SELF-FORMATION AND INNOVATION

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Accepted: September 27th, 2015

ABSTRACT
Contemporary architecture and product design is confronted with a rapidly increasing offer of new materials and technologies. At the same time a growing consciousness can be observed that some established solutions need a fundamental change in regard to sustainability. This paper discusses self-formation as a method for sustainable innovation on the basis of three projects that have been recently realized: *A cloud for fresh Snow* – a commissioned research lab to produce artificial snow, the production of kayaks and the art project *Baetsch in the City*.
A cloud for fresh snow is a collaborative project at the interface of engineering research, economic innovation and architectural design. As climate is about to change and average temperatures appear to increase most skiing areas invest a lot of money to artificially produce snow to guarantee winter tourism. Hence, the economy of skiing regions strongly dependents on the technology for snow making. As the current technology requires a lot of energy and water, fundamentally new approaches are investigated – as done by Michael Bacher, CEO of www.Neuschnee.co.at. In collaboration with Walter Klasz *a cloud for fresh snow* was developed - an invention, that not only produces perfect powder snow, but also presents a groundbreaking sustainable design. A self-formed lightweight construction provides space in which snowflakes can emerge, form and grow bigger. Compared to classical technologies only a reduced amount of energy is needed to provide the boundary conditions for the creation of a natural cloud, allowing the formation of real ice crystals (dendrites). The construction of the cloud itself is based on bended wood in a self-found equilibrium with minimal surface membranes. This self-found equilibrium, the self-formation process, can be used as a general design method, which is shown as well in the two other projects presented in this paper.

Keywords: Sustainable Design, Self-formation, Innovation.

THE LINKING ROLE OF ARCHITECTS IN INNOVATIVE PRODUCT DESIGN

Architecture is an integrative discipline. Architects are trained to discover relations in-between disciplines and therefore this profession gets more and more important in a contemporary increasing complex society. While natural and physical sciences tend to focus more on specific topics, architects can offer to contribute at the missing link between basic research and application. Bill Baker has said in the keynote lecture at the international conference for *Shell and Spatial Structures* in August 2015, "a sketch from an architect should be treated more like a question than a solution". May be a sketch is more likely an intuitive vision for a solution but not the solution itself. Such a sketch marks a vision, which can guide basic research and is able to lead a scientific multidisciplinary team to find integrated solutions. *A cloud for fresh snow* is one of three presented examples of how this principle is able to successfully support the development of solutions for complex and demanding challenges.

SELF-FORMED SNOW CRYSTALS IN A SELF-FORMED "CLOUD"

Together with an international team of researchers the snow scientist and entrepreneur Michael Bacher has developed a patented technology to produce artificial powder snow. At the moment his company *Neuschnee* is working on the commercialization of this innovative process. The invention is based on the observation that snowflakes form out of tiny water droplets without any additional catalyst when appropriate boundary conditions are provided. This observation of self-formation was the concept for the construction of a chamber where appropriate physical boundary conditions are provided - called "the cloud": the form is finding its inherent equilibrium of forces without external energy and with a minimum impact on the environment (Klasz

W.: *A Cloud for fresh Snow*). This minimal impact on the environment is the link to the historical photo in Figure 1 left hand side: Over centuries farmers lived in mountain regions in a self-found equilibrium. Such labor intensive life urged farmers to be open for changes. Tractors using diesel engines replaced horses and in course of time tourism partly replaced the hard work of farming. Farmers became – at least in the winter season - technicians for ski lifts or snowmaking facilities. Since the press conference in the Austrian skiing area Obergurgl on November 13th 2014, the fact of using huge amounts of energy and water for technical snow production is no longer an open secret. After the first Neuschnee Symposium organized in collaboration with Michael Bacher and Walter Klasz other interdisciplinary working groups are emerging. While snow researches continue to work for sustainable touristic solutions, Walter Klasz focuses on the phenomenon of self-formation as a method for sustainable design.

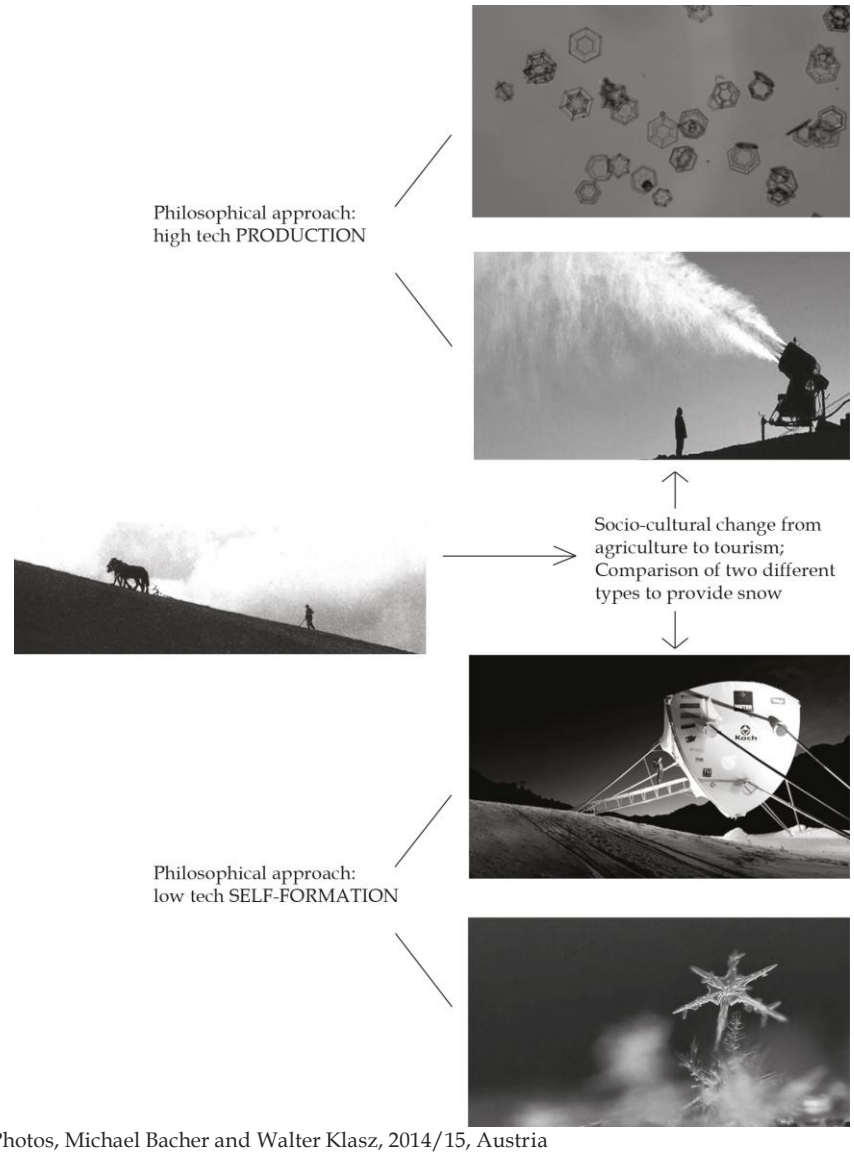

Fig. 1. Collage of Photos, Michael Bacher and Walter Klasz, 2014/15, Austria
Left: Historical Photo of a Farmer in an alpine Region (Private Archive Klasz)
Right: Snow-plates and a classical Snow-gun, Research Lab *A cloud for fresh Snow* and a Snowflake

Figure 2 describes the simplified concept of the self-formed construction of the cloud. The space of 150 m³ can be assembled only by hand, although for the first research lab a snow groomer helped out – especially to set up the technical core. An important point during the assembly is that the four cables, connecting each corner of the core with the pre-bended wooden frame, are not tightened too strong in order to easily fix the minimal surface membranes by hand. After having tightened those cables to the final position, the cables can theoretically be removed because in the final configuration there are only longitudinal forces in the wooden members as shown on the abstract model in scale 1:10. Summarizing, it is proved that self-formation simplifies assembly and reduces the amount of material to the very minimum possible. The wooden members have a cross section of only 24 to 4 cm with a length of 7.5 m. Nevertheless the construction was strong enough to resist wind forces of about 120 km/h observed during the six-month test-period in winter season 2014/15 in Obergurgl.

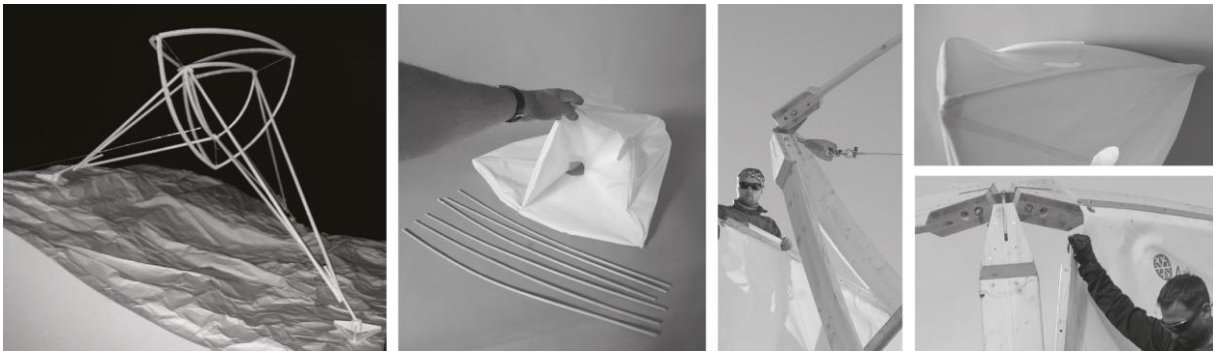

Fig. 2. Collage by Walter Klasz: Photo of the Concept-Model in Scale 1:50, Abstract Model in Scale 1:10 and Photos of the full Scale Research Lab *A Cloud for fresh Snow* during the Assembly by Hand

FROM THE HIGH TECH SNOW PRINTER TO THE "SELF-FORMED" *SNOW-CLOUD_m*

At the first Neuschnee-Symposium on the 13th of November 2014 at the University Center Obergurgl Klasz and his team presented the concept of a snow-printer. This first concept together with its name was influenced by the 3d-printers, which are more and more used in contemporary product design. But as the snow-flakes are not printed but self-formed, the name changed to *snow-cloud_m*. The "m" is an abbreviation for "moving". The cloud, in which the snowflakes emerge moves slowly along the ski slope and leaves a trace of powder snow. 4 m^3 water can be stored in the tubular aluminium-beam, which connects the two traction wheels. While in the first concept the form was influenced by the philosophy of 3d-printing, the new concept *cloud_m* presents an adaptable solution with a stretchable membrane as shown in the photos of Figure 3. Compared to todays´ conventional concepts the rendering indicates a far different approach to equip skiing areas with technical snow. The manager of such a new sustainable region would be able to provide secure areas for winter sports: perfectly shaped skiing slopes or just the pure powder snow. Instead of investing in ski-lifts or cable cars, *snow-cloud_m* is slowly running downhill providing fresh snow. Ski-huts offer local food and tourists enjoy the beauty of nature by walking uphill and skiing down the fresh snow: A perfect, but completely different picture from a future winter sport destination than it is known right now. A certain percentage of the energy to self-drive the *snow-cloud_m* is provided by recently developed photovoltaic foils by the Tyrolean company *sunplugged.* These foils are applied on the surface of the vehicle and are charging energy while daylight is available.

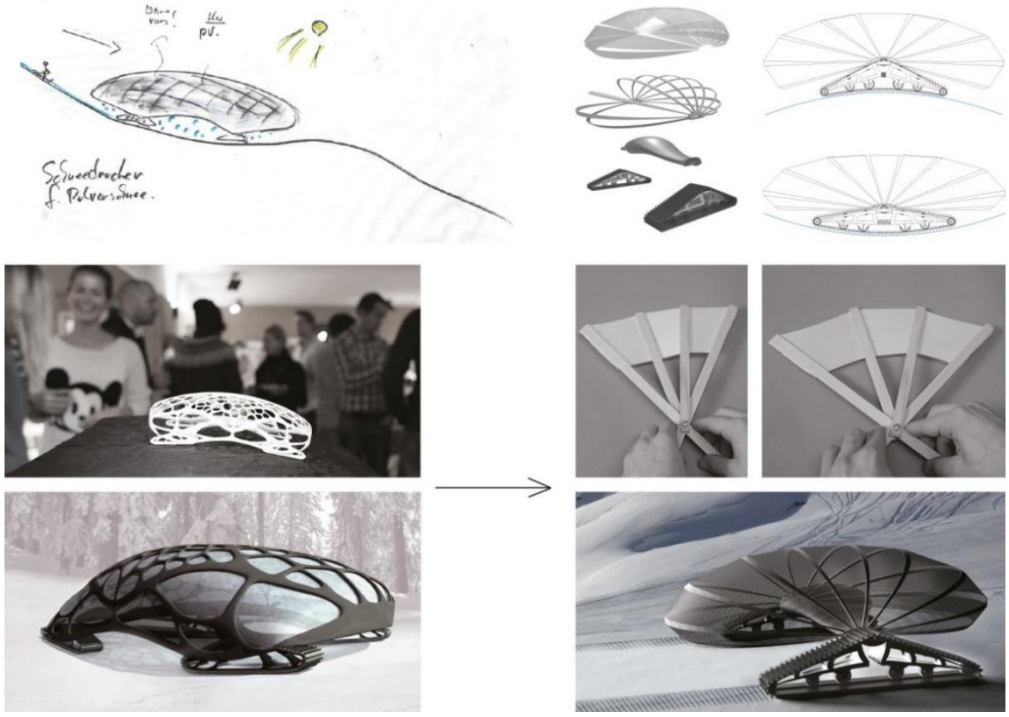

Fig. 3. Collage, Photos and Renderings by the unit koge, Innsbruck
Left: *Snow-printer* presented at the Neuschnee-Symposium 2014, W. Klasz + F. Spindler, L. Schulz
Photo top left: Conceptual Sketch by W. Klasz
Right: *Snow-Cloud_m*, Optimization by the Method of Self-formation, W. Klasz + R. Grimm, Lorenz Locher

The vision of sustainable winter tourism probably appears unrealistic. However, having in mind the increasing community of LOHAS (Lifestyle of Health and Sustainability), it could become an absolute realistic future scenario. Those people are of middle or even high income and they are willing to pay for a parking place or public transport to the region and for security to go for back-country skiing. They will pay for high quality services at a mountain hut. At the moment there are just no attractive spots available to completely satisfy this demand. In this context the word "self-formation" can be considered in a wider, more diversified, sense. There is a certain need on the market, but there are no specific and coordinated professional offers. The public funded *Standortagentur Tirol* is promoting sustainable developments. Michael Bacher will present at the second *Schnee-Symposium* in October 2015 in Mayerhofen the emerging Snow-Competence-Center. The ongoing discussions make it obvious that the topic "snow" touches many disciplines from technical sciences to architecture, marketing and sociology. As explained in the first chapter, one of the core competences of architects is inter-connected thinking and design. The method of self-formation in a wider (not just technical) sense will help to cross link all kind of disciplines, providing boundary conditions to allow new integrated regional concepts for touristic regions to emerge. The *snow-cloud_m* is not just a product, it reflects a changing philosophy of sustainable winter tourism.

THE HIGH TECH "BACKYAK" AND THE SELF-FORMED KAYAK

To underline the thesis that self-formation is a method for sustainable design the second topic of this contribution – kayaks – compares two recent innovations. The *Backyak*– already developed to the stage of successful prototyping – and a self-formed boat in the stage of a concept. Both of these projects are developed by Walter Klasz as head designer and in both projects Michal Bacher – being an expert in kayaking - is involved as test-driver and critical reviewer. The first models for the project *Backyak* were done in the inspiring atmosphere of the Institute of Architecture and Product Design at the Technical University Munich. Being a research Assistant of Univ. Prof. Richard Horden, Walter Klasz initiated and organized a commissioned research work with the well-known company Klepper in Rosenheim, a manufacturer of traditional folding kayaks. After the first phase of designing, Walter Klasz worked on prototyping for three years. After the presentation of *prototype 001* at a press conference in Rosenheim and *prototype 002* at the international fair *f.re.e.*, *prototype 003* was exhibited at the world first carbon exhibition in the Dornier Museum in Friedrichshafen in 2014 next to products from companies like Red Bull (Formula One), Ducati and others (see figure 4 right side).

Fig. 4. Collage about the multifunctional Boat *Backyak*
From left to right: Press Conference Rosenheim, *Backyak* in use, Exhibition in the Dornier-Museum Friedrichshafen 2014

Like for the topic snow, the following collage (Figure 5) enhances the sociocultural change in boat production. Handcrafted products are about to become too expensive in high-developed countries, so many companies are forced to outsource to low-wage countries. Instead of outsourcing a production line, these companies could also consider two alternative strategies, which probably could positively interact with each other. To sharpen the two different approaches, this paper stresses the differences of both strategies.
Backyak represents the first strategy: This involves investing in new materials and technologies of minimized handicraft but high constructional efficiency. As the multifunctional demands for *Backyak* are high – according to the wishes of the contractor the "boat" can be also used as a sledge in winter (see figure 5, top left) – contemporary techniques like thermoplastic solutions do not fit the required properties of minimal weight and strength. Therefore it was planned to build the product out of a 4 mm carbon-sandwich material. The decision to use a sandwich is based on the goal to achieve a reduction of weight and at the same time to meet the required strength for the boat. When it was about to find a company able to build such a free formed boat, there was no one around in southern Germany willing or able to start the development. Only a small, but highly innovative company in Berlin offered collaboration and worked hard on the realization of the prototype. In the meantime many global and powerful companies like BMW also focused in this rising trend and started intensive R&D activities to explore the potential of this new material. As a result, the price of carbon fiber did rise up and the producer of *Backyak* was fighting with the economic efficiency of a serial production. Other more ecological approaches like using hemp instead of carbon fiber do not yet reach the desired qualities. So for the *Backyak* new materials will be tested as well as an optimized serial production is in development. It is therefore obvious that customers need some more patience until *Backyak* is available on the world market.

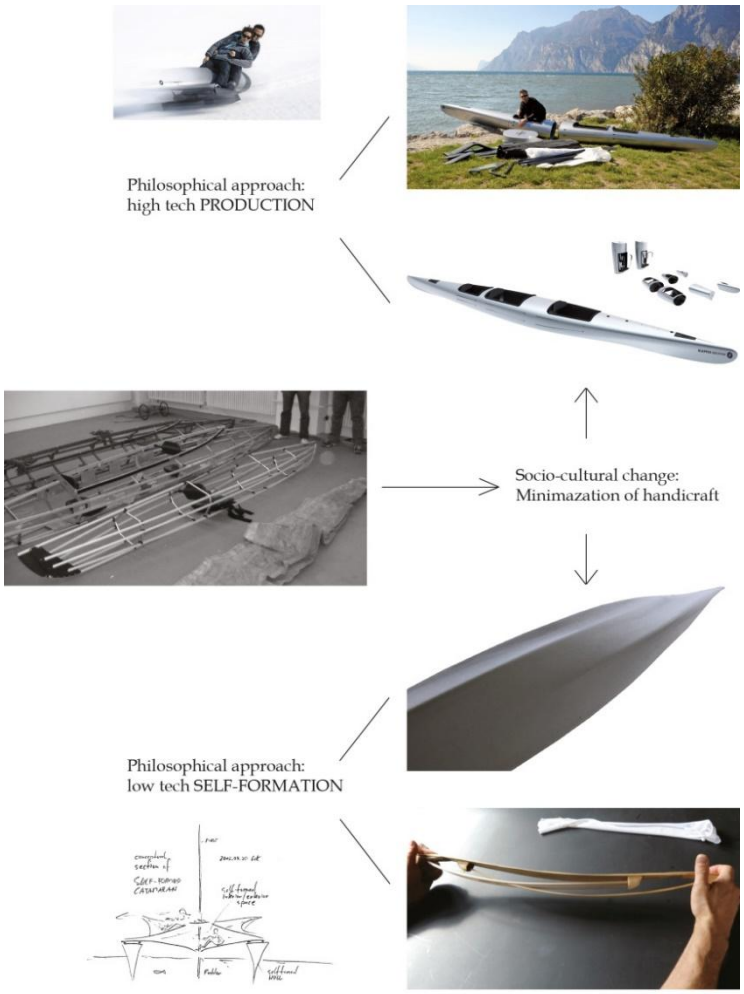

Fig. 5. Collage of Photos by Walter Klasz
Left: Foldable boats from the company Klepper in Wood (from 1908, 2008 - partly CNC cut) and out of Aluminium (2008)
Right at top: Photos by W. Klasz testing Prototypes of *Backyak*
Right below: Photos of the Concept-Model of the self-formed Boat in Scale 1:6 by W. Klasz

The second strategy to minimize handicraft in the production of kayaks is self-formation. Figure 5 shows the abstracted concept model for a self-stressed membrane hull and a sketch for a self-formed catamaran. The hulls consists of revers bended wooden bows – similar to a classical violin bow (Figure 6). This bow is appropriate to pre-stress a membrane (the hull) without relevant material fatigue of the bow. This static self-stressing and self-interlocking phenomenon of the violin bow is presented by Klasz at the international conference *Structural Membranes 2015* in October in Barcelona (Klasz W. 2015, Barcelona). The concept model of the boat combines the phenomenon of "compressed wooden members" in minimal surface configurations (see Klasz W.: *A Cloud for fresh Snow*) with the phenomenon of the violin bow (see above). The main potential of this concept is the simplified assembly, the low-cost production of the components and the durability, as material fatigue plays no relevant role in such a hybrid configuration. To optimize the holistic sustainability of this invention, ecological materials for the tensile hull will be used. First kayaks consisting of a wooden frame structure and a skin have been produced and used by the Inuits since many centuries by employing sealskin for the hull (FRIEBL J.; *Kayak-Selbstbau; page 3)*.
In our research project not only the boat hull is designed by the method of self-formation. For the concept of the catamaran (see sketch in figure 5), the construction for the interior and exterior space is self-formed in a hybrid configuration of bended wood and minimal surface membranes, simultaneously providing a firm connection between both hulls, including the fixing for the mast and the blade. Even the rudder blade (see Figure 6) is designed based on a self-formation process: an active bending composite solution is in ongoing development. Pulling one side causes a self-forming process of the composite to a curved configuration, allowing the streamlines of the water being smoothly deflected along the boat hull to the very end of the rudder without any sharp deflection angle as one usually can observe. The goal is not to reinvent a boat, but to use it as a research vehicle to deepen the knowledge about self-forming processes.

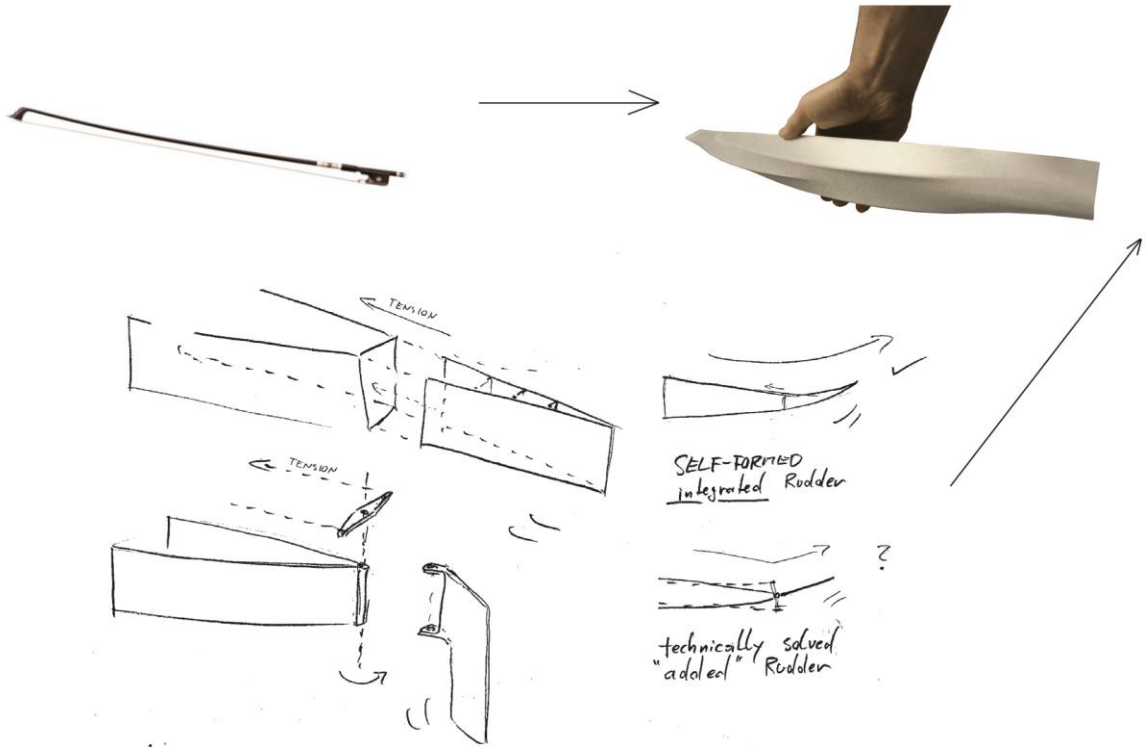

Fig. 6. Collage of the self-formed Boat Concept including a Sketch for an active forming Composite-Rudder; W. Klasz.
The concept for bending Wood is related to the Developments by Festo: Fin Ray Effect, EvoLogics GmbH

THE INTERPERSONAL ASPECT OF SELF-FORMATION IN A DESIGN TEAM

The EU funded art project *Baetsch in the city* proves the efficiency of a self-forming process regarding the interpersonal aspect. In the case of the *Baetsch* the international artists have provided only the boundary conditions for a self-forming social, but also structural process at the *Nietzscheplatz* in Vienna as described in the art-magazine sculpture (WOODRUFFE P., *Washington 2013)*. With the help of *SOHO inOttakting* the residents of the multicultural area of the city Vienna were invited to bring their unused materials to contribute to a hut to be built at the site. The main important result of this artistic research was that all participants perceived themselves being part of the design. This self-formed publicly usable urban sculpture provided a high level of identification. In terms of sustainability the temporary building consists only of unused material which would have been ended at the rubbish dump before.

For a successful interpersonal culture to develop within a design team working with a self-formation design methodology, it is crucial that the ability of the individual team members abandon the notion of ownership they may feel and they have over the project, and instead develop a sense of trust towards the abilities of the other team members. Another important factor is obtaining a complimentary range of skills, knowledge and culture within the team. In the case of the *Baetsch* project (Figure 7) there were representatives from both Europe and the South Pacific. This diverse group brought experience in architecture, interior design, fine arts and landscape architecture. The diversity of this combination created a dynamic mix of approaches to problem solving and creative expression, which was assisted by sharing food and drinks. It led to an evolution of a highly interactive and social team culture. Self-formation was facilitated by the exclusive use of limited materials available to influence or determine the design outcome, as no drawings or diagrams were made in advance of the construction except the conceptual sketch (see Figure 7). It was this absence of preparatory drawings and the limiting of the available materials that drove the necessity of developing a highly interpersonal design construction process, one that produced a very successful example of self-formation, while also achieving a high degree of functionality and aesthetic quality. The surprising result – the built hut and the changed perception of the public place - was appreciated by local authorities as well as by residents and visitors.

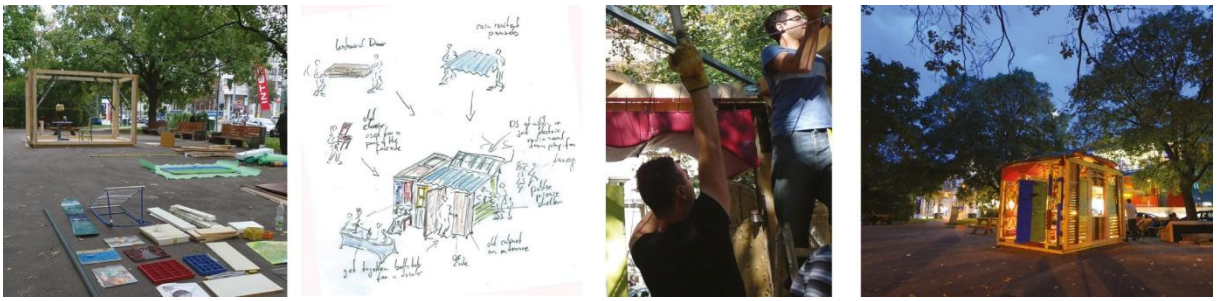

Fig. 7. *Baetsch in the City*, Vienna 2012, Collage about the Self-Formation-Process of the public Art-Project (EU-Competition) P. Woodruffe, W. Klasz, V. Kotradyova; Photos Vojtéch Vlk

Fig. 8. *A cloud for fresh Snow*, Obergurgl 2014, Collage enhancing the Inspiration for the self-formed Structure of the Research Lab. Photos: W. Klasz, Michael Bacher; Sketch for the responsive self-formed Structure by W. Klasz

Relating to the described research lab at the beginning of this paper, Michael Bacher and Walter Klasz developed the design for the *Cloud for fresh Snow* as well in an interpersonal self-formation process. This development was supported by consultants like the German engineer Switbert Greiner, representatives of the construction companies like Sebastian Koch from the membrane company *Koch Membranen* and by students from the *unit koge* at the University of Innsbruck. As described earlier, the concept for the "cloud" was found by understanding the inherent order of a snowflake (Figure 8). The material – in this case frozen water – finds its inherent equilibrium depending on the climatic boundary conditions in one unique form. The straight wooden beams of the *Cloud for fresh Snow* find their form in the equilibrium of forces with the minimal surface membranes. All the other details like the technical core or the decomposed tripod to lift the structure off the ground have been integrated in one design. The largely self-organized international press review on the realized research lab in print and TV-media reflects, aside from the general public interest for the topic snow, the success of this self-formed design in the sense of accordance of the self-formed structure and its content – the emerging self-formed snowflakes.

CONCLUSION AND PERSPECTIVES

Our contribution describes that high tech production and self-formation are not necessarily competing concepts, but can complement each other. The evaluation of choosing the appropriate method must be done individually, taking into account sustainability - such as preferring local materials, reduction of energy for the production, assembling, socio-cultural issues, and live time. In this context self-formation opens new perspectives for sustainable innovations. Summarizing, this paper emphasizes the benefits of self-formation to develop sustainable products. The described conceptual and realized projects prove the potential of this approach in a qualitative way. Limits and freedom of self-found equilibrium, in self-stressing and statically self-interlocking structures, consisting of bended wood and membranes, are about to be investigated in our ongoing research. Our goal is to develop abstract physical and digital models in order to provide a general method for self-formation as a tool for sustainable design. In a wider sense, self-formation implicates an inter-personal aspect for team collaboration. A self-found equilibrium in a non-hierarchical team-organization and the consciousness of completing each other has the potential to save energy and resources in the design process itself.

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