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1:1, A Transdisciplinary Prototyping Studio

Fig. 1. Loop Pavilion

photo: Marie Davidová

The main author is using transdisciplinary studio courses as a research tool in the field of performative wood. Through sharing the knowledge between architectural, environmental design, and wood science researchers and students, we managed to develop complex 1:1 scale prototypes. The course process is a learning arena for students, teachers and researchers and the skills, competences and insights are being developed through experimental practice. The second prototype of the Environmental Summer Pavilion II course was created from reflection upon the first one while both serve as complex material-environment interaction studies for the development of responsive envelopes.

I. Introduction:

The theme of this paper is to present and discuss the experiences of working in a transdisciplinary prototyping studio forming a learning framework for a collaboration between two different university level institutions, working with full scale prototypes. The research guest studios have been led parallel at architectural schools, the Architectural Institute in Prague [1]and the Faculty of Art and Architecture at the Czech Technical University in Liberec [2]in 2013 and 2014, respectively and at the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague [3].In both of the cases, there were three guest tutors, the first author, being the project leader and being responsible for the material and architectural performance of wood, Martin Gsandtner/Šimon Prokop, responsible for coding and Martin Šichman/Martin Kloda, responsible for structure, detailing and realisation. In addition, different specialists from both of the faculties were available for the consultations and prototypes testing.

The work conducted in the presented collaboration is based on material research by design on the dynamic features of wood. Following the work of Hensel [4] and others in using the performative material features of wood, for example shrinking and warping, as a dynamic material feature from which one could benefit, the research ought to further develop this approach.

The methodology for the research is based on Research by Design (Research through Design) as described by Frayling [5] and others and developed in more detail by e.g. Sevaldson [6], [7].

Research by Design is in the process of being established as a solid approach and a more effective version of the practice of Research in Design, [8] where uniqueness, reflexivity, discourse and generalization are addressed.

All modes of modelling in physical materials and digital models are applied during the experimental design work. Full-scale prototyping is central to this method. The models and prototypes work as a dialogic platform for interdisciplinary inquiry. This way of design research had been common during the Renaissance times, for example in the work of Leonardo da Vinci. Highlighted by the most advanced structural experiments by the end of 19th and the duration of the 20th century, prototyping became a key method for material research and is used by the academy as well as by the industry.

Michael Hensel explains it as follows:

'…. The findings of the material experiments are the basis for computational modelling and analysis, which serves to further elaborate the design as it gains in complexity. In most cases, the design experiments culminate in full-scale constructions that can be further examined in order to empirically derive reliable data for the further development of the specific material system, working methods and approach to design.' [9]

From the philosophical point of view, the method is argued for by Wallner:

'We understand what we have constructed. We cannot understand anything else.' [10]

We could add that only when our experiments are finalized can we fully understand what we have constructed and what its implications will be.

Schön is describing the design process as reflection in action, explaining the reflective conversation within the situation, while gaining the skills by experience [11]. Reflection in action has been central to the research process, beginning with sample observations and concluding with the built prototypes. The success or failure of design actions has been central in building a body of methodological and technological knowledge. Numerous failures were unavoidable due to the lack of particularly developed methods suitable for the case. Samples, prototypes, and measuring had to be repeated because of the utilization of methods that in hindsight proved to be inappropriate. As Sevaldson stated in reference to designing with digital tools: 'clear models and methodologies do not yet exist – these are being developed through practice' [12]. The same can be applied to material research by design, using digital tools and prototyping in 1:1 scale. The design problems we are discussing here are of a nature that confronts the designer with wicked problems [13]. There is no right or wrong answer, each problem is to a certain degree unique and it is only possible to base a resolution on prior experience to a limited degree. Therefore, the researcher needs to base her or his learning on practice, reflecting the failures that also bring the new findings. This process develops in iterations, which makes every new prototype more complex.

II. The Project: Wood as a Primary Medium to Architectural Performance:

The introduced prototyping studios are part of the first author's PhD research project, Wood as a Primary Medium to Architectural Performance, where the key interest is the development of environment responsive screens/envelopes. During the spring semesters of 2013 and 2014, the courses Environmental Summer Pavilion I [14] or II [15] were conducted at the Architectural Institute Prague and the Faculty of Art and Architecture at the Technical University of Liberec, respectively, both in cooperation with the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague. Prior to the start of the first course, various theoretical studies, speculations, and sample observations were conducted by the first author and research questions for the first course were established in the paper for the 33rd eCAADe conference as follows:

'• The main area of our investigation lies in the material performance of solid wood: Wood - Humidity - Temperature Interaction (see section 'Material Performance').

• A second topic is the question of how to create parametric models of the design and produce CNC fabrication data, leading to the question: Can parametric design cover all the design tasks? (See section 'Design Process in Grasshopper for Rhino 5'.)

• Finally, we discuss the structural possibilities of CNC fabricated design (see section 'Structural Design').' [16]

The course lead by the author, Šichman and Gsandtner lasted only a half semester, so much of the production data and industry negotiations had to be finalized by the tutors until the students returned to physical prototyping when their school duties finished in ARCHIP's students case, or in FLD CZU students' case it was their new course of professional practice. This situation was not ideal, but it was the only possible option. However the main focus on material performance was maintained in the course. The observation of warping of the panels and structure from torqued greenwood planks locked in a triangular structure was described as follows:

'…The pavilion designed for reSITE festival, is a möbius shaped structure, built from torsed pine wood planks in triangular grid with half cm thin pine wood triangular sheets that provide shadow and evaporate moisture in dry weather. The sheets, cut in a tangential section, interact with humidity by warping themselves, allowing air circulation for the evaporation in arid conditions.' [17]

Along with this project, mapping the overall performance from worldwide orientations mainly focused on sample measuring, the speculation of particular application in the building industry was investigated on prototype Ray 2. The prototype developed further the combination of design with material science. This was published in 33rd eCAADe proceedings:

'Ray 2 is a wooden environmental responsive screen system that reacts to changes in relative humidity. Based on the material properties of wood, cut in the tangential section, the system opens in dry weather thus airing the construction. Whilst in the humid conditions it closes, not allowing the moisture into the structure.

Ray 2 was developed from the concept of Ray with the fact that it resists to sudden rain. Based on the properties of tangential cuts from different position of the tree trunk, the plates are combined in diagonal directions...' [18]Both of the prototypes were observed and analysed and reflected upon and the findings were used as a starting point for the next pavilion course, led by Davidová, Prokop and Kloda. This time, a full semester was provided for the course so the schedule was not as tight. The resulting Loop pavilion utilised and developed further the gained knowledge to its fullest potential and increased the performance by design. The panelling was laid not only in combination of the left and right side of the tangential section, but also in spatial organisation into the structure. In this case, as it was observed on the prototype, the circulation of humid air was better. The team work was organized in a much more efficient way by arranging regular meetings with GIGA-mapping [19] for team work, an online file-sharing offered by *Copy* cloud service and a private Face Book group. This was especially useful because the two participating faculties were located in different cities [20]. The GIGA-mapping method proved to be a perfect tool for interdisciplinary communication both, within the team as well as with the invited specialists. The performed sampling, as well as parametric analyses of joints, wood extension or FEM simulation, was more promising in the end than the final full-scale prototype. This speaks to the fact that full scale prototyping is necessary within architectural research.

In both cases, the pavilions were designed by the entire team-the students as well as by the tutors-, after the initial concept sketch was selected through a competition. In the second case, the responsibilities within the design tasks were more clearly outlined after being discussed by the entire team over a GIGA-map. In both cases, the students followed up observations of the prototype originally made by the first author. The students with backgrounds from different disciplines were initially not assigned to particular tasks but all were coping with design, engineering or environmental issues. Later in the process, the responsibilities were assigned according to particular interests relating to the profession that they were studying. In addition, the researchers from both of the faculties were engaged to assist with particular design questions.

III. The Transdisciplinary Prototyping:

The cooperation between the disciplines proved to be smooth while each of the professions followed their particular missions. The cooperation between the Architectural Institute in Prague (ARCHIP) and the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague (FLD CZU) worked well as continual prototyping and designing were interchanging. Students from both institutions cooperated well during the overall process, exchanging their skills and using their institution's facilities and studios and competences e.g. structural engineer of ARCHIP and wood workshops and wood technologists of FLD CZU. The mature and experienced students of FLD CZU, many of them with architectural background, organized the prototyping and fabrication as well as helped with digital data.

The Faculty of Art and Architecture at the Technical University of Liberec (FUA TUL) was well-suited for concept design and this part of the project was performed there, including regular meetings over one common GIGA-map that also served for the organisation of the team work. The Faculty of Forestry and Wood Science at the Czech University of Life Sciences is well-equipped with wood workshops and testing machines. Therefore the prototyping, as well as the final fabrication, took place here. This time, we had few students from FLD CZU following the overall process but we had also a student with building engineering background in the architectural team, who could be involved full time.

The skills of the students perfectly complimented the equipment of the school. The wood engineering students had much better practical experiences with machines as well as with the materials and the architectural and environmental design students were learning such skills from them. On the other side, the architectural and environmental design students were better in following the complexity of the overall project while still maintaining responsibility for certain tasks.

Due to the different missions of the faculties, architectural and environmental students possessed a time advantage in having the studio as the main subject. This changed when it came to the building phase, when wood engineering students were given the task as their full time exercise in professional practice.

Though we believe it would be ideal if both teams could have participated equally, the division of the work intensity according to the different professions worked well. The wood engineering students focused on material and prototyping consultancy or small tasks within the concept design phase, which was mainly executed by architectural and environmental design students. The architectural students had a perfect overview of the design and fabrication data and could organise the building process when the wood engineering students were engaged in the workshop.

IV. Conclusions:

The 1;1 scale prototyping is necessary for Research by Design development when it comes to material-design experimentations. Though the sample observations and digital simulations are helpful, they are not fully representative for the overall situation. So, despite that constant learning was achieved through action and analysis throughout the whole design process, the main learning input was obtained from the full scale prototype. And thus the loop pavilion gained the most from the previous prototypes and studio experiences while it brought forth new questions for further consideration. New experiences, successes as well as errors were recognized.

The transdisciplinarity of the project played a crucial role within the process. While the wood engineering students proved to have the best experience with physical prototyping, the architectural students were better equipped for design tasks, using digital tools and handling fabrication data. At the same time, the environmental design students had the best understanding of implementing the local conditions. One of the students had a graphic design background, which was of great assistance, when deciding the organisation of the GIGA-map, as well as its finalization for print. GIGA-mapping turned out to be an ideal tool to bridge differences between the groups and for coordinating the work.

The full scale prototype generates a distinct and clear transdisciplinary understanding because all team members focus on one common product while implementing their professional background and observing and analysing the common result at the end.

V. Participating Students

V.1 pareSITE:

Yuliya Pozynich, Jason Nam, Alena Repina, Daria Chertkova, Yana Vaselinko, Mikkel Wennesland, Dan Merta, Daniela Kleiman, Liv Storla, David Lukas, Christopher Hansen, William Glass, Jiří Šmejkal, Milan Podlena, Josef Svoboda, Tomáš Pavelka, Miroslav Runštuk, Ladislav Rubáš, Radim Sýkora, Anna Srpová, Ivana Kubicová, Gabriela Smolíková, Karel Ptáček, Jan Matiáš, Tomáš Mišoň, Lukáš Růžička, Jan Hyk, Marian Loubal, Jan Dostál, František Juhász and Jakub Vykoukal

V.2 Loop:

Alena Novotná, Anna Hrušová, Antonín Hůla, Barbora Slavíčková, Jakub Kopecký, Jiří Fáber, Jiří Pokorný, Petr Tůma, Tereza Jílková, Radim Sýkora, Eliška Antonyová, Tereza Lišková, Filip Janata, Tomáš Kytka, Marie Kortanová, Vojtěch Holeček, Martin Vaníček, Jakub Hlaváček and Petr Havelka

VI. Thanks

VI.1 pareSITE

The project was accomplished with the kind support of Skanska, Eurodach, Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences Prague, Lesy České republiky, reSITE, ARCHIP, Collaborative Collective and Oximoron.

VI.2 Loop

This project would never happen without a kind support of the Faculty of Forestry and Wood Sciences and the Czech University of Life Sciences in Prague, the Faculty of Art and Architecture at the Technical University of Liberec, Stora Enso, Rothoblaas, Nářadí Bartoš, Eurodach, Lesy České republiky, Natura Decor, Easy Moving, and Collaborative Collective.

VI.3 Systemic Approach to Architectural Performance

This paper is a result of Systemic Approach to Architectural Performance project [21]that was kindly supported by EEA and Norway Grants [22].

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