Material Based Design. A Teaching Methodology for an Introductory Making Course in Architecture Education

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ABSTRACT:
This paper proposes a teaching methodology focusing on the overarching principles of a material-based approach to design-teaching in architectural education. Rather than focus on specific tools or materials, the method employs critical thinking as a starting point for individual student exploration and, by doing so, encourages debate about the weight of different steps taken towards the finalization of a project. Along a project development path, regular material experiments, detailed studies, and full-scale mock-ups link form thinking to physical conditions of shaping and joining and their associated processes. Along the way, so-called "quick exercises" are interjected into the design phase to disrupt set patterns and habits. Facing the inherent resistance of construction, referring to the need for discrete solutions, and working with material systems in 1:1 allows for instant feedback between the material-world and the object, and it generates an iterative design loop based on the physical world. This loop is didactically designed to lead to a deeper understanding of design, material systems, and construction through tangible firsthand experience that interweaves with preexisting theoretical knowledge on the three subjects. The proposed methodology is discussed in-depth through four workshops, led by the authors in the last years, to illustrate its goals and effects and, more broadly, reflect on the potential for design teaching.

1 Introduction

1.1 *Material-based design*

Most of the time in the history of architecture, materials were predominantly sourced from our immediate surroundings. Working and designing with such locally available material presupposes a significant level of craftsmanship and intimate knowledge of how, when, and where to select materials for a specific use. Materials, industrial or not, are made available by a selection process and deliberate processing of natural resources (Pye 1995, 18). High-grade work would be impossible without this step of conscious examination and preparation, which is true for all sorts of materials used in construction today. Industrialization and, together with it, standardization have led to significant advances in manufacturing and productivity across a wide range of fields in construction. Materials have been subjected to this process very directly and slowly changed from selectively chosen, directly applied parts to complexly engineered material systems (Hummel 1998, 314-349). Although this new industrial material culture stands for robust supply, high reliability, and precise predictability, it has also largely affected how we source and handle materials, distribute work and define social structures. The drive for better living standards and greater comfort in some parts of the world have led to a great social divide, the depletion of natural resources, and had a devastating impact on our planet as an inhabitable home (Chomsky 1999, 65-87). The recent global status report for buildings and construction from the UN environment program highlights the massive consumption of materials and energy in the construction industry (37% of all global CO2 emissions in 2020) and calls for a global reconsideration of the use of resources (UNEP 2021). The urgency to react to the resource problems of our time on various levels is naturally also aimed at the education of architects. In their role in the planning and construction process, they are agents of new behavioral paradigms and central enablers and multipliers of a new material consciousness.

The concept of material-based design proposes material-conscious, resource-based design and construction thinking that critically examines all activities related to building practices. It does not set out to cope with the problems mentioned above as a whole; instead, it tries to enable us to critically rethink paradigms of the recent past, like the naive assumption that resources are limitless, to envision better what constructing could look like in a post-industrial world. Reclaiming, in that sense, becomes a synonym for critical thinking and critical practice, i.e., in a wider sense the reprocessing of intellectual and material resources, and is, in this approach, exemplified by the proposed methodological concepts that have a great emphasis on growing instead of purely looking at the act of making itself.

1.2 *The Nature of design workshops*

Dealing with building materials and practices is the subject of many hands-on workshops in architectural education today. Many of them are intensely focused on either tools or outcomes, the latter of which leads to the reproduction of an image, neglecting the didactical strength of placing the act of making at the center of the teaching activity. The so-called design & build workshops bring together the conceptualizing and the construction as two complementary activities within the process of making. The principles Otto Solomon laid out in his *Teacher's book of Sloyd* (Solomon 1802, 2) underline that making is not about tools but instead cares about the personal growth of the student as an independent and self-reliant individual:

- To instill a taste for and an appreciation of work in general.
- To create respect for hard, honest, physical labor.
- To develop independence and self-reliance.
- To provide training in the habits of order, accuracy, cleanliness, and neatness.
- To train the eye to see accurately and appreciate the sense of beauty in form.
- To develop the sense of touch and to give general dexterity to the hands.
- To inculcate the habits of attention, industry, perseverance, and patience.
- To promote the development of the body's physical powers.
- To acquire dexterity in the use of tools.
- To execute precise work and to produce useful products.

The formative nature of these statements exemplifies the underlying idea of education as an essential foundation to the development of society and democracy. Considering these aspects as a cornerstone of practical workshops enabled us to work in a larger framework and develop a methodology and teaching environment that fosters personal growth (Dewey 2008, 15-26).

1.3 *The Workshops*

1.3.1 *FORMFUL WOOD (2018), ETHZ & HSLU (Zurich / Lucerne, Switzerland)*
Mario Rinke, Alessandro Tellini, Lukas Ingold, Joseph Schwartz, Christoph Schindler, Florian Hauswirth

Set up as a collaboration between two disciplines (architecture and product design), the workshop *FORMFUL WOOD* explored bent plywood as a material. The students were asked to design sitting objects and develop fabrication methods to realize their design during the investigation. A vital part of the workshop, which lasted a full semester, was the exchange between the students from different disciplines. The architects' more conceptual design approach was contrasted by the formal and material-related strategies of the product designers.

1.3.2 *INTIMATE MATERIAL SPACE (2018)*, ETH Zurich and TU Vienna (Nanjing, China)
Mario Rinke, Alessandro Tellini, Klaus Zwerger

The idea for the workshop *INTIMATE MATERIAL SPACE* originated in questions about the borders of public and private in a hyper-capitalist society like China. How do we create private spaces, or how is privacy articulated through space? The material-based design approach allowed for an open discourse with the students to understand and reflect on their needs. The whole investigation led to a series of prototypes, material tests, and construction experiments. The pavilion and the corresponding furniture are the fruits of an intensive three-week workshop wherein a common terminology and cultural understanding of design and making had to be established.

1.3.3 *1:1 STUDIO (2021) "Seven worlds of concrete", UAntwerp (Antwerp, Belgium)*
Mario Rinke, Alessandro Tellini, Jan Degeeter, Johan Van Rompaey

The *1:1 STUDIO* is part of the BA architecture program at the University of Antwerp that combines technical knowledge, construction, and design. The students were asked to design a small intervention in concrete, a sitting object, in a self-chosen spot on campus. During the studio, they develop their own approaches to deal with the different challenges ranging from fabrication to function to design and construction. The students continually produce models, prototypes, and material tests that eventually lead to a final design proposal built during the "maakweek" - an intensive week of fabrication and making.

1.3.4 *RECLAIMING GROUND (2021), UAntwerp, ETHZ, TU Vienna (Antwerp, Belgium)*
Mario Rinke, Alessandro Tellini, Klaus Zwerger

The two-week summer school *RECLAIMING GROUND* at the Kinderboerderij Rivierenhof in Antwerp was aimed at architectural students. During the workshop, the students designed and built a small pavilion for the visitors of the children's farm on top of an old WW2 bunker, reclaiming its ground and making it accessible to the children and visitors. The students formulated several design interventions at the start of the analysis of the complex site. They

voted on which strategies should be investigated further, resulting in a medium format structure, built with reclaimed wood from the harbor of Antwerp, that offers shelter and various opportunities for workshops and encourages play.

2 METHODOLOGY

2.1 *Preamble For Teaching*

As design & build workshops are often unique and complex projects, the tutors and workshop leaders play a significant role. They have to design and implement all aspects of the didactic program and must be highly competent in the making process itself. Therefore, the teachers must have extensive knowledge of the techniques central to the workshop. In this bridging function between architectural expertise and craftsmanship, they must become empathic craftsmen of their respective fields (Sennett 2008, 246-252). With their distance from the professional craftsman and the precise goals of architectural training, they manifest the overarching skills such workshops teach and are aware of the problems of familiarisation and comprehension the participants may encounter.

2.2 *Cold Open*

Before any design can be started, there needs to be time to become familiar with the matter that is to be handled later. A fundamental principle of teaching is to directly gain awareness of the properties of the material and the associated tools through direct and personal experience. Instead of a comprehensive theoretical introduction or demonstration, the participants are thrown in at the deep end, or in other words, put directly into action, and work on a small design exercise. The cold open exercise is typically structured so that the students can start working with the material or construction system featured during any of the workshops in the shortest amount of time possible. This initiation requires careful consideration by the teaching team to balance the technical challenges, the material knowledge required to execute the task, and the dexterity necessary to have a successful outcome. Although success is not the primary goal of this first introduction, a shallow learning curve is desirable for the exercise to help the students engage with the material and instill confidence to develop their acquired skills further. Apart from the pride of having already made something themselves in the hitherto unknown technique, a fundamental respect for the act of making also prevails. In general, the participants are much more attentive to explanations about the materials and production processes because of their previously gained first-hand experience.

The following points characterize the cold open exercise:

1. It is the first thing the students do in any workshop or studio after the welcome.
2. There is only a minimal introduction to the task, material, techniques, and tools required (around 10-15min).
3. Depending on the subject, the exercise lasts between 2 to 4h followed by a group discussion/reflection.

The importance of the cold open exercise lies in its model character for the rest of the process. The students' research time is purposely limited, followed by testing a hypothesis and careful reflection on the outcome to formulate the next steps. In the example of the workshop *FORMFUL WOOD*, the cold open exercise was to build a simple bridge (Fig. 1). The teams of two product designers (HSLU) and two architects (ETHZ) had to span a 4m gap between two sawhorses with a limited amount of material, roof battens 2m in length. This type of exercise does not have to be particularly original, and there are a lot of different takes on it that can be implemented at the start of a workshop. In our case, the main interest was not the bridges but how the two distinct mindsets and problem-solving approaches of a product designer and an architect came together to navigate this challenge.

Figure 1. Cold open exercise. Workshop *FORMFUL WOOD*, 2018.

The final discussion and reflection part focuses strongly on the individual making experiences of the students. Trying to answer simple questions like: How did I feel during this first task? What did I observe during the making phase? What was easier than I thought? Where do I need to pay more attention? What adjustments were necessary to come to a desirable outcome? Where did I struggle, and why? What can be improved for the next test? - and so on. During this guided discussion, the teaching team's task is to frame the outcome, successful or not, in a positive way to encourage continuous research through making during the whole workshop and create an open atmosphere that allows the students to leave sole fixation on the outcome behind and concentrate on individual growth instead.

2.3 *Material*

Making the construction material the point of departure for the workshop helps to frame and connect the key concerns of a design & build project. Dealing with fundamental aspects of the material, e.g. weight, workability, or isotropy, comes with the advantage that the aspects of purpose, utilization, design, construction, and fabrication become strongly interwoven during the design exploration. In that sense, the material serves as a mediator for the students and can become a benchmark for the quality of the design and the construction process.

Selecting a specific material to work with should be guided by availability, workability, and skills required. In this context, again, availability is understood in a broad sense and covers not only locally available material but facilities, suppliers, tools, and, more importantly, the existing experience of local staff or partners. Therefore, it is sometimes difficult to achieve a satisfactory result for all these various aspects mentioned before. The evident desire to use locally sourced materials is often undermined by overriding market mechanisms or even political circumstances. For example, during the workshop *INTIMATE MATERIAL SPACE*, the decision to work with timber imported from Canada was based on facilities and locally available expertise. This was a tough but necessary decision since China's logging ban included in the Five-Year plan from 2016-2020 significantly reduced the already limited availability of locally sourced wood (Sun, Canby, and Liu 2016).

2.4 *Scale*

The scale at which construction is to be discussed has a great influence on the complexity of the workshop. Does one delve into small objects where connections hardly play a role or are they the subject? Should the focus be on the 'building' itself? Of course, it is desirable to establish a reference to the construction reality and discuss real dimensions of components and problems. In contrast, there is the difficulty in handling the project with simple means and focusing on the process of growth rather than on the result. In addition, it turns out that, according to Solomon, in the sense of the participant's involvement with an object and the intimacy of craftsmanship included in it, the commitment and obligation of all actions increase enormously. Therefore, it is advantageous to ensure manageability in terms of complexity, scenarios of use, and scope of work with both the scale of the group and that of the object. Experience has shown that objects on the scale of furniture or moderately sized pavilion-type structures correspond very well to this. The students can understand the scale of the construction and handle it as a group, establish a relationship between their body size and that of the object, and at the same time understand it as a problem in the sense of an actual but small architecture or structure.

Figure 2. Construction process in two scales. Workshop, *INTIMATE MATERIAL SPACE*.

In the case of the workshop *INTIMATE MATERIAL SPACE*, wood allowed us to work in two different scales, i.e., furniture and architecture (Fig. 2). Both parts of the intervention required a similar skillset from the students but had their respective challenges. On the one hand, the furniture scale demanded an elevated level of precision and craftsmanship that employed traditional manufacturing techniques. On the other hand, the pavilion roof was logistically much more complex and dealt, even with its relative simplicity, with a complex mixture of assembly strategies for its prefabricated parts.

Understanding the role of material as a co-creator allows one to appreciate its importance for the process. We tend to have images of us manipulating material and assume the role of imposing our vision onto the material. This is hardly ever the case, as the material is rather a counterpart that we should allow its agency to have a successful and creative design and construction process. In reading, working, and re-reading it, we have better access to it and, vice versa, it has that with us, changing us and making us better makers (Ingold 2013, 6-8). This insight helps the students to understand that material is not simply something to be used, but a partner that demands a deliberate decision and helps to ground our ambitions and roots them in a natural, built environment.

2.5 *Construction*

Comparable to the reciprocal relationship that should be established between the student and a construction material, there should also be a clear relationship between design and construction. By helping to group the most important aspects of construction, the material also clearly shows that making itself is not a final translation of a design idea into the material but a mediation between goals and given boundary conditions. The material itself is also a part. According to this understanding, *making* is translated into a continual process of *growing*, and the maker becomes the central figure that mediates between the material world and the object. This insight challenges the conventional approach to making, wherein growth is happening between idea and object and shifts the emphasis from an object-focused understanding to a transformational human-centered process (Fig. 3).

Following the idea of the cold open exercise, any workshop should be structured by regular steps of making, stimulating a certain "synergy of practitioner, tool and material," but more importantly, to go back and forth between making and designing to have "perception and action" coupled (Ingold 2011, 56-61). These should increase in size and complexity to follow the participants' experience and continually offer new challenges while corresponding to the developing design concept. This principle of parallel progression within a project is central: as superficial and rudimentary as students' construction knowledge is at the outset, so general should the design concept be. The construction system and associated uncertainties are formulated then checked in material tests based on the design vision. Through the experience gained in the regular use of materials, the design concepts become more precise, as the limits and potential become much more apparent. The material-based design decisions thus gradually become more intuitive but always remain self-determined and searching. In the end, for the final production of the object, the students have developed a good understanding of constructive principles but, above all, solid constructional self-confidence (Fig. 3). They make final constructive and design decisions based on the tests conducted, and the overall experience gained.

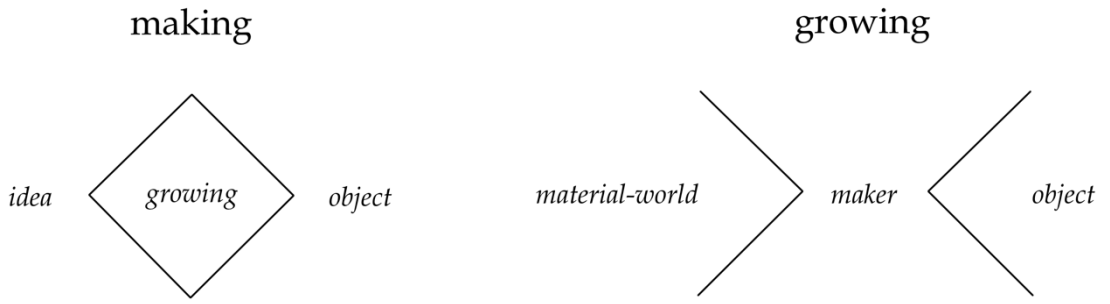

Figure 3. Understanding 'making' as an act of translation and mediation, after Ingold 2013.

2.6 *Design*

The definition of design is subject to constant change and largely depends on cultural understanding, local currents, and individual influences. Material-based design, as a method, refers to an initial necessity that wants to be fulfilled. Thinking of design merely in queries of form, color, space, or other common aspects seems not to be addressing the ever-growing convolute of subjects important to the field of architecture. Deeper insights into the meaning of 'design' might come from its etymological roots, originating in the lat. word 'designare,' 'to designate,' or more accurately 'to identify.' (Ursula Hermann 1998, 136) Identifying the "why" is the foundation of our understanding of design. The students are asked to use the why-question along the entire process as a critical reflection tool. Intensifying the

relationship to the task is an important strategy to engage students and create a higher level of meaning in making. Workshop topics can usually address this by asking for improvements or alterations of existing infrastructure, like campus furniture, places to retreat, and other similar topics. The underlying subtext of these subjects is that they are, in their nature, public spaces, but at the same time, the students should have a clear and personal relationship with them. As an individual need becomes contextualized, the question of 'What do I need' becomes a question of 'What does my school, other students, the neighborhood, or even society need.'

During the *1:1 STUDIO*, the students are asked to improve a specific spot on the campus of the University of Antwerp with their intervention based on their experience as regular campus users (Fig. 4). The interventions usually start as complex arrangements of furniture-like objects with all sorts of functions tailored to their perceived needs. During the design process, with the help of prototypes and mock-ups and the feedback from the entire group, they slowly realize that their initial assumptions were built upon an incomplete picture, and a wanted ambiguity enters the design process. This ambiguity is needed to react to the simple fact that designers cannot take every single possibility on how a particular object or space might be used into account. In the beginning, this loss of control supposedly feels like a minor defeat. Still, throughout the process, the students learn to deal with ambiguity and embrace it in their projects.

Figure 4. Developing campus furniture as personal interventions in the *1:1 STUDIO* "Seven worlds of concrete".

2.7 *The Model and the One to One*

The model in the context of this methodological proposal is understood as an investigative and extendable tool for carrying out almost all design-related work. As such, the scale and material of the model are frequently changed to suit specific purposes during the design and making phase. This fluid transformation of the model is essential because it enables the students to constantly work in three dimensions to obtain a holistic understanding of their project. In this context, the students start measuring and evaluating their design decisions based on the relationship between model, body, and surroundings. This type of evaluation helps to understand the influence of the different parameters and manage a complex set of open questions to not revert to a purely imaginative realm. Therefore, the models become a continuum. Towards the end of the project, the fabricated full-scale object becomes another 'test' in a series of scale models, material experiments, mockups, and prototypes.

At the end of the initial design phase during our summer school *RECLAIMING GROUND*, two competing approaches to the roof's construction emerged from our group discussions. The first proposal used V-shaped supports, while a second alternative featured a more conceptual approach, using short overlapping timber pieces to create a woven arch-like structure. It was clear to everyone that both options had advantages and disadvantages with consequences for the construction process, but a decision had to be made to proceed. The students themselves came up with the idea to test both options in full scale but simplified to understand better how each type would affect the structure's character and the entire fabrication process (Fig. 5). After the test, it became evident that the arch-like option was too difficult to control and did not deliver the spatial quality the students were aiming for. Making this prototype, together with the group discussions, delayed our work for one morning but resulted in a clear understanding to everyone of how and why to proceed this way. The group learning effect, possible by allowing this prototype-driven design loop, was comparatively large and helped the group refocus on other important design aspects.

Figure 5. Prototype testing for two design options in the summer school *RECLAIMING GROUND*.

3 Conclusion

The concept of material-based design in architecture education, discussed in this paper using the design & build workshops, proposes a material-conscious, resource-based design and construction thinking that critically examines all activities related to building practices. Put in place as a reciprocal relationship between designing and making, it enables the students to critically rethink their relationship to construction materials. Placing the conditions of the material and thus the process of making at the center of a construction workshop creates a circular experience of frequent design and making loops within the larger construction workshops. Decisions about form become reflected conclusions from material and process insights, following individual design paths of material inquiries.

As a consequence of the workshop experience, the students can ideally not separate anymore their form discussions in design projects from the underlying material assumptions; they no longer draw a line without the awareness of what that line means in a material world. Transformation processes through concrete experience occur in both directions: the students transform their surroundings and are being transformed themselves through the act of making. Students realize during the workshops that they become active participants investing in their growth through their actions. Taking this a step further would mean that the students become fully responsible for their own learning experience in such an open setting. Under the perceptive of *growth,* the idea of education as a formative measure is changed into a genuine learning experience that acts as a fertilizer of novel and not preconceived learning outcomes. A material-based design understanding is necessary for architecture curricula today, especially in the light of design discussions that become primarily influenced by digital means in sketching, conceptualizing, planning, and representation. Prospective professionals in a profession that deals exclusively with a constructed, physical world should be exposed to key experiences of materiality, scale, and the unpredictability of the building process as early as their undergraduate years. When students can intrinsically pursue a material experience, a mere technical education can become a powerful creative tool that also allows them to grow personally as competently acting and designing individuals.

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