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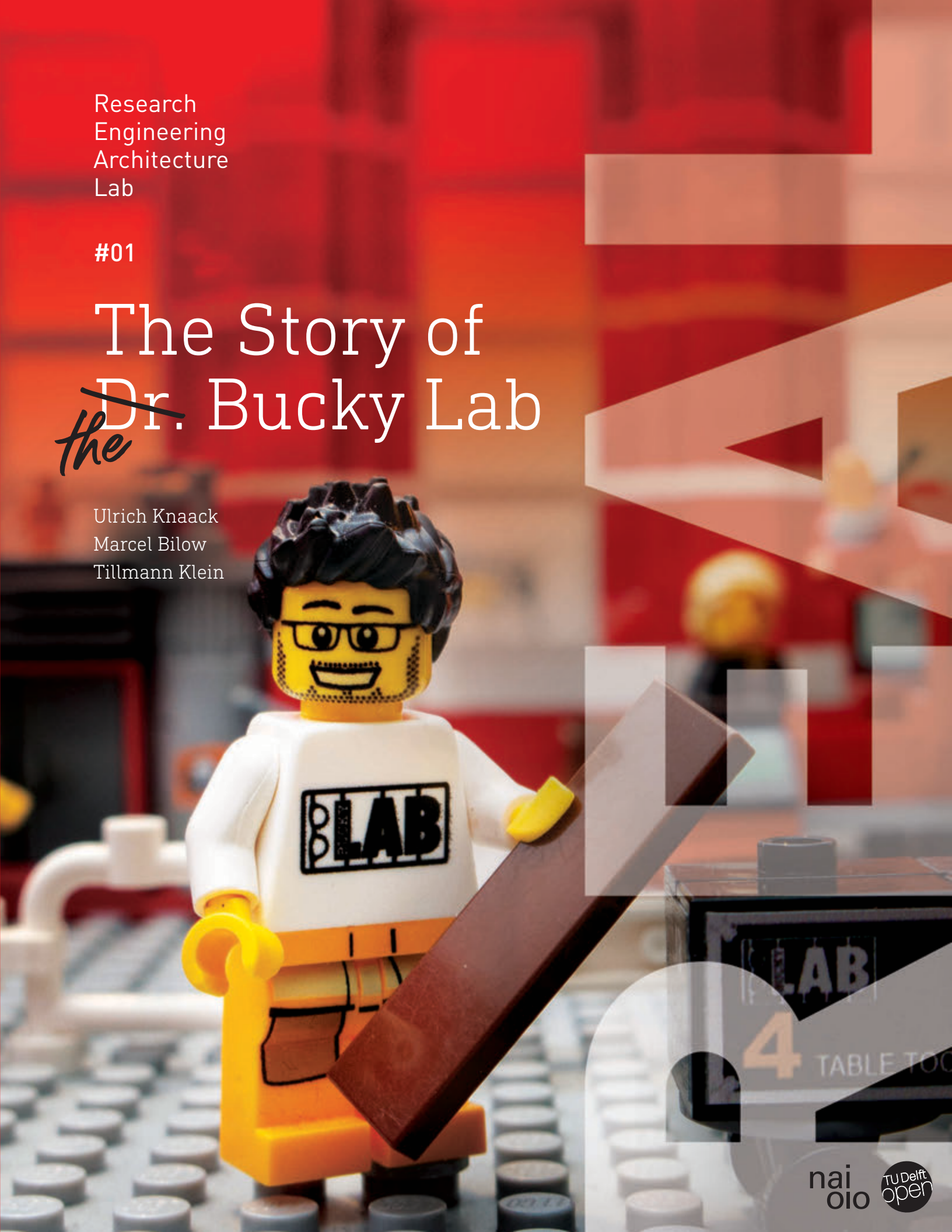
#01

The Story of ~~Dr.~~ *the* Bucky Lab

Ulrich Knaack
Marcel Bilow
Tillmann Klein



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#01

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Preface

A book about a university docent and one of his courses – why would you do that? And what is the academic impact?

The question of impact, especially as it relates to the rapidly developing culture of publications in scientific journals, should be the topic of a separate discussion. With all of the related advantages and disadvantages it could fill an entire book – however, not this one. And yes, buildings do impact the user, the environment and the planner – those already active in the field, as well as the next generation that learns from the results and will enter their own discussion for future developments. A friend of Marcel Bilow's and mine, Thomas Auer, known for his exceptional work as climate engineer with the company Transsolar in Stuttgart, Germany, has, for example, certainly made an impact, influencing and inspiring generations of architects and engineers. Faced with the decision of whether or not to continue spending the majority of his time with projects rather than as a teacher and researcher at TU Munich he based his decision on the premise: you can best multiply impact by affecting the next generation, buildings alone cannot achieve it.

And affecting the next generation is the motivation for this book, because it is the motivation for Marcel Bilow's work and his approach to teaching, be it about a concrete product to be developed or an individual's experience. It is about teaching students to physically exercise practical application rather than merely thinking about it: we can contemplate a hole in a wooden plank; however, actually creating it, experiencing the consequences and identifying limits and failures is the most valuable aspect. Any and all construction is based hereupon, a combination of both: the activity of constructing itself but also constructive thinking, thoroughly understanding a solution – essential skills that any architect needs to experience.

And the tool to accomplish this is, of course, a practical, hands-on course. Going conform with the generally established tradition in construction-related university subjects at TU Delft of having students build small projects, the faculty at TU Delft has a history of conducting hands-on courses. But Marcel Bilow certainly breathed new life into these courses that are part of the Master's program at the Faculty of Architecture at TU Delft: by setting up the Bucky Lab. Buckminster Fuller, constructor and inventor served as inspiration, for the name as well as for the program: to be able to think, conceive and realize sensible and practical solutions. It is therefore no surprise that Marcel became known as Dr. Bucky Lab.

Is there more to the course? Yes, there is another, very important part that goes beyond practical application. It's all about stimulating the students' desire to make things better, to introduce technical developments into construction, and to utilize new methods if they make sense in a given context.

The course is designed to make the students look for traditional as well as non-traditional, out of the box ideas. With his constant questioning, continuously asking why, Marcel Bilow drives his students to question every single step they take in a project, every design decision they make along the way, every choice of material. The course requires them to generate initial concepts that will be revisited, re-evaluated, redefined several times as they learn to focus on the important, justify their decisions and gain knowledge in conceptualizing and ultimately realizing their ideas. The experiences gained in the course are valuable for any project the students work on during their studies or in their later professional lives.

Marcel Bilow has a brilliant mind, he is extremely motivated and motivating, sometimes a little stubborn but always driven by an innate desire to understand and, above all, to share his knowledge and experience. And this is what he does in the Bucky Lab, a course that is coined by his convictions and approach to disseminating knowledge as well as by interdisciplinary work that is embedded in and connected to the overall curriculum.

Ulrich Knaack

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It's all about stimulating the students' desire to make things better


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1

Semester set-up

1.1

Let us start by looking at the semester program, how it is set up and organised.

The semester is divided into four different, consecutive phases: concept, engineering, building, finalizing. The concept phase takes place in the first four weeks; the students receive the assignment, a general introduction, and have to develop concepts individually. We ask them to think outside the box, while staying within the framework of the assignment. The concept phase concludes with the elevator pitch in which each student presents their best idea in one slide in one minute.

We start with individual work, mainly to generate a large number of concepts. However, we also ask the students to work in groups during this phase to allow them to brainstorm together and test their ideas on each other. Group work is also more interactive and stimulates the brain more. The students are asked to develop at least ten concepts during these four weeks, since a large number offers many options to choose from and helps to teach the students how to evaluate their own work when the time for selection comes. During our weekly consulting sessions, they gain expertise and theoretical background knowledge in the field we work in according the assignment. Therefore, they are well equipped to judge their own and each other's concepts during the elevator pitch. A mutual selection takes place at this time, and with everyone's input the best ideas will come forward.

Possible group work during the initial phase can also offer them the opportunity to get to know each other since, for some, these are the very first weeks in Delft – but ultimately everyone has to present their own concept for the above-mentioned reasons. Later on, they have to work in groups, which is an important skill that they will need in their respective jobs; projects are rarely done by one person alone. It is the discussion with and within the group that helps to develop the best ideas.

The one-minute one-slide elevator pitch is a powerful tool. While it initially stresses the students, they quickly understand that the key to success is a condensed story about the idea that emphasizes the "Why" more than the "How". Being able to create emotions and the desire to see a concept becoming reality, means one is on a good way. Small models help to illustrate the initial ideas.

1.2

Do you and the other teachers pick the best and most promising ideas?

No, the students do! This may sound strange, but we made the decision to let the students themselves select the best concepts right at the beginning of the program. Interestingly, they always pick the best and strongest concepts to continue to work on, regardless of whose concept it is. By the time of selection, they have gained a lot of expertise on the subject, theoretic and practical, and can judge good from bad. We have a right to veto, but rarely have to use it. Sometimes, the reason is that selected ideas have already been tested or executed in the past, and sometimes certain concepts require difficult to get or exceedingly expensive materials. Even though our motto is that we can build anything, the truth is that sometimes we just can't. We often have guests from the industry and our colleagues from other courses that ask valuable questions and give feedback during the elevator pitch which will also help to make a good decision.

1.3

Effective teamwork obviously requires a team that can work together well. How are the groups formed after the selection of concepts?

Once we had two similar ideas that were really promising. Quite a few other students liked these ideas so much that we ended up with a large 8-student group. Looking into the faces of these students, there was no way to tell them that they could not work on it. Our solution was to make two groups who worked on the concept in parallel. Just after a few weeks the projects had developed into two entirely different concepts, even though they were based on the same idea.

We ask the students to form groups of three to four students around the strongest concepts. Typically, we see two different approaches; On one hand, we see students group due to the fact that their ideas have a common ground, sometimes they are even very similar. Even though this happens often, we don't tell them that in the beginning, because it would undermine their motivation already in the first weeks if we did. If an idea is good, it's worth it to see variations developing. On the other hand, we also see students who give up their own idea completely because they fell in love with and saw the potential of another concept they saw during the presentation.

FIG. 1.1

FIG. 1.1

On the first day we gather on top of the faculty building for our campfire; in winter, a real fire would make the introduction a more comfortable affair.

1.4

How do you come up with fresh, motivating ideas, not mere copies of older courses?

We create different assignments each semester to motivate the students. We usually team up with an industry partner each semester in order to get realistic questions and real feedback for our students. The companies or branch associations we work with typically work in the field of façades, shading or daylight directing, but we have also had cooperation's with a furniture company or a festival organization. The main advantage of working with such a partner is that it makes the course more realistic, it boosts the students' motivation and sometimes allows us to work with materials we would otherwise not have easy access to. We develop the assignment in cooperation with the partners. Often, the starting point is a very specific question from the partner's side, which is then mutually translated into a topic that is sufficiently open and flexible to leave room to think outside the box. We openly discuss the possible outcomes with the company, shaping their expectations to fit our academic goals.


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FIG. 1.2

FIG. 1.2

At the end of the elevator pitch the students discuss and select the best concepts, which will be further developed during the semester.

We have to make sure that every assignment suits our general learning objectives, so the restraints include applicability to the course, budget, material and technology availability. Therefore, we rarely see duplications of concepts, but a nice example is the sunflower concept; imagine your façade is covered with flowers and when the sun comes out the petals open and shade the façade. We get this idea almost every year if the topic is somehow related to façades or sunshades and have already built ten or more versions of it. But, all ten are different and it is difficult to identify the common origin of the finalised projects. It would not be helpful to stop this idea just because the students all started with the same inspiration. There will certainly be more great sunflower shades in our future, and it will be very interesting to see in which direction they will be developed.

FIG. 1.3

FIG. 1.4

FIG. 1.3

Semester work in the studio. Sometimes, there is no visible difference to other design studios, but when it looks unruly, it's obvious who is to blame.

FIG. 1.4

If the students are in full swing, we welcome a bit of a mess in the studio.

1.5

How do you stimulate the students to actually think outside the box?

Thinking outside the box to us means to begin by searching outside the box. Typically, our students start to search, or better "google", for innovative sunshades or whatever product we are asking them to design. That approach is not helpful and does not stimulate out of the box thinking. We ask the students to search in fields beyond architecture. Based on the belief that by combining already existing technologies from other disciplines we are able to improve our built environment. Often, we send the students to the zoo, a trade fair, or even into a toy store. There are so many mechanical solutions, great little ideas and inspiring things that can be translated into an innovation for building construction. It's the little things that the students should look out for. How exactly do the three different colours come out of a toothpaste tube? How is it that an excavator can rotate forever without snapping a cable or hose? Considering such unconventional things is what might offer a solution to realize an idea.

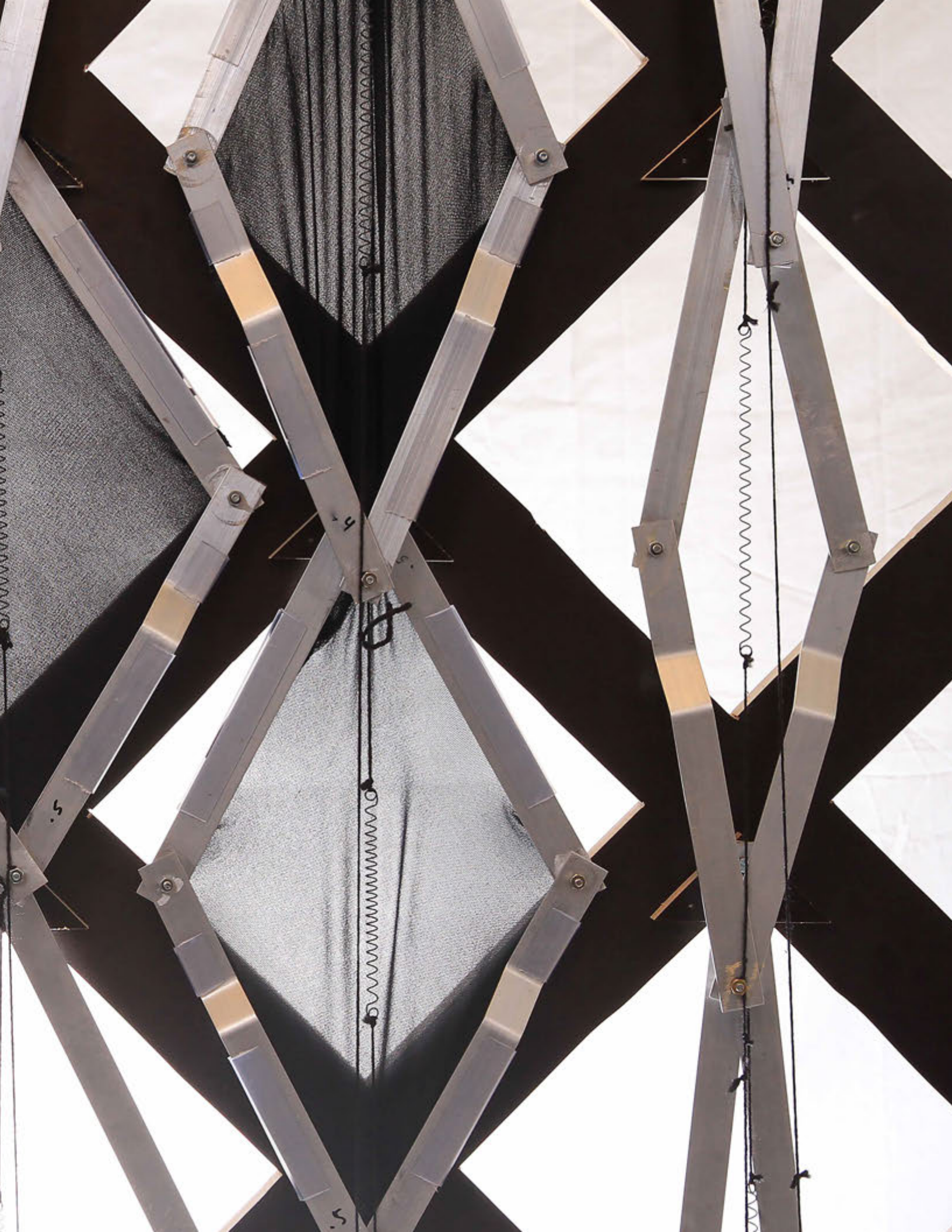


FIG. 1.5 Photo: Marc Den Heijer

FIG. 1.5

The only thing we need is an empty hall; after two hours our prototyping workshop is up and running, fully operational – coffee corner included.

1.6

Back to the set-up – what happens after the elevator pitch?

The engineering phase is the longest phase of the semester. It's the period in which the students develop the ideas into a stage from where they can build them at full scale as a first prototype. We start by asking the students to write a design vision about their idea and to sketch a set of design criteria – this is done in the group and initiates a good discussion about the product requirements. Typically, there is one member of the group who envisioned the chosen concept. But the other members can now ask the right questions, often similar to those we asked them weeks before during the introduction of the course. Often, the concepts presented during the elevator pitch are not yet sharp enough. Therefore, the students need to boil the ideas down to their essence. A truly good idea does not have to do it all; if it serves a very special niche, it might already be the basis for a great product. After some time of writing, sketching and brainstorming, the most appropriate materials are identified, first 3D models are built, and even the first structural calculations are done.

During this stage, details come together from various, different disciplines. It is the best part of the course, the interaction within the different disciplines. Almost a full semester, Monday through Friday, surrounded by various disciplines, all being exploited to translate the ideas into good products.

Besides searching for inspiration in non-architectural contexts during the initial conceptualisation phase, the course involves input from various university classes that are not directly related to architectural design. We set up a plan to define when the different courses engage in the process, while the design consultancy runs through the semester like a common thread. The courses are not very long and come in cascades. They do not always come exactly at the right time for any given project, but by the end of the semester the students realize that it all made sense – that this type of input helped them to forward their idea. The weekly schedule is as follows: Monday morning start with Material Science, on Tuesdays, the students meet the experts for Computational Performance and learn CAD and, if needed, Arduino, on Wednesdays they get instructions in Structural Mechanics or Building Physics, Thursdays are reserved for Research and Methodology, and Friday is the time for self-study. And on Tuesdays, we also see the students. Each of the different courses has its own set of learning goals and other assignments, but in general we try to make the concept or the prototype the common thread that is discussed in every class throughout the semester.

1.7

Integrating the different disciplines sounds like a challenging task.

It is a challenge, yes, and if we wanted to integrate every class to an equal extent, we would have to ask for weird products – like a fully autonomous sunshade that spans 50 meters without any support, withstands hurricanes as well ice storms, shades and redirects the daylight while also creating a comfortable acoustic environment.

In reality, sometimes Building Physics plays the leading role, and Structural Mechanics has to give smaller assignments to cope with the time shortage, sometimes it is the other way around. Material Science is easier to integrate in any assignment, since everything requires the right combination of materials. Research and methodology can also be integrated more easily due to its more general focus. It is probably obvious, but the course is more about the process than the final product – even though this is not something that we tell our students. Ultimately, we aim for our students acquiring a good set of skills to design any kind of product, up to entire architecture projects. The learning goals will prepare the students for their later work in the office.

We assume that not every student in his professional life will develop a building component or product but will rather be challenged to solve technical problems as part of a team. Therefore, our special approach is to identify possible and suitable

methods of product development to find these innovative ideas. During the later design education, the students rarely define criteria that are measurable or write design visions to help judge their ideas and variations according to the assignment. So, we offer tools that will help them to become better in the future. A critical view and opinion might be the most valuable aspect they learn.

1.8

We notice that the technical drawing skills of our students deteriorate from year to year; we ask for 2D drawings to build these prototypes and receive exploded 3D perspective views without a single measurement. Therefore, we now tell the students that they may have to hand over their drawings to another group which will build their design for them during the building weeks. We never yet asked them to actually hand the drawings over, but it would teach them what kind of information needs to be integrated into a drawing to provide all the details needed for actual building.

So, during the engineering phase the concepts are developed to a degree that they can be built in the workshop?

Yes, at the end of the engineering phase we ask for a set of drawings that describes the construction and helps during the building weeks. The projects have been developed, smaller prototypes have been built, and the ideas have been transformed from concept to product.

But these engineering phase prototypes are not built using the tools in the workshop, because the tools are stored in a dedicated space that we only have access to before and during the actual building weeks. But the many prototypes the students build during the engineering phase are done with the best prototyping tools there are for this purpose: a hot glue gun and cardboard paired with a Stanley knife - a powerful combination.

1.9

And the actual building weeks are the most anticipated part of the program, right?

Yes, the building weeks start in phase 3. This is the most challenging time and, for me personally, the busiest. Usually we spend one day per week with the students in the studio, while I prepare the building weeks months in advance, filling up the screw containers, sharpening the tools, getting machines fixed or maintained, building tables and preparing a myriad of other little things that need to be taken care of in advance. When the mobile workshop is set up, I spend two entire weeks with the students.

FIG. 1.6

FIG. 1.6

As long as the days may seem and as difficult the projects may become, there is always a smile on the students' faces.

I am the first to arrive in the morning and the last to leave in the evening. I don't run the workshop weeks all by myself because safety is my biggest concern and I therefore need at least one more person to help me. When we started, I had a very handy student assistant, and Kees Bardolf from the metal shop joined us during the building weeks, as well. Unfortunately, he did not have the time to join the building weeks in later semesters, but I always have a student assistant for support. Today, our retired building construction docent Maarten Meijs joins me during the building weeks. That's a great help and allows me to troubleshoot the last details of the prototypes with the groups when needed, while he helps to set up machines and keeps an eye on the general safety of the different tasks the students have to perform.

FIG. 1.7

FIG. 1.8

FIG. 1.7

On day 1 of our building weeks, Frans and his colleagues from Festool teach the students how to use the power tools safely and accurately.

FIG. 1.8

Jakob, the youngest workshop participant ever. He did a good job and was a quick learner.

FIG. 1.9

Every group has their own table; we started with five and now have twenty.

FIG. 1.10

With the flight cases open, the workshop is running. The concept of the mobile workshop still proves successful.

1.10

How do you make sure everyone is able to work with the tools?

We teamed up with Festool for equipment and training. Some of their best instructors join us on the first day of the building weeks. Frans van Dijk, the former head of the trainers, and his colleague Hans or a friend of mine, Jaap Bosma from woodworking.nl, and myself set up three different stations to provide the students with a proper introduction to the tools and the workshop itself. At these stations the students receive a thorough explanation of our routers, saws and other tools. After one hour, the groups rotate and join another station. In general, we introduce the most important tools and demonstrate what they can be used for. As safety is the most important aspect, we work with the best woodworking tools used regularly by professionals, meaning that they are safe, but any tool handled incorrectly can cause danger. The introduction will not turn the students into professional woodworkers, but they do learn about safety aspects and get a feeling of what is possible and what isn't. Over the course of the first days the students grow accustomed to the tools and we have to help less and less toward the end of the period. In the beginning, it's about the basic use, later into the weeks we show them small little tricks to create nice results quickly.

FIG. 1.9

FIG. 1.10

One other essential item explained during the introduction tour through the workshop is, of course, the coffee machine. Good coffee is most important. It keeps you awake and patient while waiting for a machine. Visit the shop, and you will get one.

1.11

You never mentioned any injuries during the building weeks. Is the workshop really that safe?

Knock on wood, nothing major happened yet. We had splinters in the finger, paper cuts and scratches of course, but nothing really serious. Most frightening was a bike accident a student had on his way home, the front tire got loose, and the student lost a tooth. Casper, one of our guest docents, took him to the hospital and, today, you can't see anything anymore... But we are constantly monitoring the table saw. It is the most dangerous tool in our workshop, therefore one of us is always close-by to guide the students and keep an eye on them.

FIG. 1.11

FIG. 1.11

The erection of one of the three cardboard domes we built in 2012. All hands on deck made it an easy task and the reward at the end even greater.

1.12

Which tools do you have, people say you have everything you can dream of?

I believe that this is the wrong question to ask. Don't ask what we have, ask what we can do! I will give an explanatory intro to our mobile workshop and the tools in a following chapter. But in short, we may not have all the tools you can imagine but we are able to build nearly everything. And it's true, it's not about which tools we have, but what you can make with them.

You can create a lot with a mere set of basic hand tools, but we have opted for a good selection of power tools in order to increase efficiency and safety. You may be surprised but a big router with a proper guiding jig is a lot safer than a chisel and a hammer if you are not an expert. It's not our intention to teach our students to become expert builders or woodworkers. They have to understand the different steps to produce the parts they have engineered, get a feeling of the different materials and how to connect these with each other.

We usually work with plywood; therefore, we have everything to work with wood, but we also have tools to work with metals and plastics as well as sewing machines since we often work with fabrics. There are certain things we can't do in the mobile workshop; if we can't find a way around, we try to find someone on Campus who can or a company in the neighbourhood willing to help. But mostly we will find a way, and I have more tools at my own shop to help out if needed.

1.13

I haven't heard you mention CNC milling or 3D printing even though the faculty has these tools available. Why is that?

Yes, that's right, we have all the digital production tools in our model building workshop at the faculty, but that's exactly the reason we try to avoid this. The students have already learned to use these tools during the Bachelor programme and may have already mastered them. But the way you construct if using a laser cutter, for instance, is different from classic woodworking joints, for example. I think you have to have used the more classic tools at least once to understand material and construction in general. You need to learn about skills, craftsmanship and precision. Handing in a CAD file and receiving your laser cut parts three days later disconnects you from the material and the process. So, in short you might say we teach to walk first – dancing comes with practice.

1.14

So, no robots in the future Bucky Lab?

No!! Just kidding – I would love to have ten of them, but I have a strong opinion about digital tools in general and robots in particular. We build prototypes; therefore, we only build one item, and this item actually means the result of a very intensive engineering phase coming to life. In general, we believe that the prototype works but – failure is always an option. And maybe we have to figure out an entirely different way to make it work. Every now and then we decide to use a CNC mill if precision and a larger number of parts are used. But making 30 identical elements can be easily done with one master form and a copy ring on a router. You would be amazed how quickly you can produce these parts exactly as the master form.

1.15

What exactly is the purpose of the prototype?

It's the first attempt to materialize the idea, it's a proof of concept. Earlier in the second phase we discuss which features the prototype should highlight. Sometimes it's a folding mechanism, sometimes the functionality of a special material, sometimes the look or the function of the product. The prototype should be as close to the final product as possible, but it doesn't have to be. Sometimes we are able to mimic the real materials the product is intended to be made out of later; a bit of silver paint will make a wooden profile look like extruded aluminium; a bead of hot glue looks like a welding line on steel. And if we have to mimic a cast piece of steel, we may use a 3D printed part. It's all about the concept first; then we find the best way to make it, and finally we look for the best way to produce it. In my opinion, that's the only way to make a convincing prototype that illustrates the idea of the product and shows its potential. We have seen other approaches in which the tools are leading, our robot group does that; in a way they already have the solution and need to find the matching problem. We work the other way around; we think about the problem and then find the best solutions. In the beginning, the tools don't matter. I can show you how to make one concept out of 10 different materials or with 10 different tools. After building the prototypes we test them, evaluate them and learn from the things that didn't work well. In phase 4 we transform the prototype and the conclusions we drew into the final product.

1.16

So, the building weeks are not the end of the semester?

No, building the prototypes is a proof, a test. If everything works, we can continue to design the product in the finalization phase. This is done with 3D models, technical drawings and renderings. While the prototypes sometimes look a little clumsy or not real enough - the final renderings will show the design of the products in a much better way. These pictures will make the concepts sell, while the prototypes will show that they are principally possible. Next to our dedicated production technology course, the students also learn about production technologies in the Material Science course. With the knowledge gained by building the prototypes we are able to define how the different components should be built, but that's only a first attempt, really. We know that the batch size makes a huge difference in determining which production technology would be the most efficient and therefore the most affordable. You need 100 pieces? Maybe milled out of massive aluminium is be the best way. You need 1000? Injection moulding or casting would be more efficient. And if you need a hundred different shapes, 3D printing or CNC milling could both be an option. Cars are not sold because they are made by robots, but because they are efficient, cheap or fast. Some people want to make us believe that "made by robots" is a selling argument. In my opinion, that's the wrong way of thinking.

We often use Simon Sinek's talks about advertising, focusing on the 'why'. He used the example of Apple advertising the iPod. They advertised their music player by saying that, with it, you have 1000 songs in your pocket. Sony answered by advertising their player had 8GB storage. Sony failed because nobody was looking for 8GB nor did most people know what a gigabyte was. Sony wanted to say: we give you 2000 songs in your pocket, because our device has twice the storage capacity. They wanted to outperform with facts and figures but didn't address the why – because people want to listen to music. To most, 1000 songs in your pocket already sounded amazing, and nobody got the fact that Sony was doubling that number.


Think
twice,
cut once!

We love to make jigs in the Bucky Lab. Sometimes it takes an entire day to build a machine or a jig, but the result is that, with it, a perfect final product can be produced within an hour. We have seen small production lines up to a jig that was able to guide a router to cut perfect ellipses. Whenever precision, repetition or speed is needed, a jig comes in handy.

1.17

Do the groups already know how they will build their prototypes before starting the workshop?

That depends on the prototype, in general they know what most of the parts should look like. The students have made paper templates or detailed drawings that help to describe the parts. Also, the material is known in advance. We supply plywood in different thicknesses and these measurements are also known in advance. If they need a sheet of Plexiglas or a piece of fabric, we need to order this in advance or use whatever we may already have in stock. If a glass fibre reinforced plastic piece is needed, we make sure we teach them everything they have to know in advance to be well prepared during the building weeks. For the wooden parts they have an idea, but that may change due to efficiency, availability of a tool or other reasons that can't always be predicted ahead of time. We try to show them YouTube videos about different techniques or show the tools we have on my YouTube channel during the consultancy meetings. I can show you many ways of making a part. Sometimes it's the order of steps, sometimes the use of different tools that makes the difference.

1.18

Any general advice on how to use the tools?

Yes. Take small tools to big parts while taking small parts to the bigger machines, not vice versa. It is easier and safer to shape long profiles first and to then cut them into smaller elements instead of trying to shape a lot of smaller parts. And, of course: Think twice, cut once! I have a workshop at home, and I make smaller projects to learn new techniques or the use of tools. I film the process and upload the videos to YouTube. These videos can be easily shared with the students during the consults. I haven't had the time to do much lately, but you will find videos how I made bags on the sewing machine, laminated carbon fibre parts, or cut windows to the moon (it's a restroom door window - have a look – it will show you how to use a router and a jig to cut circles). I also started a series in which Frans van Dijk from Festool tells me how to set up their tools. These were so successful that his boss decided they need their own channel; now Festool has more than 60 videos on different machines. They are great, we sometimes use them as well. I love to watch videos on YouTube in order to learn new skills and making videos myself is quite a lot of work; good winter projects.

1.19

Wood seems to be the predominant building material. Don't you use steel?

Yes, we mostly use wood, its cheap, forgiving and easy to work with. Before I was running the course, the prototypes were built out of steel, but this was done in our former permanent steel workshop, including welding lessons. And back then we had 10 to 15 students per semester. Nowadays there are up to 80, therefore working with steel only would be impossible in the mobile workshop. We still use steel every now and then, most often for axles, when higher strengths in smaller dimensions are needed. We can cut metal, bend it or drill it and cut threads. As much as I like to work with metals (I did this my entire youth, my father is a plumber and my best friend's father was a big façade contractor for whom I worked for a long time. I only learned to work with wood years after mastering metal) it is much more difficult and takes a lot more time. Back in the old days of the Bucky Lab I saw students building for more than 2 months, not being able to finish their prototypes in time for the finals.

1.20

So, your students build their prototypes in only two weeks?

We try to get everything we need to build the prototypes on time, but every now and then we have to deal with delivery time issues. The longest delay of an order was for a big sheet of polarisation filter we ordered from China because of the low price. The shipment didn't make it on time and we had to salvage a couple of sheets from old LCD screens. Exactly 6 month later, one week before the next semester's building weeks started, a crumpled cardboard roll arrived – one big sheet of polarisation filter – damaged beyond use ...

The idea is that they are able to complete their prototypes within the two building weeks, which generally works for 90 % of the groups. Some will have produced all their parts and may need a couple of days to assemble everything. Sometimes it takes a little longer, especially when parts need to be painted – I am not a fan of paint, but sometimes it adds realism or enhances the focus on a certain aspect. We always make sure that the parts are cut by the end of the 2 weeks, and the students only need a couple of hand tools to finish their prototypes in the studio.

1.21

And then there is a BBQ!

Yes, you are right, on the last evening of the building weeks we celebrate with a big BBQ with German bratwurst and beer in the summer, hotdogs in the winter. That's a nice happening and we invite the supporters and sponsors of the Bucky Lab – it is also the first moment you are able to get a sneak peek of the prototypes.

FIG. 1.12

FIG. 1.12

The conclusion of the building weeks is celebrated with a big BBQ on the evening before the last day. In Summer, we serve German Currywurst, in winter we have hot dogs, besides catering for various alternatives to accommodate different diets, religions or personal preferences.

1.22

What follows after the building weeks?

After cleaning the workshop and putting the tools back in the Cave, when the dust has settled, we will enter the fourth and therefore last period of the semester, the final product phase.

In this phase the students will utilize the feedback of the building weeks and the details they generated to develop an industrialized product. We ask them to transform their full-scale prototype into a final product design on a detail level that can be produced and manufactured by a suitable company – most likely our semester partner. So, parts made out of wood will be digitally translated into parts that can be forged out of steel or cast in aluminium. Small mistakes that occurred in the prototypes will be fixed; bearings will be added in the drawings wherever bare metal met pure wood during testing, profiles will be redesigned so they can be extruded. To sum it up, during this phase we ask the students to create a set of details based upon which companies can generate a first price offer.

This is also the moment to finalize the report. We ask the groups to start writing the report from the beginning like a log file to save time at the end. If they follow the advice, they may only have to refine the text passages that describe the different steps of their development. We specifically ask them to take notes of the decisions made during the engineering phase. If written properly they are able to understand or remember the reasons behind their decisions later on, which will make the report more valuable for later use. Simultaneously to the report the groups also create renderings which are supported by the CAD docents. We usually ask for an exterior and an interior view in order to create a real impression of the product in use and in an architectural context.

I am often asked which tool is the most important one in the Bucky Lab. I tend to choose between two answers: my camera or the coffee machine. The first creates interest in the course, the second keeps us all focused and awake.

1.23

The report and the final poster of the concepts also contain professional photos; do you teach the students how to take these?

I would love to, but I have to admit that I take these pictures. With some experience and a professional set of flashes I am able to complete the photoshoot of all projects within one day. The quality of the pictures is key in order to advertise the concepts as well as the course itself. We place the pictures on our blog as well as on social media. Our PR department loves them, as does our department who often uses them for their print products to advertise our educational programs. In addition, the concepts are published regularly in magazines and journals, and honestly, this book would be rather boring if it didn't include interesting images. Last but not least, I owe good pictures to our semester partners; the prototypes may get lost or damaged, the pictures will last.

1.24

So, the groups hand in their reports and they are done?

Oh no, the best part is yet to come - the final presentation and our exhibition. Whenever possible, we do this in the beloved orange hall of the Faculty. We invite the semester partners, friends and family of the students to attend the final presentations. Each group has 5 to 7 minutes to explain its ideas from sketch to final rendering. Sometimes we also see short movies. Depending on the number of groups that participate this can take quite a while, with a feedback and question session after each of the presentations – sometimes up to an entire day.

FIG. 1.13

FIG. 1.13

The final presentation is organized in the beloved orange hall of the Faculty of Architecture. With guests from the industry, all of the students and their friends as well as the docents of the different disciplines it's often crowded on the orange staircases.

We end the day with the opening of the exhibition, which is usually open to the public for a week or two. I like the building weeks and the challenge to find the best way to produce different parts – sometimes out of the box –, but the finals are the most intense day of the semester. That's the day that everything comes together. The groups are focused, have prepared slide shows, practiced their presentations and have the prototypes polished and fine-tuned to the max. We had semesters with as many as 80 students, which means around 25 groups present their ideas. That makes for quite a long day but due to the fast pace it never gets boring. We always have the semester partners in house next to our team of docents who supported the groups during the semester. After each of the individual group presentations we have time to ask and give feedback, sometimes we have to help a little to bring the essence of the concept to the surface or help with the most difficult questions from the experts if certain topics weren't addressed during the semester. The semester is based on a set focus; therefore, we can't always take care of every possible facet. The idea and the concept of the course is to advance the ideas as far as possible but, naturally, they are not ready for actual product development yet – we are working on possibilities to continue these developments if the concepts have potential.

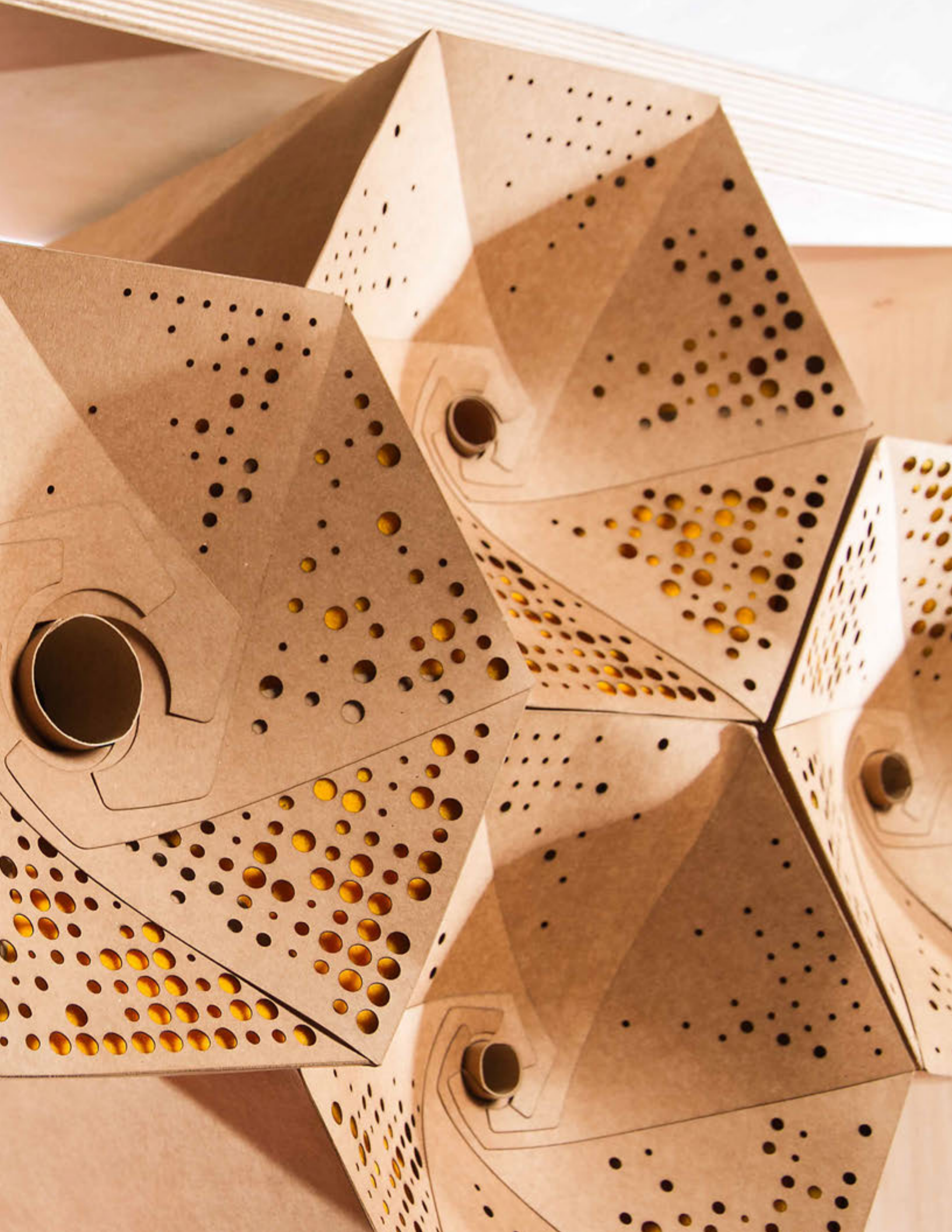


FIG. 1.14

FIG. 1.14

The best boost for the course - winning first, second and third prize at the façade fair in Rotterdam in 2012.

1.25

And then?

We have a well-deserved drink at the end of the day and two weeks later we meet for a last time to disassemble the exhibition. For us docents, this is when the most difficult phase begins; we have to grade the projects. We take notes during the semester in order to judge the groups' work, their progress and ability to work in groups, but we also have to read the reports and evaluate them. As mentioned before, we focus on the process and the various decisions the teams made throughout the semester, and the documentation thereof. The approach they followed is valuable for later projects, all the way to entire architectural designs. We hope the knowledge can be transferred to following projects and challenges. We start by evaluating the work individually, and then discuss the grades within the team, sometimes also with the other colleagues from the different courses.

1.26

Is there something specific you are looking for in the reports?

Firstly, we look at whether the report covers the entire process, how the idea has evolved, what the options were that they chose from and the struggles they encountered. Next to the process, I look at the personal reflection. We ask the students to write a self-critic but also ask for a feedback about our work and the course itself. Based hereupon we can fine-tune the course, and we received good points for improvements over the years.

1.27

Your students have won several awards and prizes, is this part of the semester?

No, it is not an intentional goal, but it is nice when it happens. A while ago, we were invited to join a competition during the Dutch façade trade fair "gevel" in Rotterdam and won all 3 prizes. And our students were able to replicate this success in the following year. We also won several other prizes like the International Velux Design award, but these were all handed in by students' own initiative after the course was completed. Taking part in competitions is not a typical part of the curriculum, since usually the timing isn't right, or the topic does not match well with the assignment we have agreed on with our industrial partners. But in general, it is, of course, a good thing to happen, which creates great publicity.

1.28

Any secrets about this success?

We keep asking "Why" – thus enabling our students to develop a very clear concept, to address the problem and their solution very clearly. That's what a jury wants to see. And, of course, the many hours put into the projects; we don't know of any other university that offers an entire semester to create such concepts. Of course, others also build full-scale prototypes, but they don't spend so much time on them; usually it's a small part of their building construction courses or a practical part of CAD courses.

FIG. 1.15

FIG. 1.15

Several cardboard projects exhibited in the orange hall; it's quite a happening when the prototypes are that big.

1.29

You have travelled the world building with students and teaching this approach, do you see ideas copied?

Yes, but never as a direct copy. We share all of our projects on our website, the Bucky Lab blog, and therefore we invite others to become inspired. In my opinion, this is the best way of teaching students, it is also the best way to keep them motivated. Sharing some insights in this book will hopefully inspire more universities to do similar education projects – don't copy the logo, but the way we teach, study our concepts and get inspired by them, I am open to help anyone who likes to build.


BOARD
FESTOOL WINBAG
- pump it up..!
raaco
BUCKY LAB
HECO SCHRAUBEN
FESTOOL
raaco
SOLARLUX
breur.nl
wiha
BUSCH-JAEGER
Hettich
1 POWERTOOLS
International Plywood BV
TU Delft
1mag1ne

2

How it all began

2.1

We already talked about the course set-up, but I would like to know how it all began.

The history of the Bucky Lab already started a couple of years before I joined. The original course was first introduced in 1992; it was called The Delft Prototyping Laboratory and was set up by Prof. Mick Eekhout, former professor for product development, to teach students how to develop and make prototypes. Peter van Swieten, a docent at the chair, was in charge of the course, using the facilities of the faculty's metal workshop to build the prototypes.

Since the course was conducted at the former metal workshop, almost everything built there was made out of metal. The students were asked to design an innovative façade concept which was to be built at full scale by the end of the semester. The course included instructions on metal welding to enable the students to produce the prototypes. Back then, in the 90ties, the course had between 10 to 20 students per semester, a perfect number to work with in a workshop area that was usually used to build scientific testing equipment and prototypes from various different disciplines.

The key player in the workshop was Gerardus Baardolf. Known to everyone as Kees, he gave the students welding instructions and taught them how to use metal for their specific plans. As the master of the workshop, he was the one to ask if the students needed to know how to make things while the docent was consulting in the studio to improve the overall designs. Due to the fact that the students were still novice welders, even after getting their student welding diploma, their capabilities and skills often lacked the expertise needed for the prototype details that are part of building. Sometimes, the students were machining parts and components for days or even weeks, and Kees ultimately took care of the welding process to save their precious work and preparation.

Looking through the projects archive I discovered that everything, and I mean everything, was made out of steel. I found one single project with a wooden frame. When I asked why they had used wood I got a surprising answer: "No, it is made of steel, it is a refurbishment detail for wooden window frames and the steel square tubes were painted to mimic a wooden window frame. Isn't it great, it looks like real wood!" Asking why they did not use wood in the first place, the answer was also rather unusual. "It's easier for us to do it in steel, because it's difficult to talk to the guys in the woodworking shop across the street, they don't appreciate us".

FIG. 2.1

FIG. 2.2

FIG. 2.1

The former metal workshop fully equipped with mills, lathes and other heavy machinery to work with metals of all kind.

FIG. 2.2

Precision milling was the common technique to fabricate parts and components out of steel or aluminum.

During my first semester, one group built a robotic solar harvesting animal that could walk across the façade of a high-rise carrying a PV panel on its back using suction cups on its feet. To display the creation, the students built a huge steel frame, and with the help of glass researchers they also managed to glue three huge glass panes onto the frame - quite an achievement in itself. The problem was that the frame with the glass weighed more than 200 kg and was too big to leave the workshop – it did not fit through any of the doors. Ultimately, we presented the idea without the heavy framework, placing the PV animal onto a glass building next to the workshop, and took pictures of the beast in its natural habitat.

2.2

How did you become the head of the course?

I moved to the Netherlands to work on my PhD in 2008, just six weeks before the Faculty of Architecture burned down. This was a disaster, but within a couple of weeks all classrooms were set up in a tent village and all of the different departments of the faculty were moved to other places all over campus. Only one year after the fire we moved into the old building at Julianalaan in which the faculty is now located. Unfortunately for us, the new location was lacking space. There was no room for a big workshop like we had in our old building, and while two big volumes were added to serve the students as a model building hall and a lecture room, there was no space for the former metal and glass workshops. The metal machining and welding equipment that was saved from the fire had to be moved to the testing halls of our colleagues from the Department of Civil Engineering.

Shortly before I completed my PhD in 2012, I was asked to replace the soon to be retired colleague Pieter van Swieten to run the Bucky Lab. I started to work as an assistant next to Peter for the first semester and discovered what works well and what does not. First of all, the use of steel was a problem, because it slowed down the students in their building process and, honestly, the designs that were created with this heavy machinery were a little bit too bulky. It is, of course, wonderful for all of your prototypes being able to withstand an earthquake, but it does come in handy if you can carry them instead of having to use a forklift.

Not being able to work at our own faculty caused logistical problems, and the shop in the Department of Civil Engineering was not as comfortable as we had wished. In addition, we also had to pay rent for the workshop. I was asked to think about a solution, and considering one aspect was to save money on the yearly rent, this was the opportunity to rethink the concept Bucky Lab.

FIG. 2.3

FIG. 2.4

FIG. 2.3

In the metal workshop, welding was the most common method to connect steel parts; all students got trained and practiced a lot.

FIG. 2.4

A typical detail of a steel frame: a steel window frame built to last for centuries.

By the way, the course had been named Buck Lab a few years earlier – I was involved in the process not knowing I would be in charge later. My colleagues at the Department of Building Technology and I decided (not unanimously, but that's a different story) to give up the metal working workshop and to create a mobile workshop, a workshop primarily based on smaller power tools and wood as the main building material. We gave up on the idea that the prototypes had to be made of steel to increase the students' freedom in choosing which material would be the best choice to materialize their concept. From my own experience, I knew you can build anything on your kitchen table, and for the overall learning experience it is more important that students are able to finish their prototypes on time and by themselves.

The prototype is not the final product, but a first proof of concept; the evaluation at the end of the building weeks is important. The discussion on what went wrong, what worked as expected, and the students' ability to judge their own achievement in relation to the real product is essential. Nowadays, we try to create an environment in which failure is always an option. If you don't fail, you will never learn. Working with wood as the main building material serves this purpose very well – I always order a few spare sheets as a backup. And if needed, I come to the rescue, to help get a second prototype done if something didn't work as planned. Once you built the first model, it's easy to build a second one.

After the decision was made to give up the space at Civil Engineering, we were promised to get a space for a tent or another space paid by the faculty. This meant that the space issue was solved, the only thing we still needed was the actual workshop.

The prototype is not the final product, but a first proof of concept

FIG. 2.5

FIG. 2.5

A usual day in the former steel workshop: due to the size of the prototypes and the lack of big enough tables, most of the prototypes were assembled on the floor.

2.3

So, that's when your mobile workshop came to life?

Yes, inspired by the mobile workshops used in Formula One and rally teams who travel the world, we started to think about a mobile workshop for the Bucky Lab based on a set of flight cases, which were to be built during the next semester. This was the first assignment under my lead and, truth be told, it was quite a challenge. After enrolling in the course, the students expected to design and build a façade prototype rather than a set of toolboxes. Unfortunately, only a few students understood the potential to design a mobile workshop that would be used for many years, the others started to design façade concepts. The tools were already ordered, as was the material for the boxes, so we had to build the mobile workshop first to continue to build façade prototypes afterward. At the end of the semester we rented a tent and squeezed it in between the east wing of the faculty and the new model building hall. Surprisingly, the tent fit almost perfectly with only half a meter of overall clearance.

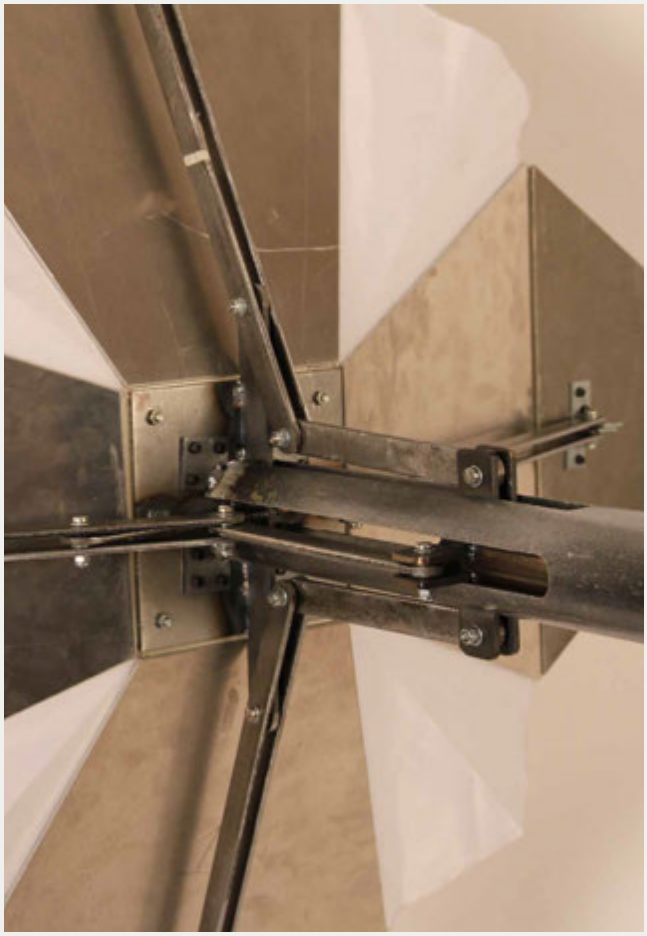


FIG. 2.6

FIG. 2.7

FIG. 2.6

Sunflower shading concept. When the sun rises and strikes the façade, these mechanical flowers open and shade the transparent parts of the building. One of the more complex projects.

FIG. 2.7

A very unique prototype, which shows freely spinning shades and elements that, when turned by the wind, generate electricity and illuminate surrounding LEDs.

Today, our tent rental partner has a different tent that features a clearance of only a couple of centimetres – no space wasted. The building weeks went well in our new tent, on sunny days we could even work outside. At the end of the two weeks we had a set of five flight cases and were good to go. I will talk about the boxes and the tools in more detail later, but in principle this was the beginning of the mobile workshop of the Bucky Lab. Our activities in the tent with students operating power tools created such interest that the number of students enrolled in the course had doubled by the next semester.

Of course, a new website, nice pictures and free coffee during the building weeks also helped to draw attention, and me wearing the new Bucky Lab logo anywhere I went did not hurt either.

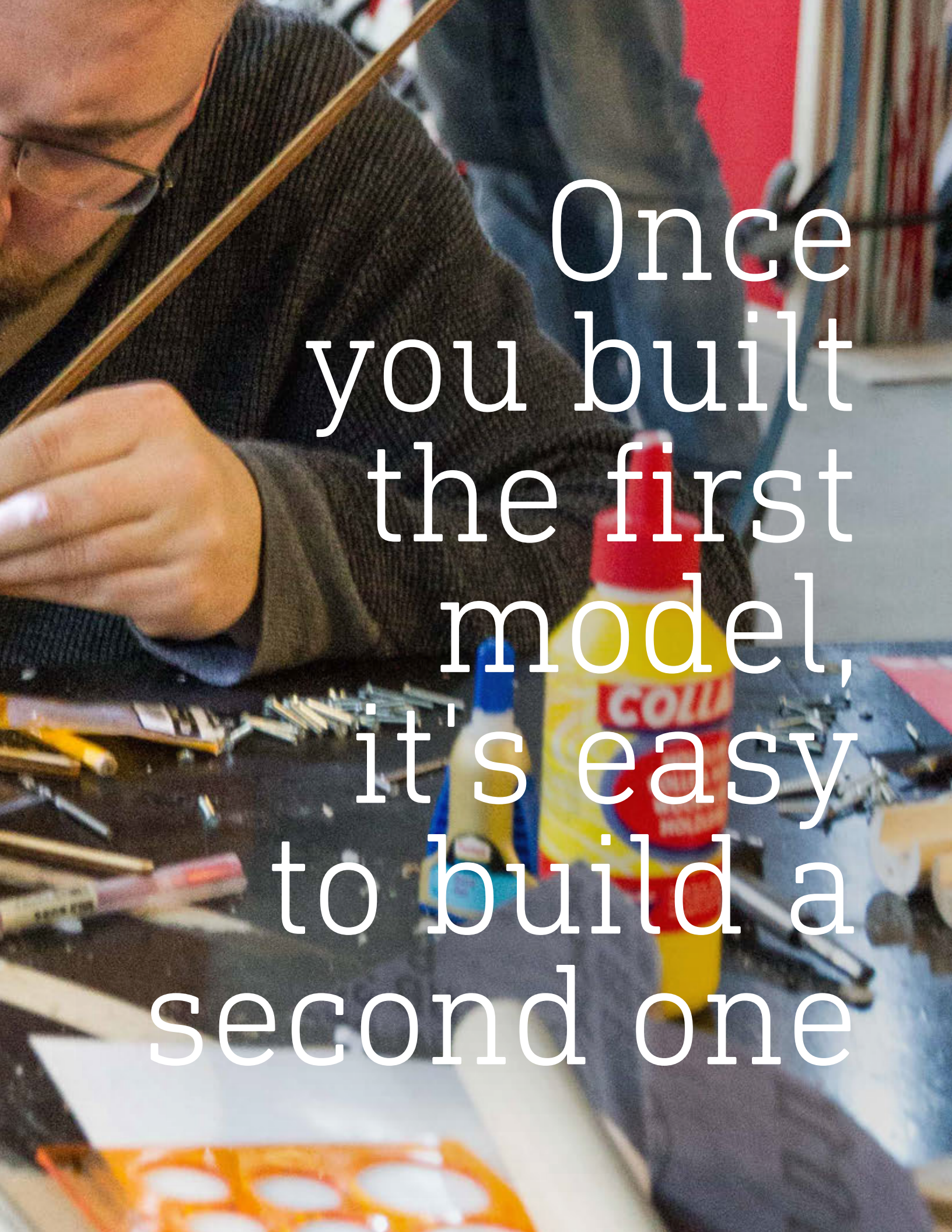

Once
you built
the first
model,
it's easy
to build a
second one

FIG. 2.8

FIG. 2.8

When we work with groups of up to 80 students it becomes very busy in the workshop, even in a large space.

2.4

Looking back, do you miss the old workshop, or the metal machining tools?

Personally, I loved the possibilities the former metal shop offered. But in terms of educational goals, the new concept works much better. Working with metal is a lot more difficult, the tolerances are smaller, machining takes more time. I have worked with metal my entire life; I have operated many machines and equipment over the years in my father's shop and in my friend's parent's company. I am comfortable working with steel and other metals, but if it comes down to the pure fact of learning achievements, you can learn so much more if you are not limited to metal. Working with wood is a lot faster and the students are able to conduct several tests if the first

model does not work. Nowadays, we can sand down a piece of wood that does not fit properly in 2 seconds on the belt sander; adjustments that would take much longer if working with steel. And the wood approach teaches the students that they can continue experimenting even after the course has ended; of course, they might not have all the tools we have in our shop but fiddling around and testing initial ideas can be done with a bare minimum of standard woodworking tools. Cutting pieces of cheap wood is easy and can be done on the kitchen table – try that with a 10 mm bar of steel in your dormitory room.

2.5

Is there nothing you would like to change?

I have not regretted any of the decisions and we do not need any changes at the moment, but there is always room to expand. If someone would give us a huge pile of money, I would build a big shop, have ten employees who are able to operate all the machines you can dream of and support the students with every one of their crazy ideas. And the word "No" would be a reason to be fired. We can make do with little but dreaming of the perfect workshop keeps me motivated.

2.6

Let's talk about the name: Bucky Lab – where does it come from?

I don't recall the details, but I remember you and I were involved in the name finding process long before I took the helm of the project. The course is based on Buckminster Fuller's credo: Anything you can imagine, you can build. Buckminster Fuller was known as an ingenious architect and engineer and for his way of thinking out of the box. Especially his practice of using production technologies from other disciplines seemed very appropriate for our approach. So, we used his nickname "Bucky" for the workshop. I actually tried to research Buckminster Fuller's statement that I quoted earlier, but wasn't successful; maybe he never said these famous words. Strangely, I did find them attributed to Jules Verne... But we will stick to the original name and not change it into the Jules Verne Lab.


Anything
you can
imagine,
you can
build


BORIS CASE
HIGH QUALITY FLIGHTCASES
LAB
mobilow
TUDelft
breur.nl
4
WINBAG
– pump it up..!
imagine

3

Tools and the mobile workshop

3.1

Your first assignment was the development of the mobile workshop. How did you approach that?

Hettich came to visit us many times to discuss the details; we learned how to design and plan with their products. The students became experts on their product portfolio. So much so that, initially, I found it quite challenging to catch up with them. Even today, I still appreciate the 32 mm system every piece of furniture is based on and have to smile when assembling an IKEA kitchen. They are all based on the 32 mm system. Two weeks before the building weeks started and after many versions of construction drawings, Aard and Mark from Hettich NL unveiled a big surprise: Hettich was so impressed with the mobile workshop and the passion of the students that they had decided to equip our boxes with their brand new ArciTech line of drawers which would be introduced to the world on the following Monday, to be placed in our boxes on Tuesday – Day 2 of our building weeks. These top-of-the-line drawers are the best, and still work perfectly in our boxes. Despite the extra hours our students had to spent to implement the new set in their planning we were happy to get this last change because the line was also designed to speed up assembly significantly – even today, almost 10 years later, we still have better drawers in our mobile workshop than most of us have in our kitchens at home.

The goal was quite clear but, at the same time, very difficult to achieve. We had a number of power tools, some in toolboxes, some of them bulky and to be placed on a table, quite a few assortment boxes, and a couple of hand tools. The budget was limited; according to our calculations we were able to build five flight cases. Ideally, everything was to be stored in these five boxes, which were to be on wheels and designed in a way to allow easy access to all tools.

It was the hard work of Ron Valkenet, Dave Letink, and Sisko Roosenboom who took the opportunity to design the boxes we are still using today. We sat together for many hours to find the best set-up and the ideal distribution of the different tools to fit in the boxes. While the students started to design, I was able to find more sponsors to help us with the completion of the boxes. One of the first was Hettich, German expert and world leader in furniture fittings. They liked the idea to equip a mobile workshop to serve future architects in their pursuit of innovation. And they appreciated the fact that these future architects become acquainted with their products as early as during their education. Actually, they handed us their 1000-page catalog – we called it the bible – and said: "Feel free to order whatever you need!" When Hettich joined, the idea of adding drawers to the cases was born, drawers to store all the hand tools, drawers to allow easy access to all of the small items you have to have in your workshop. Drawers to keep everything in check. Chaos in a drawer is only acceptable if the type of content is obvious at first glance.


Chaos
in a drawer is
only acceptable
if the type
of content
is obvious at
first glance


KNIPEX
KNIPEX
edding 400

FIG. 3.1

FIG. 3.1

All of the current flight cases and cages lined up after our arrival in Poland for a summer school. Several tools still need to be placed on top of the boxes and we have to build a case for the vacuum cleaners.

The contoured foam cutouts we used are nice but in a growing workshop you have to spend a lot of time on getting new foam cutouts and they take up space in exchange for organization.

After spreading out all the different tools in the basement, we found the best arrangement of the tools. Ultimately, our boxes were as long as three Festool systainers, as high as our bandsaw and as wide as the faculty's elevator doors minus 20 mm clearance.

FIG. 3.2

FIG. 3.3

FIG. 3.2

The flight cases are exactly 3 Systainers long, as high as our bandsaw, and 20 mm narrower than the elevator doors in the faculty.

FIG. 3.3

Box no 2 holds the miter saw and a couple of smaller cases that contain metric screws. Nowadays, we jam everything else in this box, too, and are happy if we are able to close the lid.

The boxes all have the same outer dimensions but are very different on the inside. Here is a brief description of what we found to be the best arrangement:

Box 1: Has two removable side covers and contains all the different power tools stored in their own boxes, three drawers for screwdrivers and other hand tools, the first aid kit, three small boxes that contain cables, spare parts for tools and tapes.

Box 2: Has a big openable lid and houses the Festool Kapex mitre saw, a few Raaco assortment boxes and two extension cables. The lid has integrated legs, which can be folded out to use the lid as a table.

Box 3: Also has an openable lid and stores the Festool CS70 Precisio table saw and all accessories for the saw as well as several extension cords. The lid also works as a table standing next to the table saw when in use.

Box 4: Splits into two smaller boxes on the long side, providing access to the sides. This box contains table tools like a drill press, a bench grinder, a band saw, a bench disk sander and a couple of small drawers to store bits, drills and other small accessories. It also includes two wall socket radios from Busch Jaeger with mp3 player input and iPhone charger. Unfortunately, Apple discontinued the 16-pin connector, but older iPods still work.

Box 5: This is the Bucky Box, one storage box which splits into three smaller boxes that can be aligned next to each other. These fit metric screws in Raaco assortment boxes, big drawers to store rulers, pliers, glue and towels, and one is equipped with a cordless high-pressure water cleaner and a bucket-shaped sink and a beauty mirror next to an eye shower to check your eyes in case of an accident.


mobilow
CONTIMAC


metabo
CONTIMAC

3.2

What else do you have next to the flight cases?

Next to the boxes we invested in height-adjustable workhorses on which sturdy betonplex sheets are placed as tabletops. We started with five tables – now we have 18 and the workhorses have been replaced by sturdier steel frames. The boxes are still in use today but, today, they are accompanied by a coffee kart including a refrigerator and our Heco Box that contains all the woodscrews you can imagine.

The workshop keeps growing, and I usually bring my own tools in two big containers with drawers to keep the Festool tools easily accessible. We now have a bigger bandsaw, three sewing machines, a couple of Walko workbenches which are the best addition to the Festool plunge saws. Initially, everything could be fit in the five original boxes; nowadays we need a big truck to move everything and are happy if we are able to close the boxes.

3.3

The boxes are covered with many company logos, tell me about these partners.

The Heco box is the result of a great collaboration between Festool, Raaco and Hettich. The trainers from Festool wanted to learn more about Hettich's furniture fittings, so we designed the box together and built it in Festool NL's training center in one day. Raaco provided the assortment boxes, and at the end of the day we were all a bit smarter and the workshop one box richer. (There is a video we made that day on YouTube. Look for: Heco Box)

As already mentioned, the budget was tight and without the many sponsors we have the workshop would be impossible. There is Raaco, the Danish expert for storage solutions who equipped our workshop with a huge amount of assortment boxes. We have their handy Boxxers in various sizes to keep all of our nuts and bolts, screws and washers in order. Thanks to Kelly Schaauwers, every box is labeled to indicate the different measurements of our screws.

ABB Busch Jaeger provided us with all the hardware for the electric wall sockets and also a couple of radios directly built into the wall sockets that allow us to also hook up our media devices to make the day a little more relaxing with some music.

Heco, the German expert for wood screws, joined the Bucky Lab a little bit later. After we received their entire assortment of wood screws, we built a dedicated box for it. It is the smallest but heaviest box of them all.

Today, we also cooperate with Snickers and Hultafors, who offer their hand tools and workwear to our students for a good price. Next to this, we have the most ergonomic screwdrivers and pliers from Wiha as well as their handy bit boxes.

Without these partners we would not be able to run the workshop, and we are proud to carry their logos on our boxes.

FIG. 3.4

FIG. 3.4

The team that built the flight cases. At the end of the busy building weeks, everyone was happy with the achievement.

3.4

The pictures show that Festool plays a special role in your workshop. Any reasons for that particular brand?

I have worked with their power tools since I got into woodworking decades ago, so when I wrote the shopping list their tools were first on the list. We purchased all the tools from hardware store Breur, also a long partner of the course, and after a short while we met the team of Festool NL during a trade fair. We quickly became friends and since then Frans van Dijk, the former head of training, joined the building weeks to teach the students how to use their power tools safely and accurately. When the groups became bigger, more trainers joined and without their support I would not feel comfortable to run the workshop with the given number of students. In case of damage or shortage of special tools we were always able to get a quick swap or some rental machines.

On the other side, we also built a special pavilion for Festool at their headquarters in the Netherlands and joined the team during trade fairs and woodworking events throughout the country. It became a win-win situation for both sides and, today, they call me their ambassador; a title that does not really exist, but I am proud of it nonetheless.


Ingang Oost
Espressobar
De Bouwpub
Zaal R - S
Toilet
Zwaard
ijzerhandel
International Plywood BV
LAB
TUDelft


More Core Division

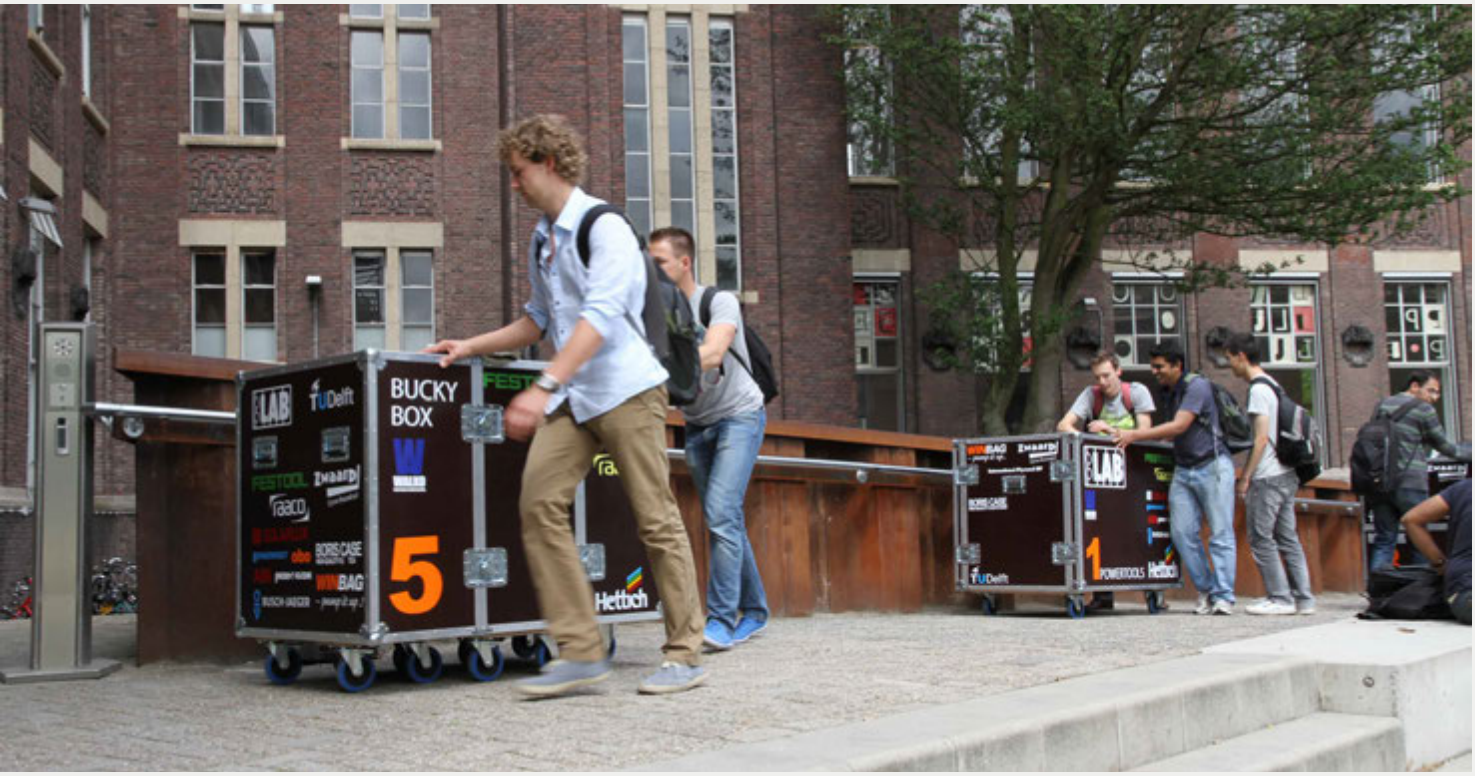


FIG. 3.5

FIG. 3.5

The first tests of moving the mobile workshop was a success, and it stills works perfectly today.

3.5

I was told you only work with the best tools. What is your personal favorite?

I will not argue that, I always try to get the best possible. It is a necessity in order to allow the novice makers – our students – to achieve the best results possible. With these tools and accessories, we are able to ensure safety and productivity. It's the details of these tools that makes working with them such a pleasure. Even if you are not a professional – working with professional tools makes it easier and safer to make quality products.

Ultimately, it is not the purchase price of the tools that matters; we use them for a long time, they are up to the task, easy to use and the service we get is incomparable.

My favorite tools are the coffee machine and the camera. A good coffee is what makes the students take a break, reconsider their work, wait for supervision and discuss problems that occur during the making process. With a cup of coffee, we solved many problems in the workshop. And the camera is the tool that allows me to talk about my student's projects.

My father always told me that we don't have the money to buy cheap tools. And that in case you need a hole somewhere, don't ask for a favor but get a drill and do it yourself. I still follow this advice today, but now he is the one who is jealous.

FIG. 3.6

FIG. 3.6

A very unique gift from Erik Schrijver: the Lego Mini Dr. Bucky Lab travels the world, making everyone smile who meets him.
The little guy is so famous he made it on the cover of this book ☺

3.6

While the tools are very important for the building weeks, they do not seem to dominate the course itself?

No, they are fun to work with and most students will say that the building weeks are the most impressive and fun period of the entire semester, but the tools are not our focus. Very rarely is it the tool that creates the concept. They are just instruments to make the prototypes happen. Of course, you can focus on a special production technology to start your design, but we do this in the following semesters, for instance with the technoledge projects, that focus on digital manufacturing technologies such as additive manufacturing, CNC milling or the use of robots. In the Bucky Lab, we try to find the best ways to build our prototypes, we choose the tools we need to build the concepts, that help us to tell the story, to "sell" the idea. In principle, we do mostly woodworking and there are many ways to cut a piece of wood. Some are quicker, some are more precise, some just safer. The goal is to find solutions for problems in the built environment – proper tools help us to make that happen, but the tools should not make us search for problems we can solve with them.

We often run through 20 kg of coffee and about 30 liter of coffee milk during the building weeks; the paper coffee cups from Breur and Festool in the shop are used up quickly during the course of the day. In view of sustainability and environment friendliness, we ask the students to bring their own mugs or cups. One time we even had an ugliest mug competition and we often see custom made coffee mugs within the different teams.


With a cup
of coffee, we
solved many
problems in
the workshop

FIG. 3.7

FIG. 3.7

A typical set up of the mobile workshop: the tools corner at the upper right, the cutting stations at the upper left, and a table for each group. And, as usual, a lot of stuff on all of these tables.

Be aware of what you show the students! Once I fixed a piece of wood that was two millimeters too long using a power sander. The next day the students continued to cut their pieces oversized in order to sand them down to precision... Certainly a way to use all the tools in the workshop, but not the most efficient.

3.7

Do you have rules in the workshop?

There is an essential set of rules to ensure safety, success and order. We never wrote it down because we never had to. So, this is the first time I will try to put something on paper:

- Never rush, think about it first and then do it.
- Bring print-outs of your technical drawings – it is easier to scribble on paper than on a laptop screen
- Exactly one paper cup of coffee powder per coffee pot
- Safety shoes are a must
- 4 eyes see more than 2 – help each other
- If you don't know where you got the tool from - place it on top of a box instead of hiding it somewhere
- A but joint is better than a miter joint
- Drill into the worktables, not into the flight cases
- Cut things to precision, the saw can cut half of a millimeter
- If you have never painted before in your life – why start during the last hour of the building weeks?
- Only use brads if you are really sure you never have to take it apart
- There is a reason why we have so many different bits

FIG. 3.8

FIG. 3.9

FIG. 3.8

Following the instruction period, the students are able to operate the tools by themselves, but the table saw is under constant observation, even if the instructor looks through a camera lens.

FIG. 3.9

During the summer, the building weeks take place in a tent and if the weather allows the students work outside.

I want to emphasize that this is not an official set of rules for safety in a wood-working workshop but my personal approach to keeping things running – I am very concerned about everyone in the workshop being safe and tell the students a lot of do's and don'ts while we are working – safety is the most important aspect!

The points mentioned are also part of our introduction on the first day. Particularly the drill bits are in the limelight during the intro day. In order to explain the differences between the bits we use on our electric drills, we have 3D printed, oversized bits to illustrate the difference between Phillips, Pozidriv and Torx heads. We love Torx screws, but we also use the other heads every now and then.

3.8

Which tools are at the top of your wish list?

The most reasonable tools on the wanted list are a few more dust extractors, with a group of 80 students there is always a shortage of these. A small metal milling machine would be nice as well as a small metal lathe. But what would be really great is this new shaper tool; it is a handheld CNC router that scans its position on the sheet of plywood with the help of marker tape and allows high precision computer-guided cutting.


Safety is
the most
important
aspect

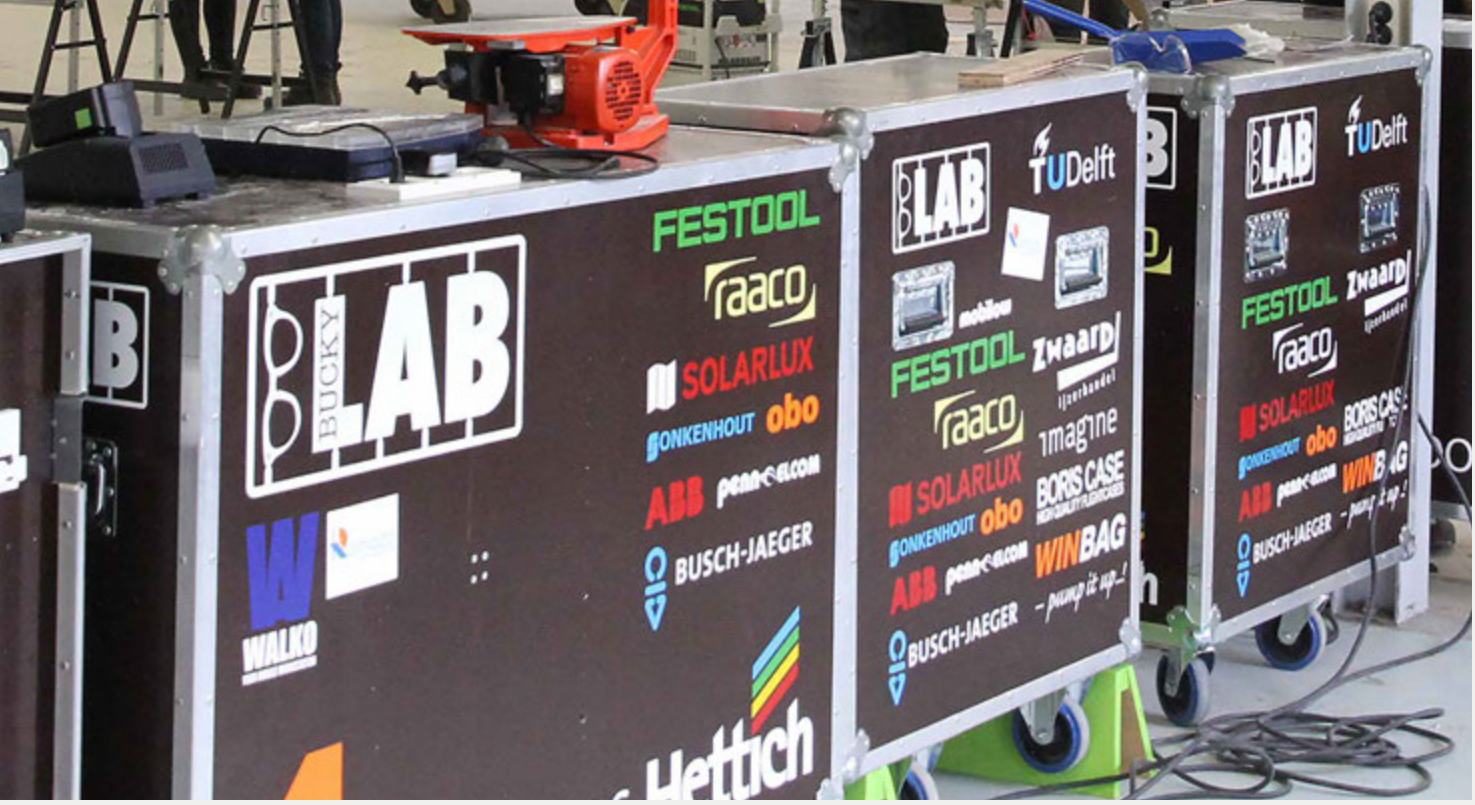


FIG. 3.10

FIG. 3.10

It took more than two days to apply all the stickers on the flight cases; today, we have our own vinyl cutter and a lot more experience with this task.

I am in contact with the American company – Festool also joined the team, and I am waiting for the European approval for this machine. It would make life a bit easier, for example for such simple things as a hole with a diameter of 76.3 mm.

One of the more extreme wishes would be a big hall covering the parking lot to work in. And a giant black truck with enough space for all of the tools to travel the world. I have already built a Lego prototype... Apart from this, we do well with what we have in the boxes; there are few things we haven't been able to build so far.

3.9

Let's talk about the logo and how you present the course.

Everything looks better with a sticker! No, honestly, the logo is very important for branding, it shows who we are and what we do. We had a design contest and I merged a couple of ideas and ultimately created the logo. We have mugs, shirts, hats and an apron available in a web shop. When using the logo, the most important aspect is: use the black one on white and the white one on dark surfaces – people have actually placed the white logo with the black frame on a white background... Hello? Architects are designers, aren't they? And getting back to tools; I also have a vinyl cutter, which makes it very easy to create logos in all different sizes. That's why you can see the logo on almost everything I own – including my car and my motorcycle.

www.buckylab.nl is our blog on which I write about our activities; it shows the concepts, our building weeks and everything we do. Right now, we have more than 500 articles, all the concepts and even an online shop as mentioned earlier. The website is visited worldwide, and we have students joining the semester as exchange students just because they found the site, followed it and decided they want to join for a semester. It is the best advertisement for our education. Our partners and sponsors follow our building weeks online – a nice way for them to stay in touch with us, and the pictures we publish are published on their sites afterwards. We like to share our ideas; the website is a great way to do that.

3.10

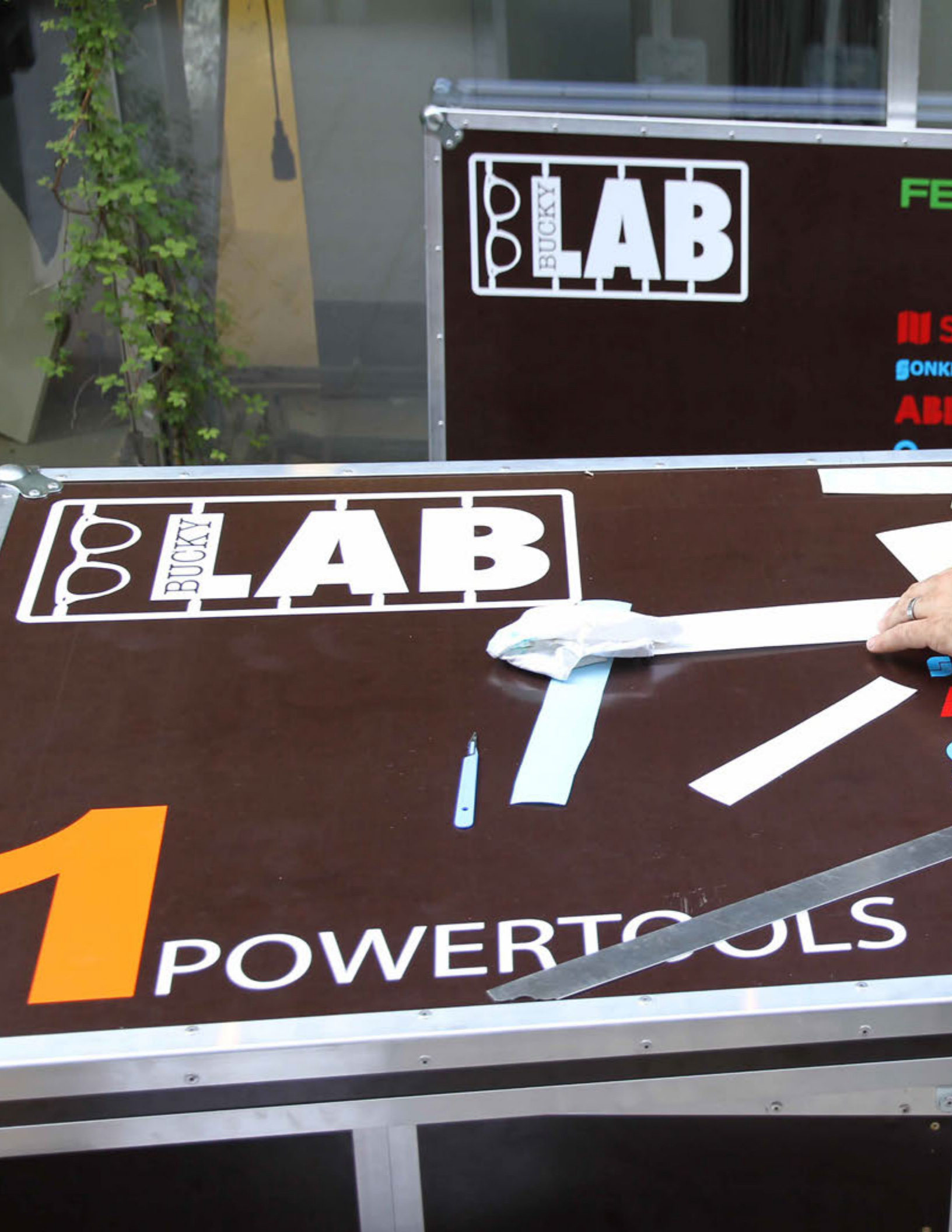
That means that every project is published online, don't you fear to be copied?

Being copied is the best compliment there is, isn't it? The question is how you copy; referring to our ideas as a source of inspiration is great, improving on them is even better. Just doing the same thing without mentioning us is plagiarism and impolite. We do not apply for patents because it does not make sense; someone clever enough can change them just enough to be able to apply for their own patent without officially violating our ideas. And honestly, most of our concepts are not worked out sufficiently to be patented directly, it is the little details that may be worth protecting. I really believe sharing is the way to go – I have met so many interesting people because of the things I have placed online.

3.11

Wasn't there a mobile photo studio in the orange hall, as well?

Yes, you could call it that. I have invested in good equipment including a set of flashes, a white backdrop and, of course, a good camera. Professional pictures are very important, the prototypes are heavy and bulky, and after a while they may also break, but the pictures will last forever. Without the "action" photos during the building weeks and the product photography at the end of the semester it would not be possible to publish our projects so often in various media. You could say that the camera is the most important tool because without it the concepts would reach no further than the workshop. And since it is very portable you may call it a mobile photo studio.


BUCKY LAB
BUCKY LAB
1 POWERTOOLS

Every-thing looks better with a sticker!

4

Brief history of all past assignments

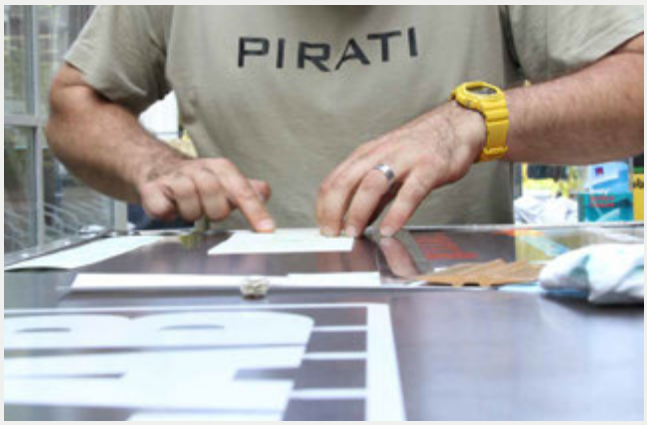
While this book is about the story of the Bucky Lab itself, it would not be complete without showing the projects that result from it. One of the next REAL books will showcase the projects in detail with a focus on sunshades, but in this book we will give an overview of all of the previous assignments.

2011 winter

Wild Façades

The first time I joined the club, after the fire, we worked in a temporary shop at the Department of Civil Engineering. This was Bucky Lab old school; mostly working with metal. The assignment was to invent an innovative façade prototype – as done the years before and therefore a wild mixture of concepts.


FESTOOL
raaco
SOLARLUX
ONKENHOUT
obo
ABB
penn ELCOM
BUSCH-JAEGER
TABLE TOOLS Hettich
TUDelft
BUCKY BOX
W
5
BORIS CASE
WINBAG
Hettich
BUCKY LAB
4
TABLE TOOLS Hettich

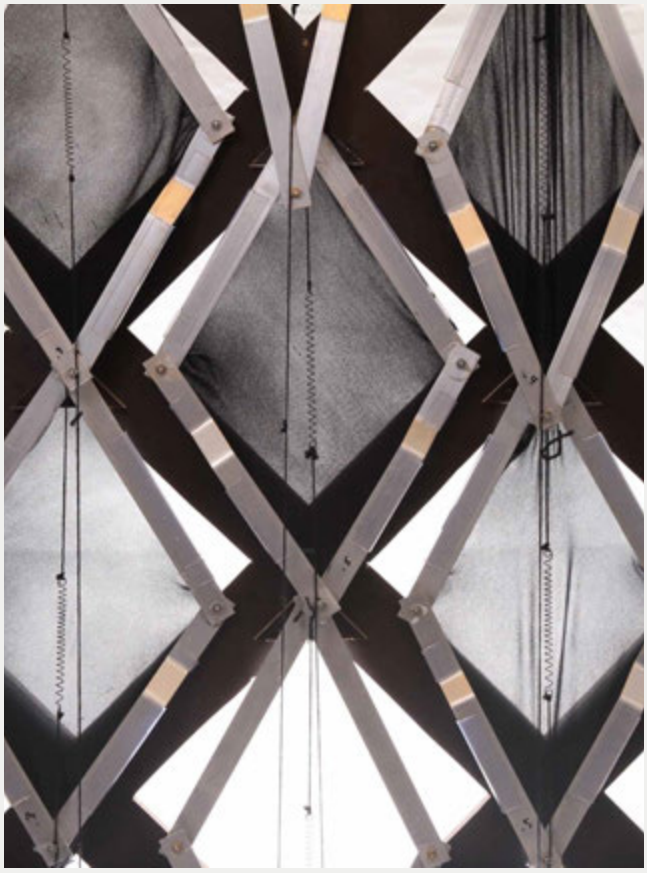


2012 summer

The mobile workshop

The first time in a tent, we built the flight cases and started to create the new set-up of the Bucky Lab. Here, the assignment was to design and build a mobile workshop to house a set of tools. The boxes have to be practical, robust and mobile – everything from this point onward shapes this book.


BUCKY
LAB
WALKO
4
TABLE TOOLS



2012 winter

Shades & Shelter

Our first semester in cooperation with Romazo, the Dutch umbrella organization for the sun shading industry. We started with sunshades and had a very impressive start with the new set-up of the course and the first test of our mobile workshop. This semester, our young Polish cardboard expert Jerzy Latka joined the course and we asked for cardboard shelters and domes as a second topic besides the sunshades.

The wonderful final exhibition which filled the entire orange hall was the starting point of the ongoing success of the course's future.


LXT
Makita
Douwe
EGBERTS
Douwe
EGBERTS
Makita 14.4V

2013 summer

Textiles

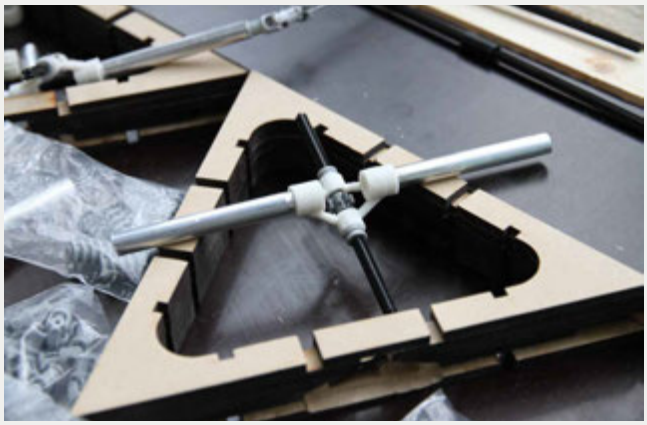
Our second semester in cooperation with Romazo. With a focus on textiles and fabrics, we discovered the possibilities of what is possible using fabrics. A big variation of shades was developed, and the workshop was equipped with its first sewing machine. The semester started with a mini sunshade symposium in which six different members of the Romazo network introduced the topic of sunshades from all different views.


LÖSEN

2013 winter

Beyond borders

The third semester in cooperation with Romazo. This time we asked to think out of the box and were surprised by the blast of crazy but inventive shading solutions. Next to inflatable shades, algae and hour glasses filled with sand we also saw prisms and other solutions that exploited the redirection of daylight.



2014 summer

Daylight

Driven by the successful cooperation with Romazo, the NSVV (Dutch association for lighting) asked us to consider the topic of daylight in the façade. The results were not only exhibited in our orange hall but also during LICHT 2014, an annual symposium in The Hague. In addition to various hairy solutions, someone used beer foam in a façade cavity to control the incoming daylight.


TEAM BLONDE

2014 winter

Wild and Bold

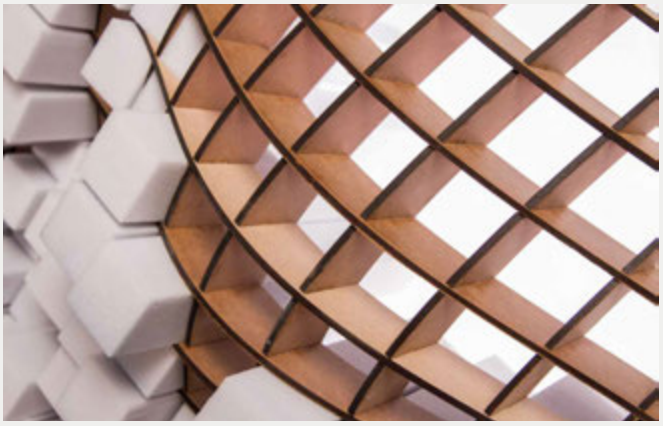
The appropriate title for a set of three different topics. We had Jerzy Latka back in the Netherlands and asked for emergency shelters made of cardboard. We joined the Architectural Engineering project for building on the Dutch coast in cooperation with the Ministry of Infrastructure and Water Management to think about sustainable solutions to build on the Dutch coastline. The results were exhibited on the occasion of the Oerol festival in Terschelling in a pavilion on the sandy beach. One group designed and built our Lightvan, a mobile light research laboratory imagined by our colleague Truus Hordijk, sponsored by the 3TU lighthouse funding. We immediately used the truck to move our exhibition pieces to the island of Terschelling. In hindsight this was a truly crazy but wonderful semester.


Dr. Lucky Lab
TRANSPORTER

2015 summer

Control the Sun

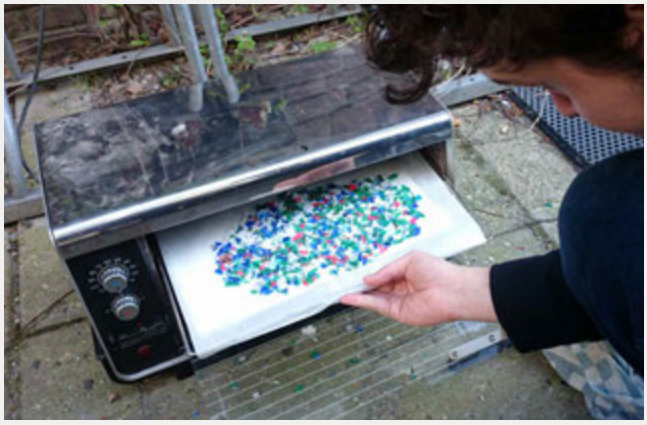
Taking the opportunity to test the new Lightvan, we worked on sunshades and tested all of them at the end of the semester. There were ping pong balls in façades and others that grew hair. Combining the results of the cardboard research from the last semester, we also built a big cardboard pavilion, which actually survived a heavy rain period on our parking lot.



2015 winter

Silence, Please

Inspired by a question from our colleague Prof. Arjan van Timmeren whose open space office at the faculty suffered from bad acoustics, we challenged the students to develop acoustic solutions. A huge variation of concepts was developed and our acoustic experts Foteini Setaki and Jochen Krimm helped to measure the results. This semester was different than the previous ones because when working with the sun the behavior of a model is immediately visible. When working on acoustic solutions, the results cannot be immediately judged, and lot of calculations and tests have to be conducted. The appearance of the final results, however, was very intriguing, and the students received a lot of compliments for the prototypes.

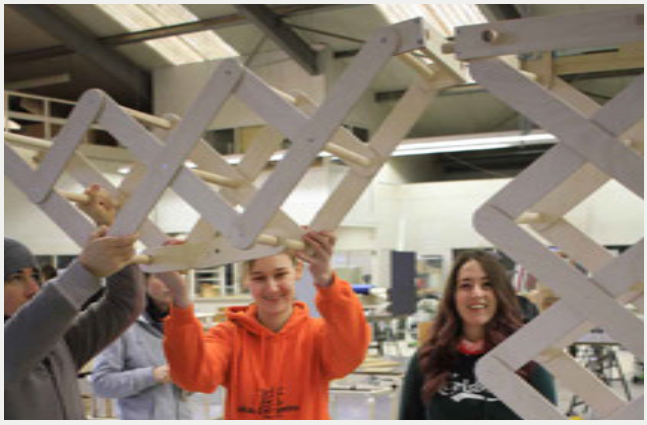


2016 summer

School of Shades

In cooperation with our colleagues Truus Hordijk and Regina Bokel, who were involved in a research project about visual comfort in schools, we asked the students to design a solar shading device suited for an elementary school. The concepts had to be playful but also robust.

The prototypes showed variations that invited playful interaction as well as ideas that allowed for improved ventilation, and one idea even incorporated a revolving garden to provide the children fresh herbs.



2016 winter

Future Festivals

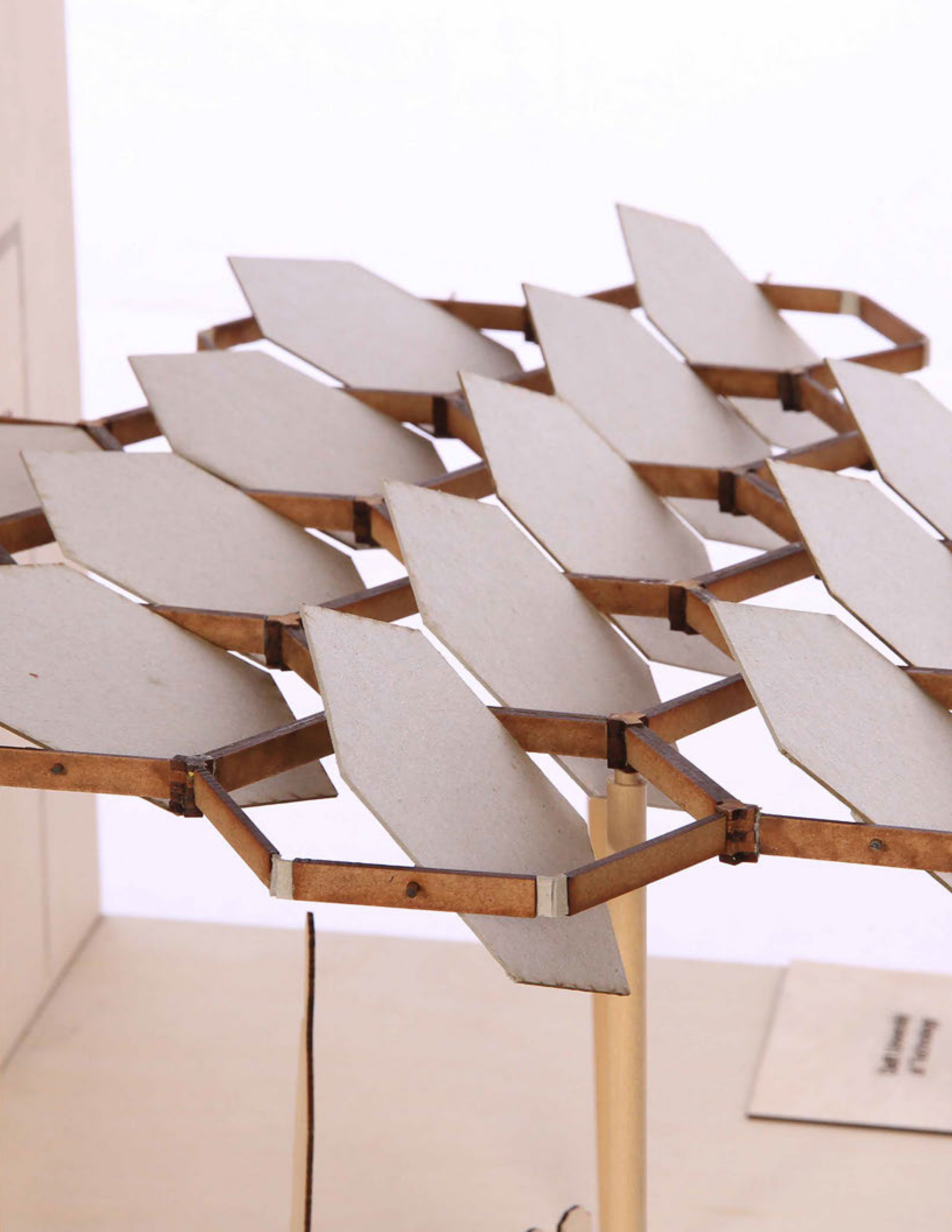
Mojo, the biggest festival and concert organization in the Netherlands, asked our students to think about the future of festivals. With the objective to design easy to erect shelters and smart solutions needed for all kind of problems occurring during huge festivals with more than 50.000 visitors our students focused on various solutions. In addition to modular tent systems the concepts also comprised interactive furniture.

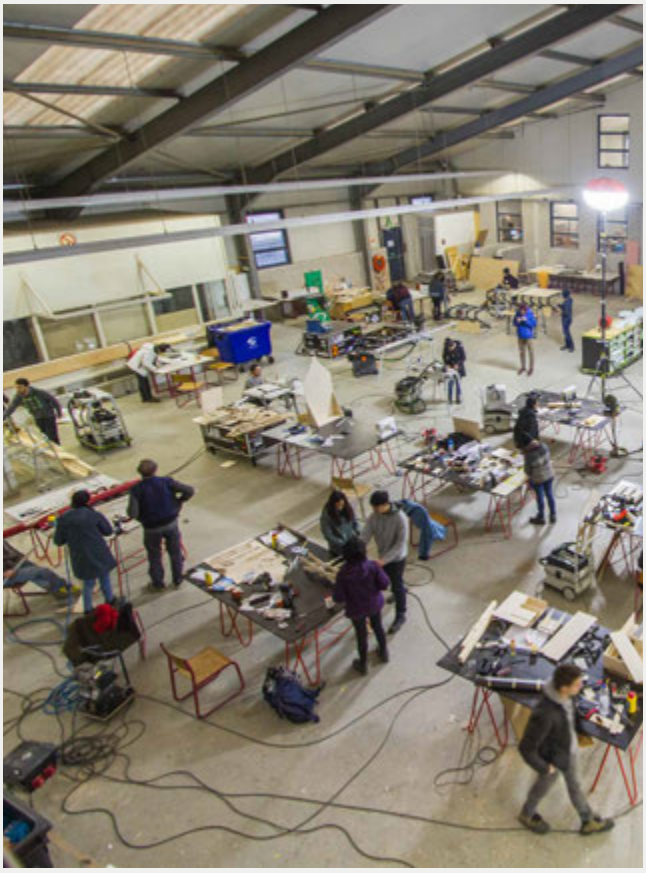
One idea addressed the problem of rain and mud at a festival – the students developed a polymer that absorbs water during rainfall and the idea even included grass seeds to let grassy area regrow after an event. The various pieces of furniture as well as the polymers were tested during the following Lowlands festival.

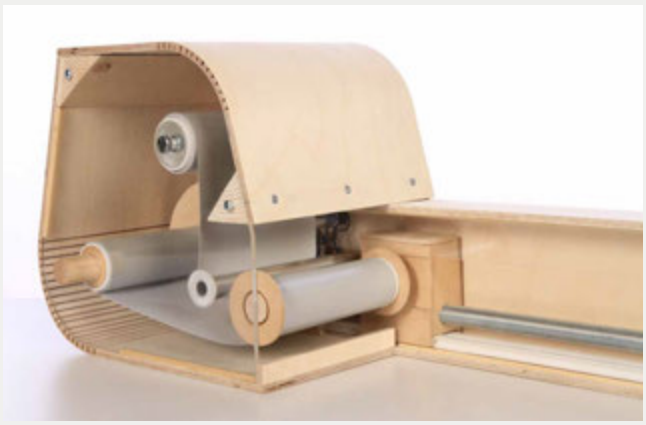
2017 summer

Personal Comfort Zone

Teaming up with Ahrend, the royal Dutch furniture producer, we tackled the concept of a personal comfort zone, a research project our colleague Eric van der Ham was involved in in cooperation with TNO. Imagine your office desk being able to create a comfortable environment to suit your needs, while the rest of the vast space doesn't need to be fully heated or cooled; this would lead to a more sustainable operation of the building with increased employee comfort and productivity. We built cooling chairs, ventilating tables and desk lights that provide light as well as a breeze. Since this was the first time that there were no size restriction, we ended up with very large prototypes in order to test the concepts on a human scale – some were actually so big that they didn't fit through the doors of the faculty.





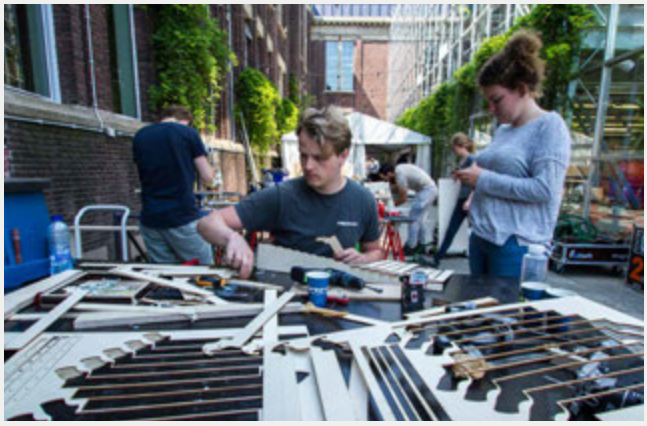


2017 winter

Terrace Shading

In cooperation with CRH, one of the world's largest building material suppliers, and particularly with their Dutch shutters and awnings division, we tackled a very Dutch problem: terrace shading for row houses. In order to improve on the common problems, the solutions the students developed were awnings and shades that are able to withstands stronger winds, are capable of fighting heavy rainfall or have added greenery to form a vertical garden. We saw compact ideas that unfold to cover the terrace and small improvements like using inflatable bladders to reinforce existing awnings. For the very first time, we not only built full scale details but also 1:10 scale models of the entire concepts, which were on display during the façade fair in Rotterdam.


BUCKY
LAB
CRH
Shutters and Awnings



2018 summer

Shades2Lease

In 2018, we set up a dedicated version of the Bucky Lab for Architecture students in the summer semester. From that point onward, we offer the usual set-up for the Building Technology master track during the winter semester only, while a shorter and smaller version is offered in the summer. Due to relatively low student numbers for that semester, this first workshop was a rather small studio with just 13 students forming six groups. Due to the current activities within our chair about façades possibly becoming a service product, we asked the students to think about sunshades that are suitable to be rented or leased. The solutions presented showed a huge variety of ideas, starting with mobile and modular systems that are able to adapt to specific locations and different needs and ranging all the way to one concept that was so small and inexpensive that everyone should have one.

2018 winter

AMC 2.0

A collaboration with the chair of Architectural Engineering, we teamed up with the Academic Medical Center, the AMC in Amsterdam, which is the biggest building complex in the Netherlands, already built 40 years ago. The students developed concepts for within the layer of the building skin in order to make the building more sustainable and circular and to perform better.

The ideas represented an interesting mixture of renovation concepts and products that will serve different aspects.

5

Beyond the course

5.1

When I browse through the blog, there is much more to see and read than just the course itself. Tell me more about what you do besides the curriculum.

Outside of the course, we can't stop doing what we love, either: publishing ideas online, giving lectures nationally and internationally. And with publications in magazines and books we draw a lot of attention and are frequently asked to participate in events in various ways. Whenever time allows, we are open for these kinds of activities. We have done workshops in San Cugat, Spain, and Dammam, Saudi Arabia, I was invited as guest professor in Lund, Sweden, Penn State, US and Darmstadt, Germany, and organized summer schools in Wroclaw, Poland and Beijing, China.

These activities can easily fill more books, not least because I never leave town without a camera and come back with plenty of pictures. I can give you but a short overview of these activities here.

FIG. 5.1

FIG. 5.1

During the last summer school in Wroclaw, Poland, we built six cardboard projects including three small houses in cooperation with TU Darmstadt.

FIG. 5.2

One of the six houses built in Okana by Laura and Ellen.

FIG. 5.3

Inside views of the Center for Change in Okana, built by Ellen and Laura. The 1:2 scale prototype was built during the building weeks. in Delft. The main structure made of bamboo is easy to recognize.

Exploring bamboo

One example was a bamboo project. Bamboo has never yet been one of our project materials, but we have a strong connection to this material. We helped building a small bamboo pavilion in cooperation with bamboo social and BOUT, our student association. The two explore lab students Laura Straehle and Ellen Rouwendal developed a community center in Okana Africa made out of bamboo – they built a half scale model of the structure during the building weeks and after graduating as one of the best students of our faculty they headed towards Africa and built the center with the local community.

A year later the two won the prestigious Archiprix award. A fantastic project that illustrates what a little support in knowledge and tools can lead to. I am always open for such challenges – if it fits in the schedule next to our regular activities and duties – let's talk!

FIG. 5.2

FIG. 5.3 / A Photo: Dominik Saitl

FIG. 5.3 / B Photo: Dominik Saitl

FIG. 5.4

FIG. 5.4

After a long and busy summer school there is nothing better than a short break; in this case in a piece of flexible work and chill furniture that can turn around to serve various activities.

FIG. 5.5

During the construction of the Paper Cave, which was the highlight of the paper symposium in Brussels, lots of honeycomb cardboard sheets were cut and equipped with LED strips to illuminate the interior of the pavilion.

FIG. 5.6

Logistic is key if you have to deal with large numbers of differently shaped elements.

Exploring cardboard and paper

All of the cardboard projects we did during a few semesters were initiated by Jurek (Jerzy) Latka who did his PhD about paper architecture under my daily supervision. With his engagement and motivation, he was able to get truckloads of cardboard to Delft which turned into wonderful concepts for shelters and habitats – Jerzy was also able to invite the Bucky Lab to Wroclaw, his Polish hometown, where we have already held 3 summer schools in which we built amazing projects with a group of highly motivated students. I just came home from this year's edition. Be on the lookout, maybe you can join a summer school in Wroclaw next year. Jerzy recently completed his PhD in Delft – becoming the Architect of Paper he always wanted to be. For us, it's a great story about our very first cardboard doctor who is now busy starting a 'paper in architecture' research group at the Technical University in Wroclaw. We are staying in touch and looking forward towards the future of cardboard architecture.

FIG. 5.5 / A

FIG. 5.5 / B

FIG. 5.6

FIG. 5.7

FIG. 5.7

In Beijing, we worked on urban furniture for the local Hutong in the heart of the city, transporting the pieces to the destination on a cart.

FIG. 5.8

A modular storage system built for small traders in the Hutong.

FIG. 5.9

Working in a Makerspace that also hosts the Festool Experience Center, the students quickly got used to the tools.

Summerschools in Beijing

Inspired by the way we teach, a few Chinese students who studied in Delft asked if we can also bring the Bucky Lab to Beijing, China. After a meticulous organization process, with a special thanks to Mara Wang, I found myself in a hutong in Beijing and built pieces of urban furniture that helped the people in the hutong to sell their products, rest and come together. Working in a local woodworking workshop with Chinese architectural students broadened my mind and proved that the way we teach from sketch to full scale prototype works across borders. A highlight worthwhile mentioning is that the concepts were exhibited during the prestigious Beijing design week!

FIG. 5.8

FIG. 5.9 / A

FIG. 5.9 / B

FIG. 5.10

FIG. 5.10

During a workshop at TU Darmstadt, students built an inflatable pavilion that housed a Zoetrope during the annual light art exhibition Frankfurt Luminale.

In Darmstadt, I joined the Digital Design Unit as guest professor for the chair of Oliver Tessmann. During the semester, one team designed a Zoetrope and another team a pavilion made out of inflatables to house the Zoetrope, which requires a dark environment. The building weeks were a great experience with a lot of experiments including plastic welding, manufacturing and the use of robots. The final project was exhibited during the Frankfurt Luminale, the annual light art exhibition which covers the entire city of Frankfurt.

Next to these and other activities beyond the course itself, the Bucky Lab projects were on exhibition in various locations. The concepts were on display during the façade fair in Rotterdam, the building trade fair show in Utrecht, glasstec in Düsseldorf, and in Vienna during a façade innovations event. A few pieces traveled around with the Material District show. The shop itself several times joined the woodworking open day in Zutphen, where we built small items with our tools to engage with the public and share our love for wood and tools.

I love these activities, it makes us more visible and draws attention to our educational program within the Building Technology Master track.

6

The future

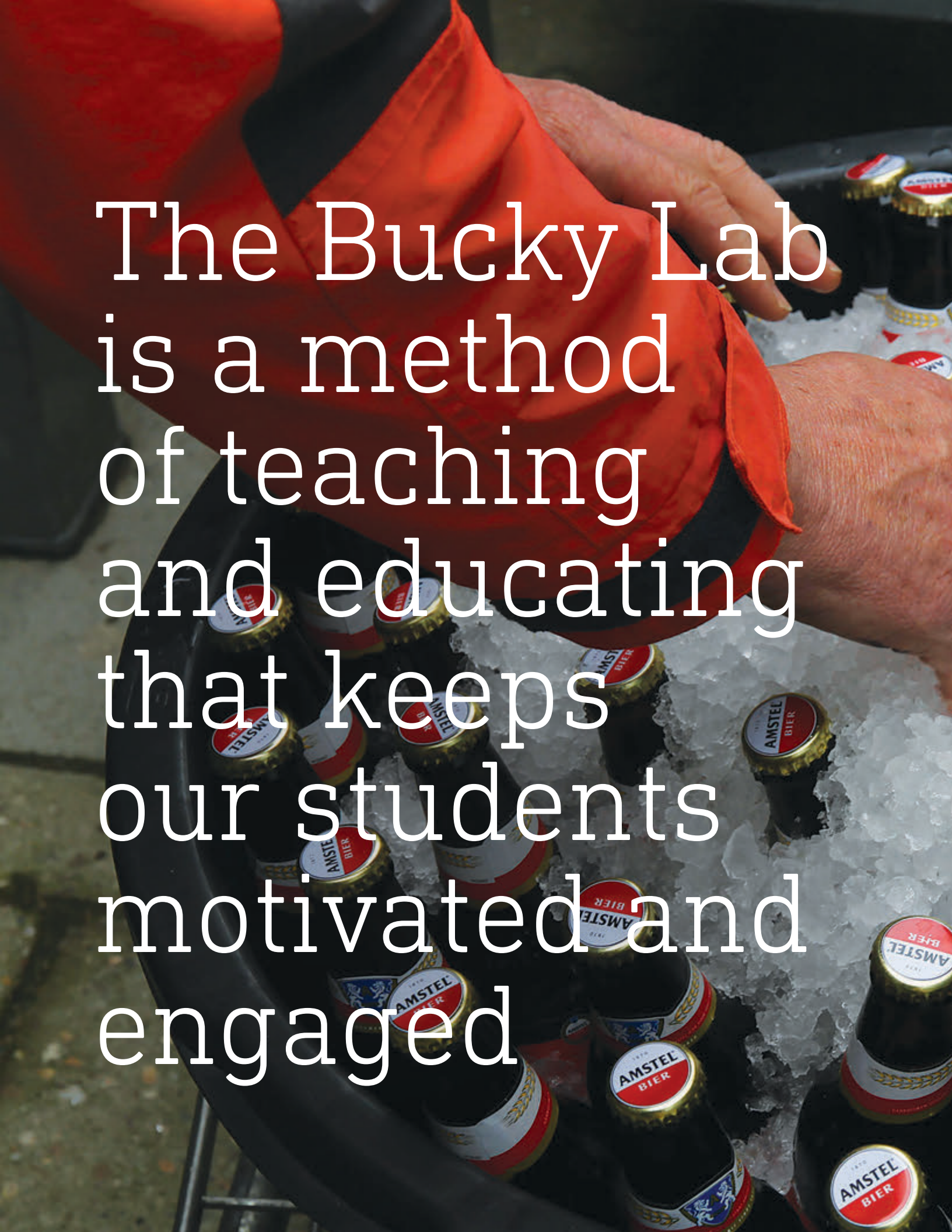
6.1

What's next, what are your plans for the future?

We would love to continue the Bucky Lab as long as possible, seeing the involvement of the students and their pride when presenting their results after a long and busy semester. It is worth all of the work and the obstacles to overcome to make the course happen. The Bucky Lab is a method of teaching and educating that keeps our students motivated and engaged.

With a growing number of students over the years, the workshop and the set of tools has grown, as well: nowadays, we have 18 tables including workhorses, a herd of vacuum cleaners, and, of course, more than eight big boxes and more little bits and things that don't fit in the boxes. This means that moving has become a logistical challenge and finding an appropriate location, especially for the winter period, is particularly difficult. Even though we have learned to solve these problems, not least with the help of our sponsors and partners, and are able to handle these issues, improvements would be very welcome, especially as they take up a lot of our time.

But next to the habitable aspects of the course, we also see the huge potential in the concepts our students develop over the year. While we publish them on the blog and in books, several of these concepts bear great potential to be further developed. Therefore, our plans for the future are to find a way to continue the development of these products after the initial conceptualization during the first semester.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6.2

So, how could you develop concepts into real products?

A couple of ideas are actually on the table. While the first semester can be perceived as a think tank that produces the first concepts and the prototypes to test and judge the ideas, we could offer a second or third semester course that would include developing these concepts further, possibly into final products, as well as associated theoretical courses. This course could be seen as polishing the rough gems from the first semester. In cooperation with the involved companies / semester partners we could team up to dive a bit deeper into the development of these concepts. This course could include industrial production technologies as well as marketing and business strategies for product development. At the same time, we do not want to copy the educational path of our colleagues at Industrial Design nor the entrepreneurs courses at our spin off / start-up agency YES Delft, but we could create collaborations with them to benefit us both.

In principle, we are dealing with building construction related products and not consumer products, in particular. Therefore, we could set ourselves apart and focus on the aspects relevant to our disciple. And with the newly shaped chair Building Product Innovation of Prof. Dr. Tillmann Klein, which now hosts the Bucky Lab, this would be a great opportunity to think about dedicated courses related to developing building products beyond what we do in the Bucky Lab. Circularity is a central focus of our chair, which will lead to new concepts and ideas.

On the other hand, we have to deal with confidentiality issues when teaming up with companies while developing more dedicated / elaborated products with more depths towards the needs of our industrial partners. Therefore, the concept of graduating with a company, which is already practiced within the Building Technology master program, could be one possible solution. In this context, we could set up a team of docents who would support the advanced development of an early student concept in cooperation with the company in a more protected manner to move it towards the demands of our partners. A problematic issue could be the timing; since this would take place in a following semester not all students of a former group may be interested in participating, nor is it very common for students to team up for their graduation projects. A solution could be to pass the concept to a different student already heading towards the graduation period. It is an interesting idea but there are still many issues that would need to be addressed.

6.3

Do you have any plans to use the innovative ideas of the course further?

We would certainly like to do something with some of the ideas the students imagined over the years; not all of them are to the point and worth of further development. But even those were educational, they helped to discover the boundaries and test if an idea has potential or not – "No" can be a positive answer, since it confirms a learning process which includes being able to judge an idea or concept. However, all of the concepts have some aspect, some ingenuity that may solve other problems or can be twisted in order to be applied for another problem. A database or open access archive would help, but this would have to set up with dedicated tags, categories in a way everyone would be able to find the solution you need. The current blog doesn't have that functionality, unfortunately.

"No" can be a positive answer, since it confirms a learning process which includes being able to judge an idea or concept

We will discuss these and other ideas further in order to utilize promising concepts as well as smart details invented and applied in others we have worked on and will work on in the future. Next to this, we are constantly monitoring the course in close collaboration with the students in order to improve it, reduce the workload or spread it more evenly.

We ask a lot from our students, but we aim at doing this in a way that everyone is able to follow and enjoy the course. The positive feedback and good grades we have received so far seem to proof the concept.


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7

People and heroes

First of all, it is important to mention that the Bucky Lab is only possible due to a large group of people. While Marcel coordinates the overall curriculum and is the one organizing, setting up and keeping the workshop running, there are many docents and lecturers that passionately teach the adjoining courses for this very special first-semester master course.

- **Material Science** – Fred Veer
- **Structural Mechanics** – Peter Eigenram
- **Building Physics** – Regina Bokel, Truus Hordijk, Martin Tempiriek
- **Design Informatics** – Paul de Ruyter, Serdar Asut, Hans Hoogeboom, Boris Bähre, Friso Gouwetor
- **Research and Methodology** – Erik van der Ham, Martin Tempiriek, Thaleia Konstantinou

Besides the ones mentioned above, there are others who provided important contributions, like Eric Schrijver with whom I did a Bucky Lab version at Haagse Hogeschool, Maarten Meijs who started helping me during the building weeks two years ago, Jaap Bosma the man behind woodworking.nl who helps during the instructions every now and then, and many others. They will certainly be featured in future books.

7.1

Who inspires you?

My personal heroes are the people who supported the course with great effort and enthusiasm, and quite a few I was fortunate enough to meet and become friends with over the last years. Without them, the Bucky Lab would not be the same, impossible or just not as much fun. Unfortunately, I cannot mention everybody who crossed my path, like the many industrial partners I was able to meet and work with, nor all of my students who joined the course or other activities we shared. Thanks to all of them! You made this course as special as it is. But I would love to mention a few persons who personally play a role in my life – either through their support, friendship or inspiration. So, here are my heroes:

Mick Eekhout

As the founder of the original course, Mick plays a very important role. He originally started a practical course in which the students learned how to make things; together with Pieter van Swieten he started the Delft Prototype Laboratory, which ultimately became the Bucky Lab. I have learned what worked and what did not from their work and was able to build on the strong pillars of their concept. My gratitude towards Mick is especially due to his openness and his way of letting me develop the course and myself – in short, I often refer to Mick as the best boss ever: he was never there – but I mean this in the best way possible, knowing he was always there watching me from afar.

Ulrich Knaack

For me personally, everything started almost 20 years ago with a telephone call from Ernst Thevis, my professor at the University of Applied Science in Detmold, asking whether I would like to work as a student assistant for Ulrich Knaack who was to become a guest professor at our school. Knaack, that's the glass researcher from Aachen, isn't he? Yes, that's him. OK, I am in! ... Our journey has filled many books and made for even more stories to tell. He was the reason I was able to discover that building things with students is actually academic work and can be a means to make a living, why I decided to start my PhD in Delft and moved to the Netherlands. We formed a company together with Tillmann Klein, and he is the one who keeps us all running. He became my close friend, my mentor. The ability to see my strengths and weaknesses and guide me through the obstacle's life puts in front of me has shaped me into the person I am. Receiving my doctoral degree from Ulrich was one thing – his honest outing of jalousie about the quality of my students' projects was the proudest moment in my professional life. I am motivated by Da Vinci's creed "Poor is the pupil who does not surpass his master", and I still look up to him!

Tillmann Klein

A close friend and former business partner, Tillmann is now also my new boss, leading the Chair of Building Product Innovation. From Tillmann, I learned how to detail a façade and to build a campus. (Literally, since we built the campus in Detmold together). He is meticulous, accurate and never stops thinking until he knows everything about the topic in question. Which might, on the other hand, be a reason why I have learned to make shortcuts every now and then in order to cope with my impatience. Tillmann also taught me to look at a detail from all 6 sides – in the classroom setting my students often have to learn by making mistakes but it is an invaluable quality if the craftsman on the building site can rely on the correctness and thoroughness of the information supplied.

Frans van Dijk

My first contact at Festool Netherlands, we share the love and passion for tools. As the head of training at Festool, he taught me how to explain the tools we work with on a daily basis. He is the guardian angel of our course, introducing and explaining our machines at the beginning of every building week. He oversees the maintenance of our tools together with his colleagues and is the best company for a BBQ or coffee with endless stories and memories to share about tools, cars, motorcycles or even airplanes; he is actually one of the few who operates the upside down hot air balloon from FESTO – look up FESTO Twins on the internet! Without him and the support of Festool, the Bucky Lab would not be possible.

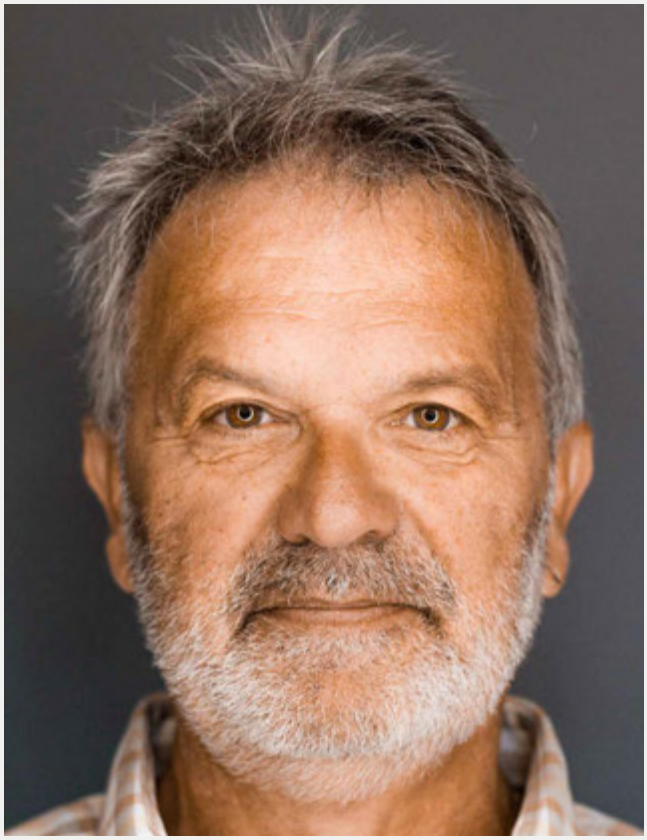
Aaron Bislip

Casper van der Meer

I was Casper's mentor during his graduation project at the Faculty of Industrial Design Engineering where he worked on the Wikkelhuis. We stayed in contact until he finally became a guest teacher at the Bucky Lab. His background in Industrial Design has shaped a lot of the things we currently teach in the course. I learned methods to design, evaluate and make decision within the design process. Both Casper and Laura Klauss, who jumps in if Casper isn't in town, share the love of making things with me, but they elevate their creations to a level that their company Better Future Factory improves our built environment. It seems as if they can build virtually anything and have solutions for the weirdest problems – I look up to them because they just do!

Johan Borgaart, Coen Kampinga and Aaron Bislip

My student assistants, named in the order of their appearance in the workshop. Johan already assisted with the course when I became involved, and I learned a lot how things were done as well as what could be improved upon. Coen got my attention on the very first day of his studies when he arrived with a Festool Systainer in hand, not carrying power tools but his sketch models. He became the mastermind of the workshop and did his magic with the tools and students. Aaron is the expert in 3D printing – he actually attracted my attention when I happened to meet him with a self-built 3D printer that was made to fit his locker to avoid having to carry the fragile machine back and forth between home and school. These student assistants plaid a vital role in our course; as student, they helped to judge problems from a student perspective but also pushed me to improve and make the course better.



Norbert Bilow

My father – one of my all-time heroes. He gifted me a toolbox when I was three years old and taught me how to make and fix things. "We don't have the money to buy cheap tools" was one of the things I learned from him, as well as how to hide the little mistakes you came across while making things. We always see something valuable in everything, we both share the aversion of throwing things away. From my father I learned that it is better to be independent by having the skills and means to do things yourself, but that it is just as much a pleasure to help friends and neighbors. He provided me with everything I needed to develop my skills and myself, and luckily stopped me before I could light the fuse of the improved version of my pipe bomb. Secretly smoking a cigarette with me and not telling mom – one of my weaknesses still, while he stopped years ago.

Jimmy Diresta

My YouTube hero who continuously learns by doing things while his camera rolls. I call myself a collector of skills; he certainly is that, too. I learned so much from his videos, tried to copy him and his fast-forward movies that allows you to follow hours of work in minutes. I listen to his podcast Making it on a weekly basis and soak up his knowledge and wisdom as much as I can. I met him in Great Britain during Makers Central as well as others of the makers community who I follow on their respective channels on a daily basis. He is a source of inspiration for me, for the skills, his collection of tools and the constant learning he does while building things.

Source: tested.com

Adam Savage

In his role as lead character of the MythBusters team, I came across Adam Savage when I moved to the Netherlands and watched the MythBusters series over and over. The show combining science and making is still fascinating, today. Later, he joined the team of Tested and started to share a lot more of his interests and obsessions. He shares my love for space and space suits but also his passion of making and educating. I have learned so much from him by following him online and via his podcast. I am jealous about his workshop and collections. I would love to meet him in person and wish we could have him as a special guest in the Bucky Lab to inspire our students and myself. From him I borrowed the phrase "failure is always an option" which originates from the MythBusters but became a mantra for our way of education – allowing and cherishing the ability to learn by making mistakes. If I had the power I would make him the honorary professor of the Bucky Lab!

Failure
is always
an option

10 THINGS YOU NEED...

safety glasses
in the summer tinted glasses will be the best

pencils
a fine and a big one, waterproof helps also

measuring tools
a 3m tape rule and a folding rule does the job

bucky lab shirt
not a must but show your passion and become part of the team ...

watch
we will start on time, so have one and look at it, better three hours too soon, than one minute too late. Don´t wear your rolex!

working pants
an old pair of jeans will do the job, but will reduce your agility and comfort and where do you put your pencils and measuring tools...?

safety shoes
a must in the workshop with steel cap and steel sole, without you are not allowed to enter the workshop. Get a comfortable one, you will need them later to enter any building site in your job !

thin work gloves
if you like to work with gloves for fine assembling jobs, if not your bare hands will do it also

ear protection
some ear plugs or a more comfortable ear muff will give you the silence

thick work gloves
for the hard work these are best and follow also the safety codes for a workshop

what you really need ● what you want ●

BUCKY LAB

...SAFETY FIRST !

Dr. Bucky Lab recommends to get proper stuff, you have to buy the cheap ones twice and good tools and protection makes the job easier and more comfortable !
And if you don´t like it, you won´t use it.

TU Delft

REAL #01

The Story of ~~Dr.~~ the Bucky Lab

Ulrich Knaack
Marcel Bilow
Tillmann Klein

REAL is a new series of publications that investigates technology and material development to provide architects and designers with concrete ideas for their designs.

This first edition of the new REAL series is based on an interview by Ulrich Knaack with Marcel Bilow, aka Dr. Bucky Lab. While the chapters run from past to future, from first steps to the big picture, the book is filled with small anecdotes that allow a look behind the scenes of the Bucky Lab.

In the Bucky Lab and the Bucky Lab Seminars the combination of architecture and building technology is brought to a higher level. Architecture students develop and build prototypes of their projects and do research on how to design innovative sustainable building solutions. The designs' materials and structural performance are both virtually and physically tested. The results are used as feedback to optimize the design.

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