinds of environments, for example those provide a virtual environment (see for example Second Life [10], or older ones such as ActiveWorlds, Blaxxun, and Holodesk [11]) show avatars of fellow users, but offer less possibilities for documentation and information sharing. In that sense Moodle was better suited for our purposes since our focus was on the mutual explorative nature of the design studio.

3. Phases In The Design Studio

The design process in the experimental design studio proceeds through the following phases: analysis in groups, individual design, creating a prototype, and public presentation. The first two phases are fairly standard in design studios. However, we require in the design studio that the students make a prototype (using untraditional materials), and additionally that they present their work and try to interest an investor to provide financial means to realize the design. These latter two aspects we believe are quite rare in design studio projects. We are not aware of any similar approach published by someone else.

3.1. Analysis

In the analysis phase, students have to study the design task of the studio. We devote four weeks to analysing, while several ways of conducting the analyses are combined.

1. Internet exploring, debate.
2. Excursion with photo safari.
3. Experiment.
4. Presentation of the analysis.

As stated in the beginning, in the design studio we have had three themes: interactive playground, exhibition stand, and garbage architecture. For the playground, the analysis involved creating a provisional playground and video observation of the activities in the playground. For the exhibition stand it involved a literature review of existing exhibition techniques and visiting a fair. For the garbage architecture an excursion was made to a dumping place. Internet was searched for the references, and experiments with concrete were executed utilizing different types of garbage in the Laboratory of Concrete at the Faculty of Civil Engineering ?VUT. For this purpose PET bottles were collected in the entrance hall of the faculty.
motivate people to hand in PET bottles we made a so-called PETlin tower where they could dispose used bottles (Figure 1). The main inspiration to the project was the film Garbage Warrior about the architect Michael Rheynolds [11] who creates sustainable buildings using among other materials garbage. We watched this film and discussed it in one of the first lectures. We aim to have the analysis as much ‘hands-on’ as possible, so that students are actively engaged in making models or testing materials.

Students are encouraged to structure the analysis by themselves, under guidance of the teachers. They also have to document their findings in the Moodle system so that they can be communicated between each other. We find that this is very helpful, as students refer back to the analysis part quite often during the design process. In the photo safari, students go out to visit concrete examples of the design studio: several playgrounds, a fair trade complex, and a waste disposal facility. The images and videos that they create during the photo safari are uploaded again to the Moodle system for documentation and presentation purposes. The physical confrontation with real existing projects and sites proves to be very stimulating. It raises new ideas what is possible, and also shows many innovative and interesting ideas that are already realized.

Figure 1. PETlin tower, used to gather PET bottles
3.2. Individual Design

While analysis was done exclusively in groups, designing in the first phase is done individually. To support the development of the project and team atmosphere, we organize a two-day workshop, where the students work exclusively on the design studio. We found that taking the students to a distant place has a good effect on the team spirit and motivates the students to work on the project. The teachers prepare the workshop by gathering much inspirational material and making this available on Moodle. The workshop typically starts with showing this material and discussion of possible implications. Further on, the students can work on their individual projects. At the end of the workshop each individual design has to be worked out in such detail, that it can be presented to a outside critics. The work in progress and presentation are stored in the Moodle system and after the workshop there is the second presentation. At the end of the single design phase, we invite a potential investor for whom the students have to present their work. The investor then decides which design he would like to acquire and how much money is to be invested. In the group, the students have to realize as a full-scale prototype of the winners design. In the case of the playground the investor chose the interactive net design, in the case of the exhibition object no design was chosen, and in the case of the waste architecture, in both finished projects all objects were chosen.

Students take the presentation to the investor very seriously and invest a lot of time and energy in the presentation. In many cases therefore, the presentation also implies a big step forward in the design process. However, also because of this, students tend to take a week “off” after this presentation because the deadline for realization of the prototype seems far away. For the teachers it is important to keep the students actively engaged in the process.

3.3. Creating a Prototype

In the last four weeks the prototype is to be produced. In cooperation with professionals, students are asked to work the details out in group. The Czech students and teachers usually search for the investor during the semester. After presentation of their work, when convinced, the investor then (financially) supports one or more projects to be realized. Students are motivated by the vision of their own product and the investor gets the original idea for free. All this activity helps to spread the idea of for example recycled architecture or interactive playground and also a basis for further research. As teachers and researchers we aim to observe, whether the initial idea is completed and if the product works as intended.

3.4. Public Presentation

The public final presentation of experimental atelier is important because not only do the students learn how to speak to non-professional public and present their project, but they must also cover the topic of sustainability or “interactivity”
and be able explain it. That is why we organize the exhibition of the products and projects in a public gallery. After a short introduction by the teacher students do shortly speak about their own projects and try to “sell them.”

4. Final Prototypes

In the following Table we summarize the prototypes that were created in the design studio.

<table>
<thead>
<tr>
<th>Final Prototype Created in the Design Studio</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive net</td>
<td>A 6 x 6 m² net suspended by trolleys from the ceiling (Figure 2).</td>
</tr>
<tr>
<td>Responsive sound installation</td>
<td>Installation that reacts to the nearness of people in a sitting area with sound.</td>
</tr>
<tr>
<td>Pavilion</td>
<td>Pavilion of which the interior decoration can be changed by the visitors (not realized).</td>
</tr>
<tr>
<td>Chair of PET bottles</td>
<td>Chair made of 120 pieces of 1.5 l PET bottles (Figure 3).</td>
</tr>
<tr>
<td>Chair of car tyres</td>
<td>The car tyre is cut at one side and then curved along a metal frame support (Figure 4).</td>
</tr>
<tr>
<td>Chair of knitted plastic bags</td>
<td>The “canvas” of the chair is created by knitting plastic bags (Figure 5).</td>
</tr>
<tr>
<td>Lamp of PET bottles</td>
<td>PET bottles are cut into stripes, which are then combined to make a lamp cover (Figure 6).</td>
</tr>
<tr>
<td>Pavilion</td>
<td>Pavilion of chicken wire, concrete, and towels (experiment was realized in small scale).</td>
</tr>
<tr>
<td>Lamp of waste-paper</td>
<td>Waste paper is used in a papier-maché fashion to create a lamp covering (realized).</td>
</tr>
<tr>
<td>Lamp of coat hangers</td>
<td>Wire coat hangers are combined in a circular array to create a lamp (Figure 7).</td>
</tr>
<tr>
<td>Stackable urban furniture of waste-wood</td>
<td>Box like structure of waste wood that can be opened to reveal the backrest; when closed it can be stacked various configurations (not realized).</td>
</tr>
<tr>
<td>Sitting object of PET bottles</td>
<td>PET bottle caps are arranged on a wooden frame. Bottles can then be screwed in various configurations and sizes on the frame, resulting in different kinds of objects (Figure 8, 9).</td>
</tr>
<tr>
<td>Chair of wire hangers</td>
<td>A chair that rests on the ring protection around trees; the sitting area is made with wire hangers.</td>
</tr>
<tr>
<td>Zippable container of water bottles</td>
<td>A large water bottle is cut open along the top; it can be opened and closed with a zip, resulting either in a storage area or a chair.</td>
</tr>
<tr>
<td>Foldable office unit of cardboard</td>
<td>A closed rectangular box which when opened contains a chair, table, and wall to work on (not realized).</td>
</tr>
<tr>
<td>Blanket weaved from PET bottle strips</td>
<td>A 2 × 2 m² blanket weaved from ironed PET stripes (8m long) bound in plastic bags. It results in a fabric which can provide shading or used to sit on (Figure 10).</td>
</tr>
</tbody>
</table>
In the following section we show some of the realized prototypes, with some additional observations how they were created.

► Figure 2. The net for the interactive playground, designed by Stanislav Moravec. By using pulleys and fixed points, the net responds to children crawling over the net.

► Figure 3. PET bottle chair, by Ana Pezdirc. The PET bottles are held together with foil and covered with papier-mâché.
Figure 4. Car tyre chair by Rodrigo Diaz. The tyre was cut at one place, and the two ends were folded up and bolted together. The steel framework was provided by a blacksmith.

Figure 5. Chair made of knitted plastic bags by Matias Saresvuo. The plastic bags were strung together by knots, and the fabric was created by traditional knitting techniques. The steel frame was provided by a blacksmith.
Figure 6. Lamp cover by PET bottles by Mikael Saurén. The PET bottles were cut in strips and weaved together. Stability is ensured by a wire frame.

Figure 7. Coat-hanger light created by David Lindecrantz. The light was made of 28 old aluminium coat-hangers, sprayed with black lack. It consists only of the garbage found, piece of metal wire and the bulb with the amenities.
Figure 8. Sitting object made of a wooden frame and screwed PET bottle caps by Magnus Samuelson. This project supports/needs public interaction because they can choose what and where to put the bottles. In the end it is actually created by the public.

Figure 9. Sitting object by Magnus Samuelson. The prepared surface with PET bottle caps.

Figure 10. Shading or sitting blanket by Zuzana Pöbišová. It was created by cutting PET bottles into strips and weaving them. Depending on the closeness of the weaving it provides more or less shade. It can also be used as a blanket for sitting on.
5. Observations

Based on the work presented here, we can make a number of observations concerning material and prototypes, CAD in the design process, collaboration, and using Moodle.

5.1 Material and Prototypes

Before actually working with the materials, the students did some analysis of previous work found on the internet, made observations at a dumping place, and in this way collected abstract knowledge. But in most cases this proved not enough for the students to grasp the nature of the material and indeed how to design with untraditional materials. In the initial phase students tried to create their first CAD models, much in the way they are taught in design studio. They produced some very nice models and images, but they were quite removed from the physical models. Nobody could tell, whether it was possible to build such designs and how they were going to look like. Therefore, when the students started to create the real products, the initial proposal started to change and looked different. So the most realistic CAD models and visualizations started to appear only after beginning of the production process. Working with PET bottles for example, means cutting with wire or sawing which does not create sharp edges and nice regular angles. Therefore the shape is always unpredictable and amorph, which is very hard to capture in CAD if not impossible.

We found therefore in the design studio, that parameterization of the materials could only be achieved on very modest levels. The CAD model cannot act as a design driver because there are too many unknowns in the material. The process therefore is much more iterative and one of documentation rather than shape creation. This observation can also be found by other researchers who worked with material/digital design studios [13].

5.2 CAD in the Design Process

As stated above, because of the nature of untraditional materials, a more or less traditional approach to the use of CAD for modeling can hardly be followed literally. The process of creating the prototype influences the final design so much, that these two processes must be parallel. Likewise, early material testing is important to gain first knowledge of the material, but in many cases the student (or the teacher) has little idea of what exactly needs to be tested because the design has not been framed yet. Early testing therefore can only be used for exploration and inspiration what can be done. Only after that a first idea and intention can be formulated. Long and difficult CAD designing is not productive in these cases because there are no useful tools that are able to characterize the special forms which can be created. It works better to work with rough design sketches and simple physical models, combined with material testing. Only when the material starts to
speak, and the student gains the first insights into its potential CAD modeling becomes possible since the students starts to know shapes, function, dimensions, and colors (s)he can afford. This phase is then used to create a more or less final design which serves as the reference to create the full prototype. These final designs have a rather close resemblance to the final product, so the students were able to create realistic designs in this way.

5.3 Collaboration

As mentioned before, there are three main phases of the studio, which differ also in individuality or group work. The analyses and experiments are done in groups. The aim is to collect a body of knowledge. The students contribute to the collection of experiences on the Moodle pages. Experiments are done always in groups. Individual designs should prove everybody’s skills and give the students a chance to express themselves. In this phase they basically are competing against each other. In the third phase, when the winner project is chosen, all participants work together to finish the prototype. We only managed to accomplish this last phase with the interactive playground, because in the other three cases there was no single overall winner project. The garbage topic allowed everybody to finish his/her design and have a prototype while the interactive exhibition stand found no investor who would be able to finance the very expensive designs. In general the teamwork went well, but because of the completion of individual designs in the second, third and fourth semester it occurred mostly in the first phase.

As we were working with many foreign exchange students we found that the collaboration was more fruitful when the students have not known each other before and speak different languages. It appears that breaking the language barrier also breaks the social barrier. In the introductory phases of the course the excursions or experiments work as a team building action. Later, we try to complete the team-building by organizing a two-day workshop in a different location than in school. This forces students to focus on the work and they are less distracted by other factors.

Systems that support group work or work by individuals have been created many times. To the best of our knowledge however, the switch from single design to group design that we introduce in our studio has not been attempted anywhere else. The pioneering Phase(x) project [8] offered support for multiple single designer, but always one student at a time. The Silk Road project [14] provides a comprehensive interactive online encyclopedia so in terms of documentation it is quite similar to our work. In the case of our design studio we feel the benefit in the switch lies in the fact that it provokes collaborative work.

5.4 Moodle

For distant communication the Moodle system at eVUT is used. Students are given the teacher status to edit the pages, so they are encouraged to
using electronic way of communication. For the teachers it serves very well for monitoring the progressing work and designs and showing it to potential investors just by sending them a link. There are also some drawbacks however. Because the system is setup as a teaching environment, it takes some guidance and constant checking whether the students are actively engaged with Moodle – the system does not really promote this as the interface is built on the assumption that a teacher creates the content, and not a group of people. The program web interface is not always very intuitive, so the students are often using the site in different ways which tends to spread out the information over the main page, personals blogs, news items, and so on. Nevertheless, the system works quite stable and after a while really starts to become an on-line memory of the project.

5.5 Pedagogical Results

In summary, we have achieved the following pedagogical results:

- Collaborating through teamwork and use of the Moodle system.
- Investigating the concept of interactivity in architecture.
- Structuring a design process with activities such as experimentation, observation, and team decision making.
- Presenting an idea to an outside investor.
- Designing and realizing an object in full-scale.

The biggest shortcoming we see in the design studio up to now is the low integration of CAD in the work flow. We feel we have the beginning of a work process established when working with untraditional materials, but more knowledge of materials is required to make this more productive. However, given the relative small of the studio (4 ECTS credits) this falls outside the scope of the studio.

Acknowledgements

We would like to thank the students who took part in the experimental design studio in the past period. Their effort provides a critical and important contribution to the results of the studio. We also want to thank the investors who financed the realization of the prototypes and exhibition of the work, and also the blacksmith who created the frames for the chairs.

References


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