TAMBAS-CHAR

THOUGHT UPON ACTION

BA-PROJECT
DOCUMENTATION
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Interaction Design | ZHdK | June, 2017

THERE ARE PROBLEMS OF A KIND
YOU COULD EASY SOLVE BY MIND.
OTHERS THOUGH TO UNDERSTAND,
YOU WILL HAVE TO TAKE IN HAND.

Hold them, bend them, flip and combine them,
Fold and extend them, kick or refine them!

DIVE IN AND DO – BUT PAY ATTENTION:
THE WORLD AROUND YOU HAS INTENTION.

Angle, rotate, observe and check them,
Untangle, mutate, reverse or wreck them!

THINK BY HAND AND FIND YOU'LL FIND OUT
WHAT THE PROBLEM IS ABOUT.
BUT WHAT THINGS ARE AND WHAT THEY DO,
FIRST OF ALL DEPENDS ON

INDEX

“SELBERMACHENLASSEN”

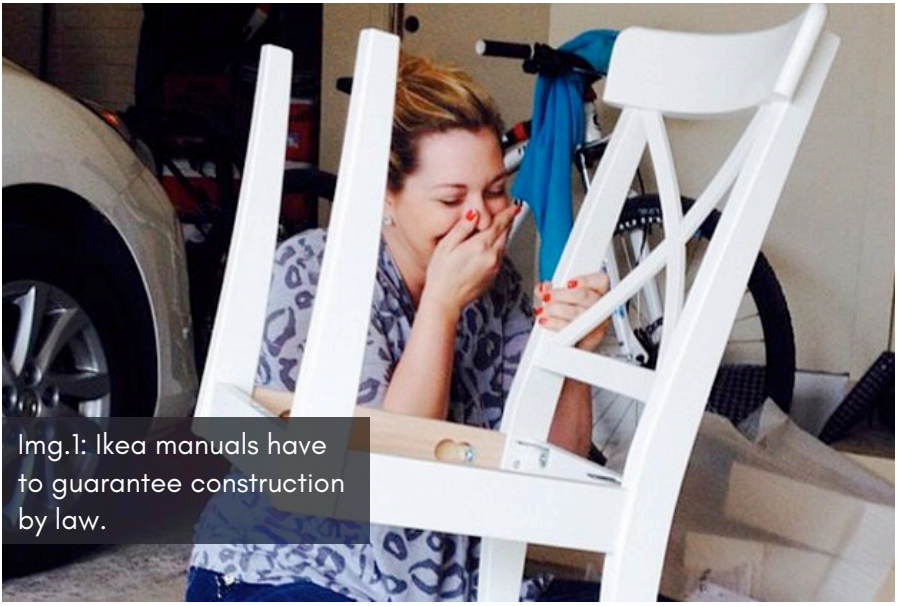
THEY KNOW WHAT THEY DO

This project is based on a thesis with the title “Selbermachenlassen - denn sie wissen was sie tun“ (enlg.: “Leave to self-making - they know what they do“). The thoughts behind were initiated by my own furious yet pleasurable creation process of a toilet roll holder in summer 2016. An experience that led me to question if I could create designs that contained such action and satisfaction of self-making things and sense.

My thesis explored principles of designs that engage people in such way that a financial or/and emotional benefit is generated from their own making processes. I discussed three ways this is achieved in a broad field of designs: Whilst IKEA creates economical profit in the customers construction labour, technical and social developments led to an ongoing boom of a passionate maker movement. Further, products like Lego have not even a result of particular use - except the joy self-making things within a system that gives the opportunity to do so. I assume there is more than just financial value created in self-making: The precious core is peoples personal expression and experience of their own action.

In summary my consideration of principles revealed the idea of designing “absolute” self-making as paradox: If a design lets you do something, it is not your own but the designers determination.

The object it all started with.



Img.1: Ikea manuals have to guarantee construction by law.

"The Toaster Knife" Youtube star, Colin Furze lives from passion and talent in self-making.

Nonetheless I considered two ways of approaching values of self making as a designer:

- One is finding the right balance of "undesigned freedom" that allows (and requires!) self-making and "predesigned certainty" that leads to desirable results.

- Another approach is questioning the idea of the user as a "given limitation" to creating desirable results. It is considering peoples perception and ability as something that can be changed through the experience of interactions we design. A way to initiate independent self-making I depict as an immersive, self-driven experience of learning: A moment no one tells you (what) to do or learn - you create your own task and get better at whatever you decide to do. Improving skills becomes part of the fun and often shifts the target you originally aimed for. Such self driven learning processes could lead to independent yet desirable creation which the designer of the experience did not intend himself.

In assumption on this statement a perspective on patterns of evolutionary learning processes was given: An outstanding principle of creation without any designer behind. Could we use these principles in the design of self-making? Their application in machine learning could be seen as digital analogy of independent learning processes; likewise the outcomes could be as unexpected as when we let people do things all by themselves.

Img. 1: Unknown potographer, "Ikea Fail", 01. 04. 2016, published by S. A. Harris, (16. 12. 2017). http://www.express.co.uk/news/weird/468059/Attempts-to-assemble-flat-pack-furniture-result-in-DIY-disaster-in-IKEA-fail-photos.

Img. 2: Colin Furze, "Toaster Knive", 07. 06. 2015, published by T. Tamblyn, (02. 01. 2017). http://i.huffpost.com/gen/3035994/images/o-KNIFE-facebook.jpg

FROM THEORY TO PRACTICE

SPAGHE-TOILETTY

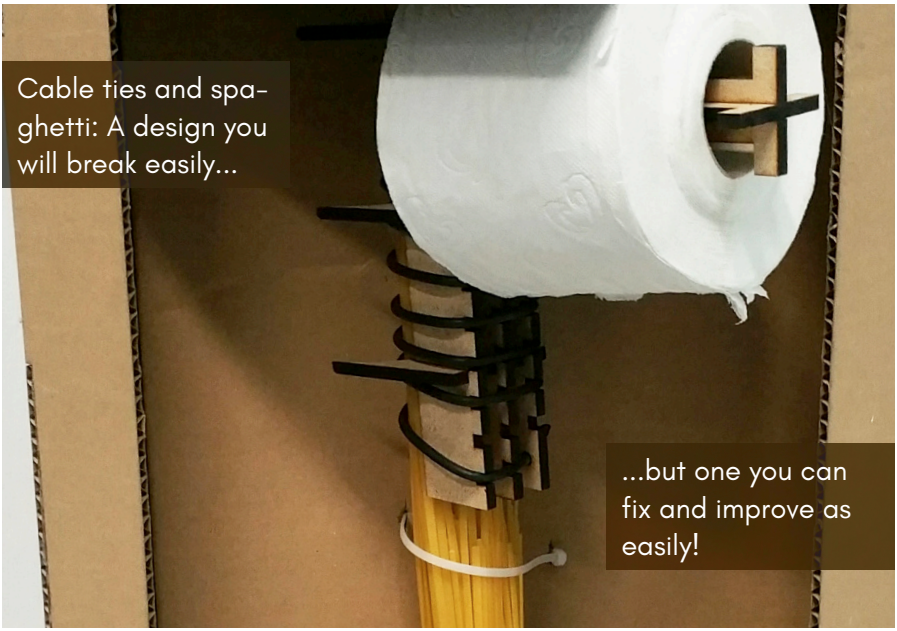
Before I dived into the actual research I tried to express the basic idea of my thesis in a speculative object.

I created a toilet roll holder that raised expectation but inevitably broke when unwrapped from its pesky packaging. The broken construction left the user in frustration and revealed a note inside: "Great! ...you just broke it. Now shame or shine!", with a short repair manual. The construction allowed replacement of the broken spaghetti-construction with almost anything that has a elongate shape: A branch of a tree, a pastry rolling pin, a candle - whatever the user finds and constructs himself.

The result was a product the user had created (or at least repaired) himself to make up for the useless "Spaghetti-Design". The upcoming trouble of breaking motivated and enforced the experience of independent problem solving. The self created solution reflected the personal achievement in the individual look and restored function of the object.

I presented this design of experience in the recently popular format of "unpacking shows" which present all kinds of promising products on digital media platforms.

More promises on the package than it can hold.



Cable ties and spaghetti: A design you will break easily...

...but one you can fix and improve as easily!

“I PROPOSE...”

A SYSTEM TO EXPERIENCE

I positioned this project within a certain problem space of the thesis I wrote: I planed to focus on the quintessence of experience designs that induce self-made creation through independent learning processes.

At the core I wanted to let people experience moments of personal joy in their own imersive course of action - get them into a flow of thinking by doing.
Unaffected, self-making of sense required something that had no predetermined form or purpose yet. Something “blank“ with a versatile potential to make sense and use of. So I proposed to design an open building system that conformed to a defined set of requirements regarding the possibilities and experience of interaction.

Slides from the presentation of my first project proposal.

A SEED...

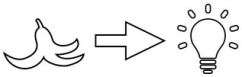
...that grows in unexpected ways

...has simple rules 

...allows big complexity 

... involves kinetic principles 

...balances freedom and certainty 

...provokes mistakes to learn from 

...gives a certain direction but uncertain journeys

THE AUDIENCE SHOULD...

...have fun and learn to playfully create their own solutions

...not be afraid of doing things wrong

...produce unexpected results

...optimize but not to perfect creations

...discover and enhance their skill and motivation of doing things themselves

Setting the aim as clearly as possible.

MY PROJECT SHOULD...

...evolve into a fully functional prototype

...not rely on a manual or explanation

...fulfill both, the BA-requirements...

....and Jon's personal passion!

GUIDELINES TO TAKE OFF

Setting such straight requirements at the beginning might seem like a narrow way to go. I did this consciously: They allows me to follow my personal course of lateral thinking and intuitive action without loosing track too much. My own strategy to compensate for the inevitable chaos that drives many creative processes.

WHAT IS OUT THERE?

WIDTH & DEPTH OF FIELD

Through the broad view of my thesis I looked into a wide spectrum of fields to find inspiration and knowledge. The following chapter covers four areas of interest containing element that I wanted to adapt.

PLAYFUL BUILDING SYSTEMS

Researching on playful building systems I found a large variety of mechanisms and principles existing. Even though I proposed to create a building system, there is a key element I wanted to question in existing products:

- Often the learning of what and how to build is achieved through a manual or a given purpose. I think this reduces chances of unexpected, personal or even new creations to occur.

- Conventional building elements (like Lego or K'nex) are meant to be combined as easily and various as possible: You could build anything with them! But would you...?

I wanted to explore if I can design constraints that motivate learning and creation more than manuals or completely open possibilities would.

Img. 4: Photographer unknown, "Activité Kapla à l'ARWSL" (18.03.17). http://www.arwsl.be/portfolio/activites-kapla-a-larwsl/#.
Img. 5: Sikkema, Kelly, "Lego World", (07. 05. 2016). https://unsplash.com/photos/JRVxgAkzlsM.

Img. 3: “The simpler the bricks, the harder the tricks” to build with them.

Img. 5: Lego requires kids to make up their own sense and task to complete. Too difficult for most adults.

PUZZLES

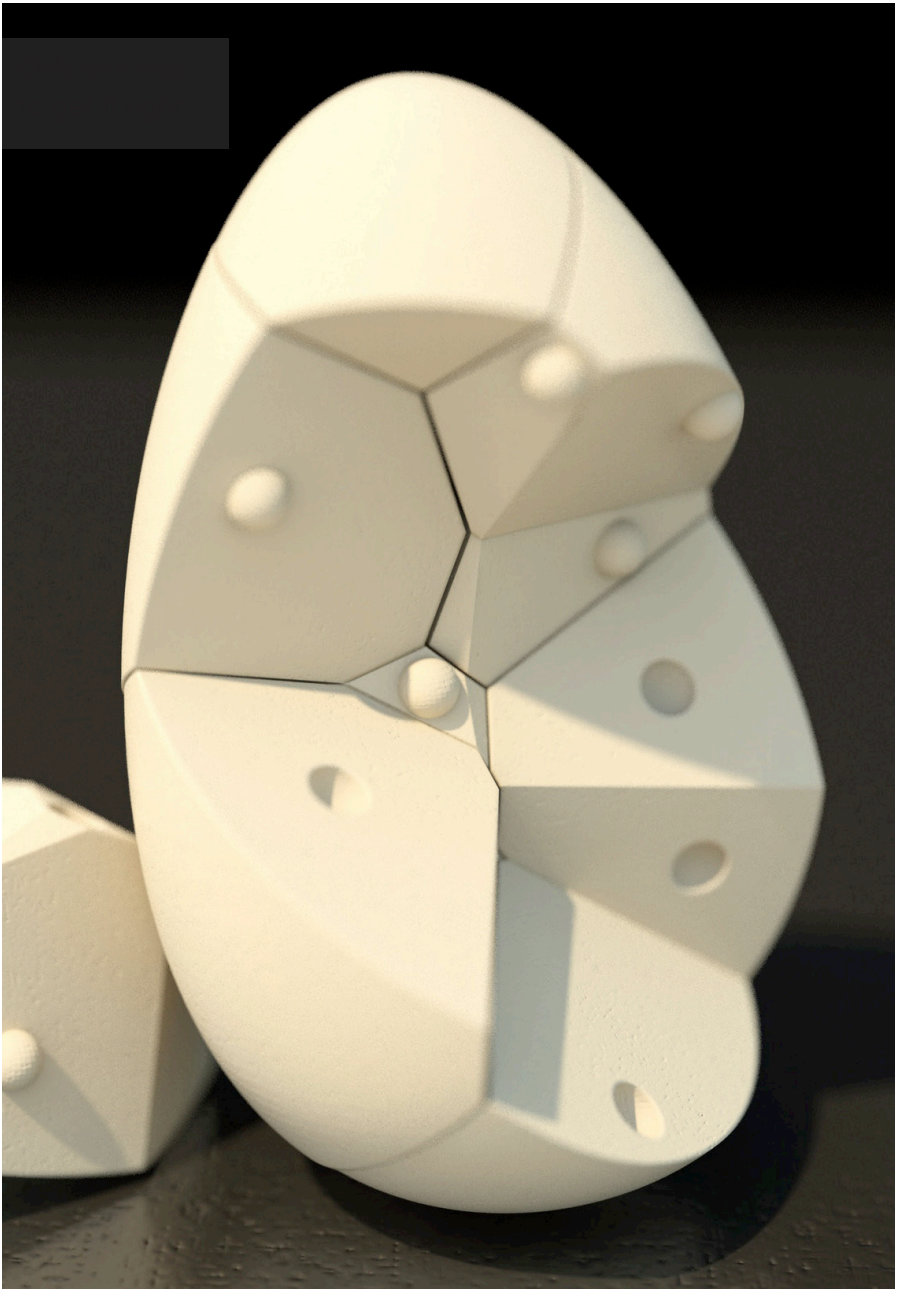
Puzzles invite to play, to learn by doing and self-making solutions. Despite those qualities, I evaluated three common elements in the concept of puzzles that I want to challenge with my project:

- Many puzzles have only one correct solution. My project should have as numerous and various "meaningful" outcomes as possible. Can I create a perception of "right" that takes personal opinion into account?

- Puzzles are defined as puzzles and do not raise curiosity in meaning or function. Thus puzzles do require interpretation and independent sense-making. I want to create something as meaningless as possible.

- They require patience and curiosity: Puzzles are only appealing to people who enjoy the kind of experience. I want to create already. How can I engage those people with less imagination and ambition?

Img. 5: Bifi, Andrea, "3d-printed puzzle", (03. 01. 2016). http-//www.instructables.com/id/3d-printed-puzzle/.



PATTERNS OF EVOLUTION

As stated in my thesis, I considered principles of evolutionary learning processes a possible way of independent learning (and individual making in consequence). I looked into different studies towards digital evolution simulation because they include certain elements I want to involve in my design too:

- Independent creation throught learning without a designers influence.
- Various solutions for a shifting definition of the problem.
- Temporarely and individually "satisficing" results (Thesis pg. 22) instead of perfect solutions.

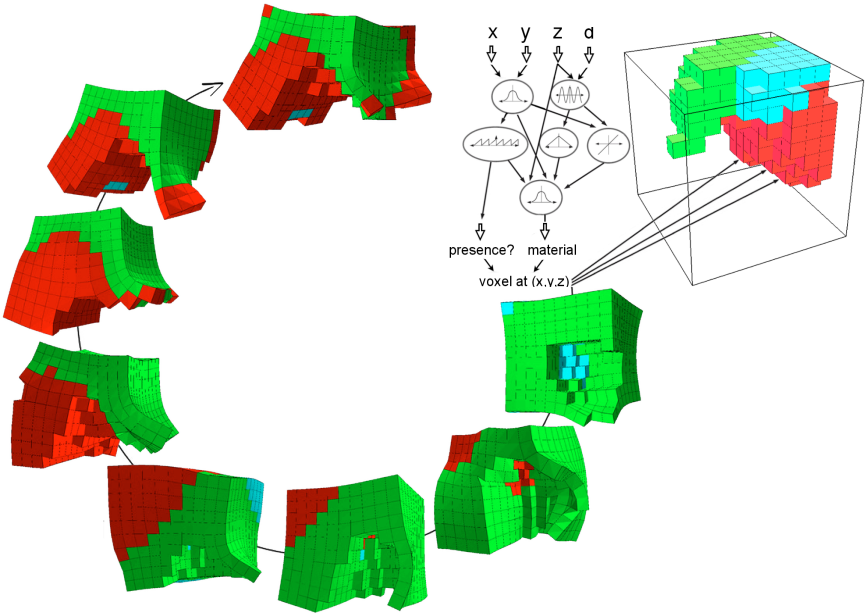
In comparison to real evolution in digital simulation can fast forward the time factor, resources never run out and physical conditions can be changed with a mouse click. This makes things less realistic but easier.

Most relevant sources:
"Evolved Virtual Creatures" by Carls Sims (1994). An early simulation of evolving creatures competing. The experiments and articles by Karl Sims showed potential of the idea long ago.

"Unshackling evolution: evolving soft robots with multiple materials and a powerful generative encoding" by Cheney N. et al. at the creative machines lab (detailed references in bibligraphy).

Img. 7: Cheney Nick, "Soft Robot Evolution", (15. 01. 2016). http://www.creativemachineslab.com/soft-robot-evolution.html.

Img 8: Sims Karl, "EvolvingVirtual Creatures", published by Silver R., (10. 01. 2016). http://www.tgdaily.com/web/134541-is-aggression-crucial-for-the-evolution-of-intelligence-and-is-skynet-inevitable.



Img. 7: Karl Sims "Evolving Virtual Creatures" competing for a green box.

SELF-ASSEMBLING SYSTEMS

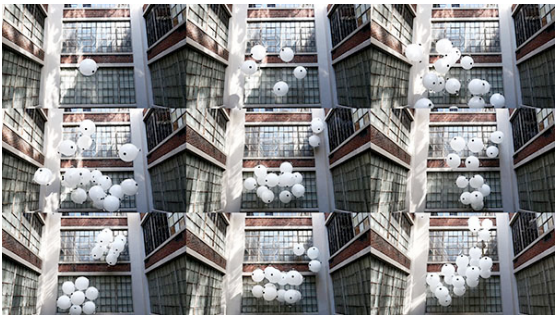
Bricks of a building systems can not only be used as passive, raw material. They can also contain knowledge and function that reveals in or through the assembly. Depending on the properties of single compartments, specific patterns and rules of assembly evolve when certain dynamics of randomness are induced.

Most relevant sources:
A leading institution researching this field is the Self-Assembly Lab at the Massachusetts Institute of Technology. Their studies cover many techniques of designing an objects intention and potential use of this. Especially the projects “Aerial Assemblies”, “Autonomous Mass Assembly” were very inspiring for my own experiments on self assembling systems (detailed references in bibliography).

Img. 9: Tibbits, Skylar, et al., “Aerial Assembly”. (08. 02. 2017). http://www.selfassembly-lab.net/AerialAssemblies.php.

Img. 10: Tibbits, Skylar, “Fluid Assembly Furniture“, (08. 02. 2017). http://www.selfassem-blylab.net/FluidAssemblyFurniture.php.

Img. 11: Tibbits Skylar, Olson, Arthur and Autodesk inc., “Autonomous Mass-Assembly”, (09. 02. 17). http://www.selfassemblylab.net/AutonomousMassAssembly.php



Img. 9: “Aerial Assemblies” at the Self-Assembly Lab: Let the wind do the assembly.

Img. 10: “Fluid assembly Furniture” by S. Tibbits: A process of 7 hours.

Img. 11: “Autonomous Mass-Assembly” used on large models of bacteria.

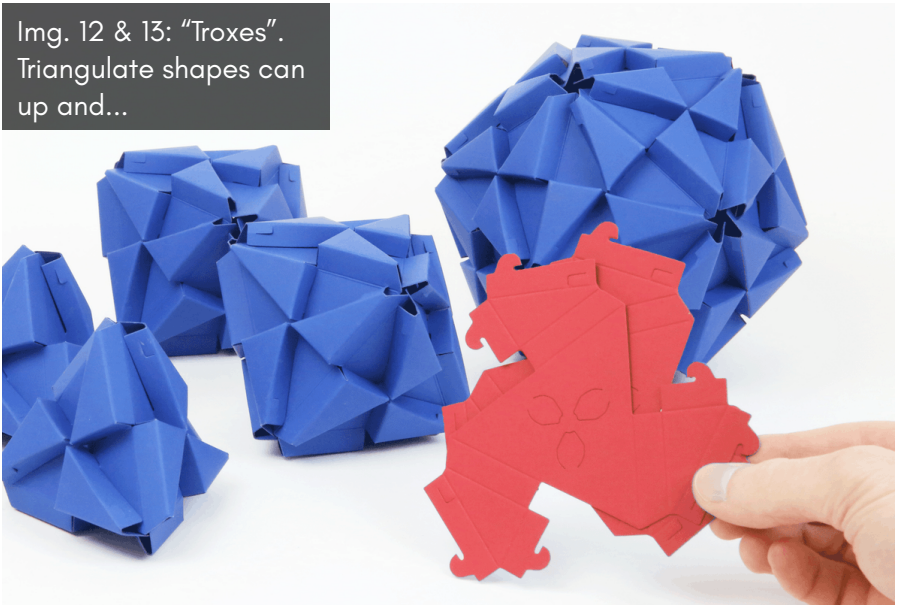
RETROSPECTIVE RESEARCH

Meanwhile I was working on this project, Jonathan Bobrow of the MIT media lab developed a project that turned out remarkably similar to mine: A foldable system, based on tetrahedrons to ingnite creative ways of thinking, doing and learning (sorry for the spoiler). Unfortunately I only noticed his work in hindsight since he published and kickstarted "Troxes" just three weeks before I finalized my own project. Nonetheless, even at this stage his project was quite important to me: It backed up the topics relevance and many decisions I made in my own design process.

But still, like most playful building systems mentioned so far, "Troxes" is aiming for maximal compatibility: Every brick fits any other in all directions. As I assered on the course of this project, this might be not enough "necessity to be the mother of invention".

Img. 12, 13: Bobrow, Jonathan, "Troxes", (19. 05. 2017). https://www.kickstarter.com/projects/1059262388/troxes-origami-building-blocks?lang=de

Img. 12 & 13: “Troxes”. Triangulate shapes can up and...



... assemble in un-expected ways and without limits.

THE EXPERIENCE

PLAY LIKE CHILDREN?

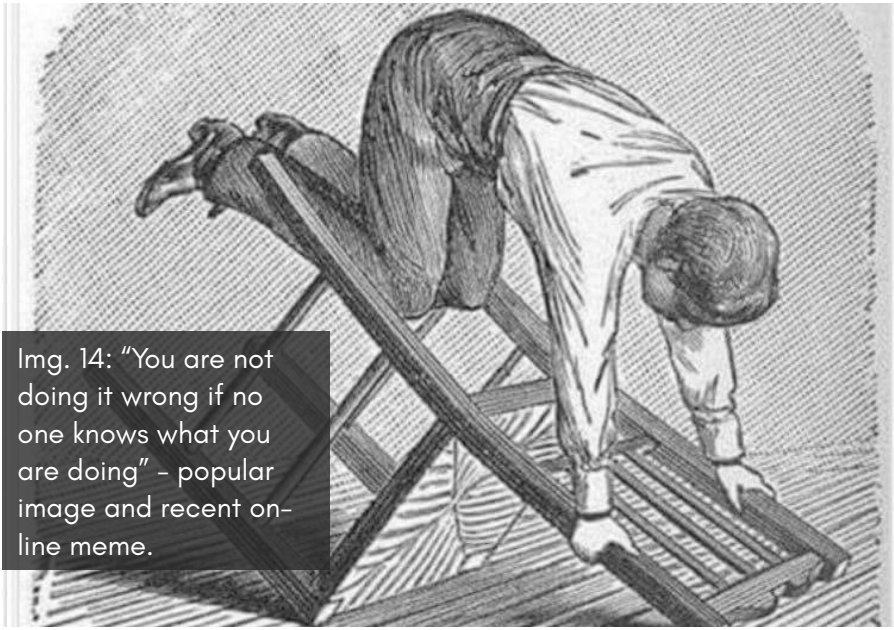
Researching and rethinking the plans proposed at the beginning I started to consolidate a more detailed vision to describe as the experience I wanted to design.
In fact many elements that seemed important to me, where typical to the sprigthly and irrespective behaviour of children discovering the world in play.

"(Re)experience the way in which you once learned" I postulated in the intermediate presentation:

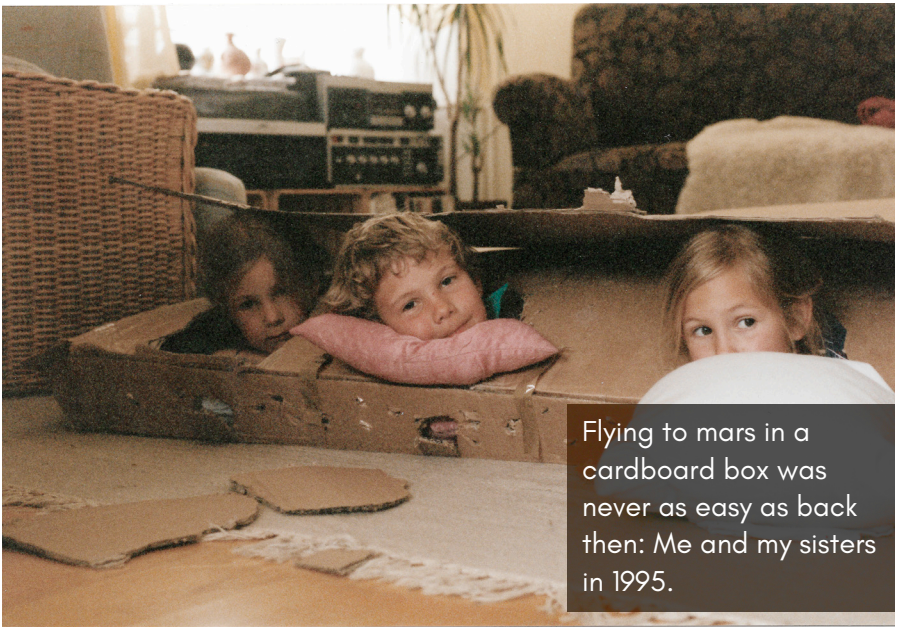
- Do before you know!
- Observe what happens.
- Redefine your perception...
- ...and test it in your next action.

This definition of children's behaviour had neither scientific intention nor proof – it was only a stereotypical definition to effectively describe my intent.

Img. 14: Illustator and name unknown, uploaded 06. 10. 16 anonymously, (26. 02. 2017). https://imgur.com/vdZ5KGU.



Img. 14: "You are not doing it wrong if no one knows what you are doing" - popular image and recent on-line meme.



Flying to mars in a cardboard box was never as easy as back then: Me and my sisters in 1995.

THINK OF NEW BOXES!

SIMPLE & UNFAMILIAR

The first fundamental decision in designing was the choice of medium: The nature of the system - I wanted people to fascinate with. For both factual and personal reasons I defined the body of tetrahedrons as the essential space of problem solving.

Tetrahedrons provide a delightful synthesis of simplicity and complexity in both structure and function. Despite their most simple, uniform geometry, we are not used to deal with tetrahedral angles because most man-made structures are based on 90° angles in orthogonal coordinate systems. The properties of tetrahedrons are so unfamiliar to us that we are all "beginners" at understanding and applying them. Further, tetrahedral bodies also have not much predetermined semantic meaning which makes them an excellent "unknown" medium to make new sense of.

Not knowing what you deal with is the perfect condition for the joy of personal hands-on discovery and independent sense -making.

Img. 15: Fentress, Warren, "Sacred geometry educational entertainment system", (14. 02. 2017). https://www.google.ch/patents/US20050014112.

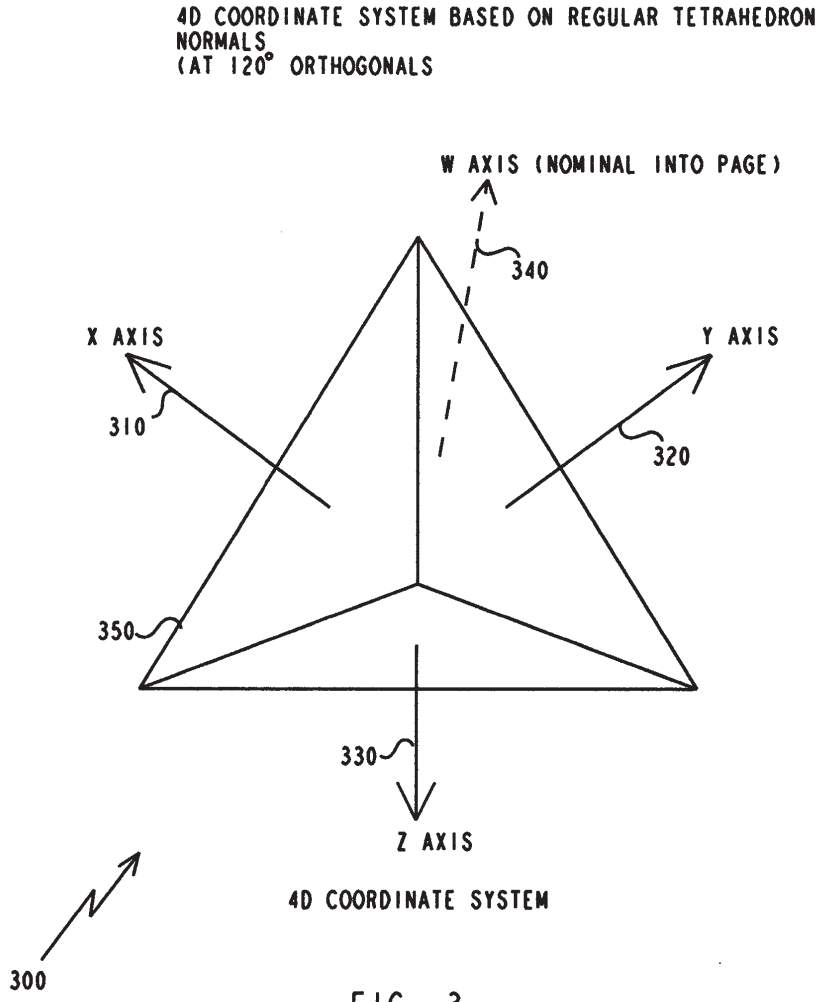


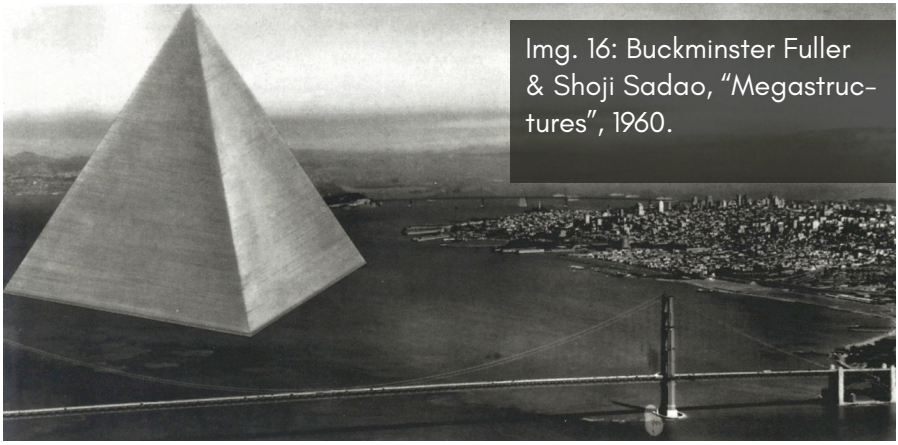
FIG. 3

Img. 15: Research quickly revealed I was by far not the first one to think of tetrahedrons as a shape to challenge the mind: Technical drawing of W. Fentress' patent "sacred geometries educational system" (2005) based on tetrahedral angles.

FASCINATION

Among many others inventor Graham Bells was intrigued with tetrahedrons. He mainly used them in aircraft construction: As the smallest platonic body they required a minimal amount of weighty bars to provide stability and volume. This even improved when combined in greater systems of the same structure.

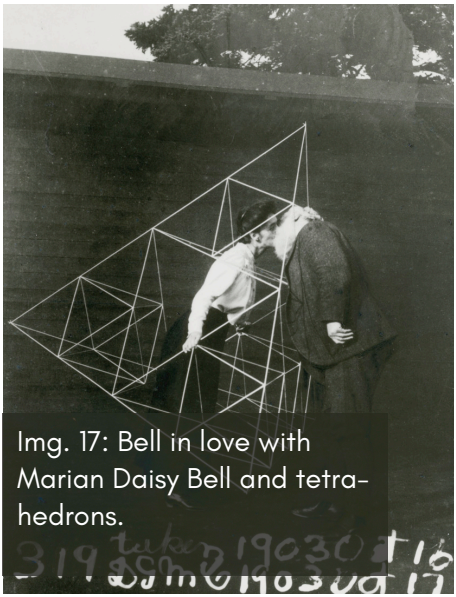
Not surprising also Buckminster Fuller found passion in the geometry and it's qualities when combined or translated.



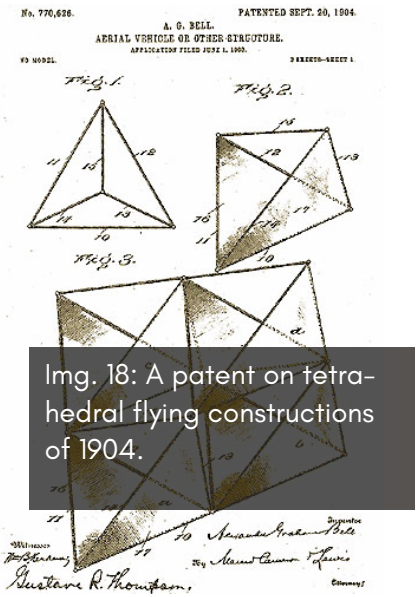
Img. 16: Buckminster Fuller & Shoji Sadao, "Megastructures", 1960.

Img. 16: Fuller, Buckminster and Sadao, Shoji "Megastructures", (18. 02. 2017). http://rudygodinez.tumblr.com/post/59792081107/buckminster-fuller-shoji-sadao-cities-in-space-1960-s.

Img. 17, 18, 19: Bell, Graham "Flying Machines of the Future", (17. 02. 2017). https://www.carnetdevol.org/Bell/kite.html.



Img. 17: Bell in love with Marian Daisy Bell and tetrahedrons.



Img. 18: A patent on tetrahedral flying constructions of 1904.

Img. 19: "Flying Machines of the Future" by Graham Alexander Bell, tested in 1898.

PERSONALLY

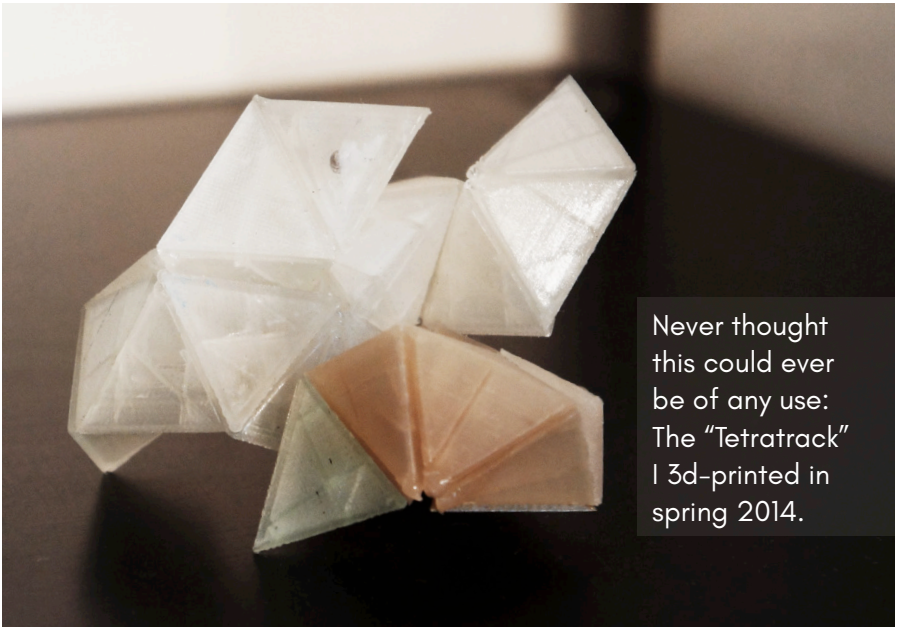
I came across the joyful difficulties of tetrahedral geometries at least twice during my studies:

- Autumn 2013: In project “Babelbam“ I created a hammer-triggered spring mechanism that self assembled in random ways and jumped apart into triangular pieces when the hammer fell.

- Spring 2014: Because I failed at recreating a functional walking mechanism, I hustled something useless but fun the very last minute before presentation: The “Tetratrack“. A toy to deal with the curios angles of “Babalbam”. Just a 3d-printed chain of equal tetrahedrons held together by a rubber band. (Spoiler: Only two years later I found a rather surprising affordance of this object - as will be described , it initiated central thoughts and experiments toward the final outcome of this project).

Both objects surprised with an addictive “touchyness“ and very unexpected shapes they could turn into. This strongly inspired my decisions for tetrahedrons.

Project “Babelbam” I realised in 2013.



Never thought this could ever be of any use: The “Tetratrack” I 3d-printed in spring 2014.

A MASTER PLAN...

...TO BE REVISED

The name of this chapter will fade in irony by the end of this booklet. However a “master plan”, is what I thought it was when working it out. A central conclusion of this documentation shall be that even master plans can and should be revised or refused sometimes.

LET IT EVOLVE!

In thesis and research I was fascinated by the idea of simulating evolution processes. Over time I figured out a concept on how to put some of its principles into a building experience of humans. In contrast to existing simulations I intended to involve peoples interaction in building as an “almost random factor”: They would come up with various solutions that compete and improve over generations of players learning from experience and each another.

THE CASE

Exemplary user "Rudolph" could learn and play in an experience as follows:

- 1) Rudolph picks up tetrahedral bricks and starts putting them together without clear intention.
- 2) After the assembly the composition starts moving (turning/stretching/shifting) single compartments.
- 3) Rudolf is surprised and delighted. He picks up this suggestion and tries to improve the movement in a forward direction (he might need a finish line to come up with this intention...).
- 4) The trial of his idea creates new insight for his own or others future buildings.
- 5) Iterating this process several times, Rudolph and others successive build-up generates ways of building effectively moving bodies from tetrahedrons the designer (me) never thought of!

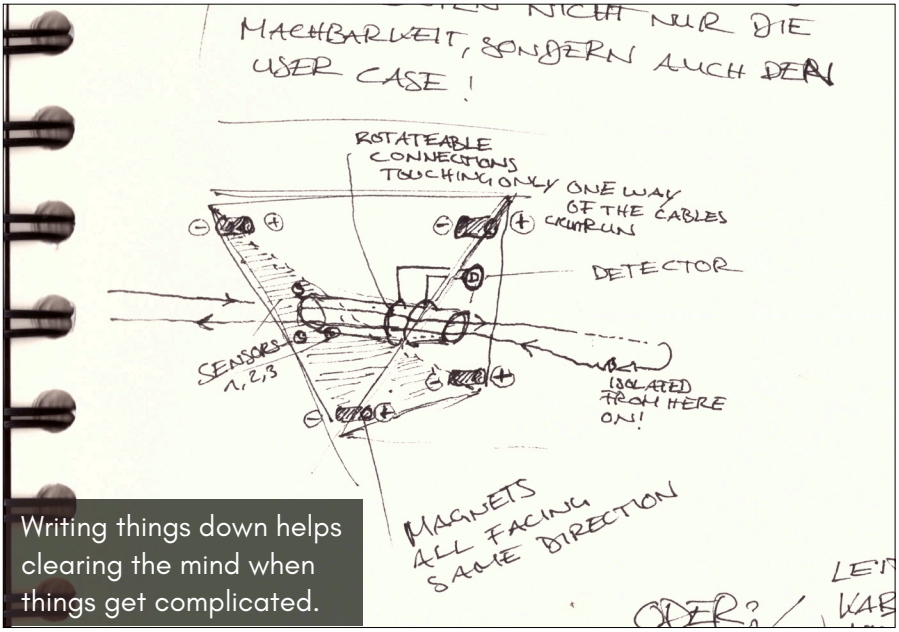
REAL VS. SIMULATED EVOLUTION

Over weeks I worked out two different options in functionality and construction of involving people in an “evolutionary building system”.

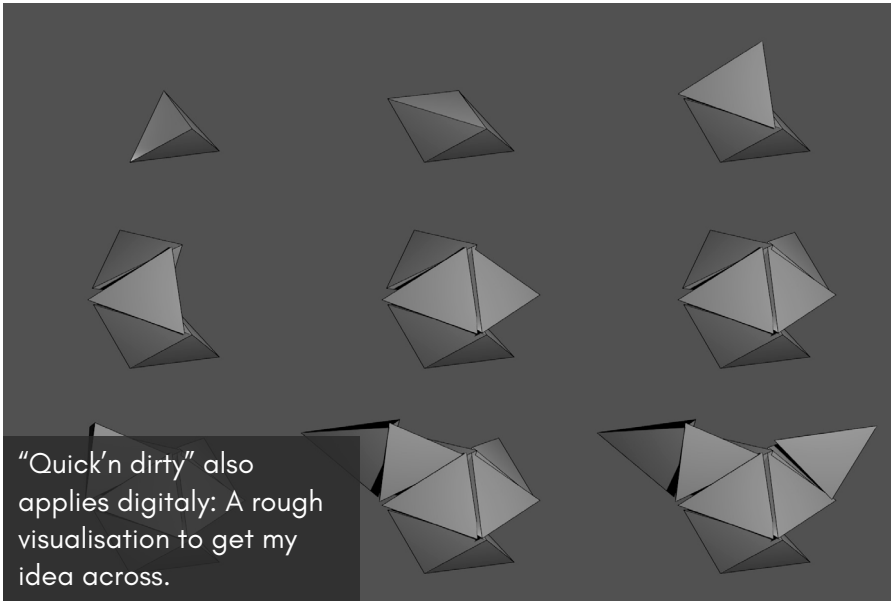
- Real building bricks that can be assembled in any possible way. They physically record and replay movements one can “teach“ them by demonstration. Here i looked into both a centralized as well an autonomous way of powering and controlling single bricks movement within the assembly.

- Real bricks to build a construction which is mirrored in a digital simulation that only moves in a virtual environment. In this virtual room technical construction and physical restraints are much easier to deal with than in reality. This would also allow to “save“ and reconstruct assemblies that have proven to be very successful.

Whilst the first version seemed to be a challenge in construction the second one confronted me with rather tricky programming.



Writing things down helps clearing the mind when things get complicated.



"Quick'n dirty" also applies digitaly: A rough visualisation to get my idea across.

THINKING BY PEN

A very important tool for both thesis and practial realisation were paper note books. Writing and sketching in different places helped me pinning down thoughts to build on them when fantasies took-off.
This was purely meant as "notes to self" and not to explain things to others. However as a "mirror of thoughts" I display some of the 250 pages I filled in this documentation.

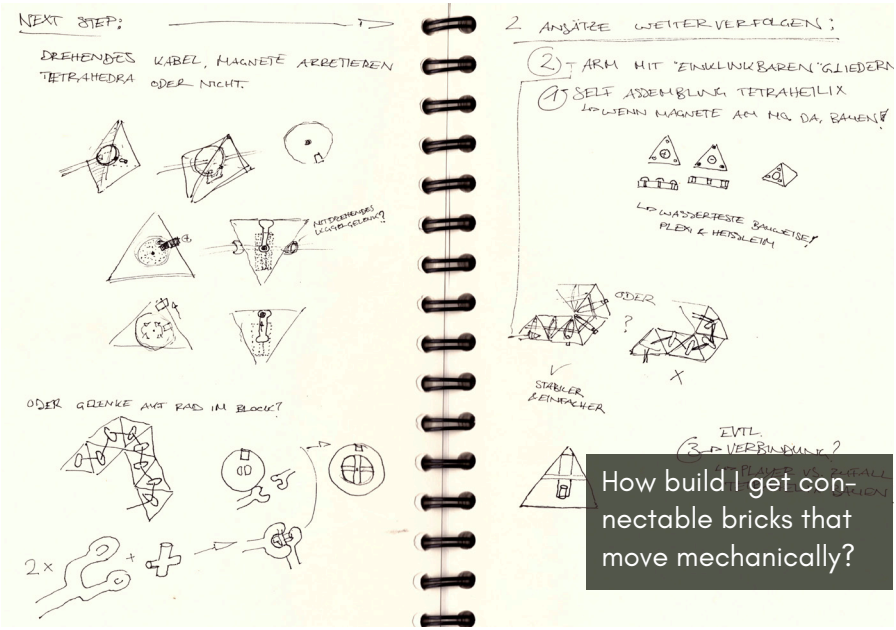
THINKING BY HANDS

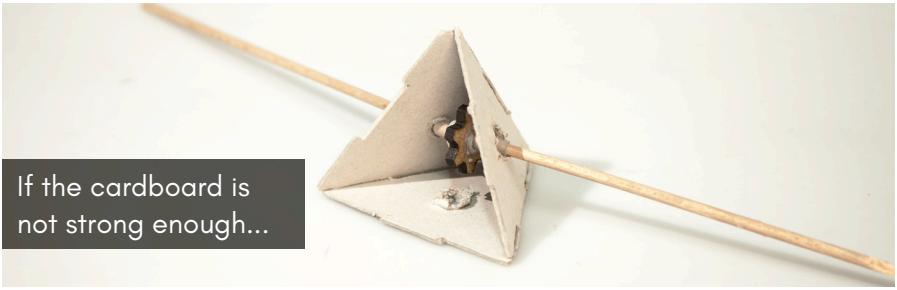
Sometimes it is hard to get started if there is neither a clear problem to solve, nor a given solution to find a problem for. I could think of more problems to solve and phenomenons to use, than I could test in the time given (if ever). Nonetheless I just started building quick and dirty prototypes of ideas whilst thinking them through. This helped in two ways:

- It often quickly proofed my imagination was much easier than reality - I got grounded and could give up my brainchild in good conscience.

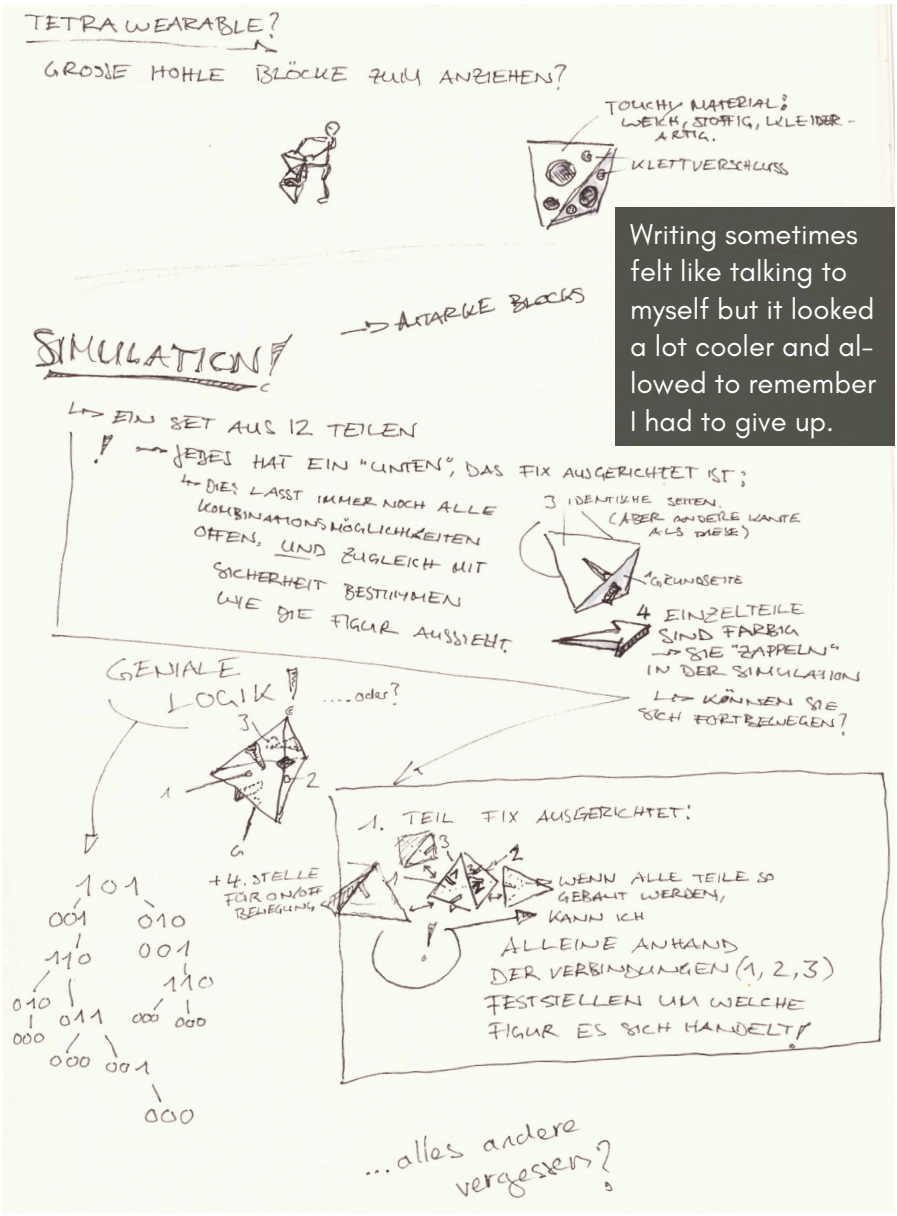
- It raised new problems and solutions that where better than the ones I started off with.

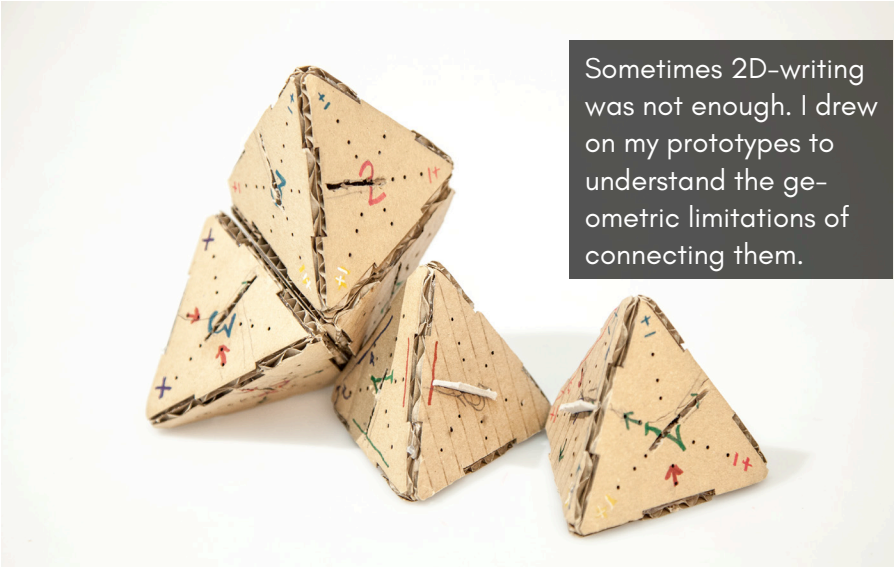
This way I build a large number of prototypes that got me further by failing.


NEXT STEP:
DREHENDES KABEL, MAGNETE ARRETIEREN TETRAHEDRA ODER NICHT.
ODER GELENKE MIT RAD IM BLOCK?
2 ANSÄTZE WEITER VERFOLGEN:
ODER
STABILER EINFACHER
EVTL.
How build I get connectable bricks that move mechanically?

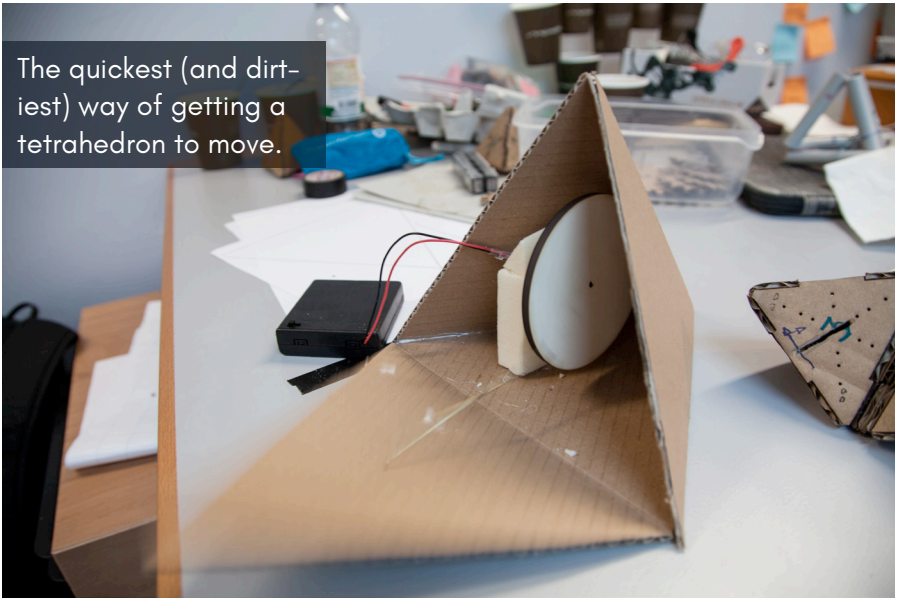

If the cardboard is not strong enough...


..transfer the blueprint onto plywood.

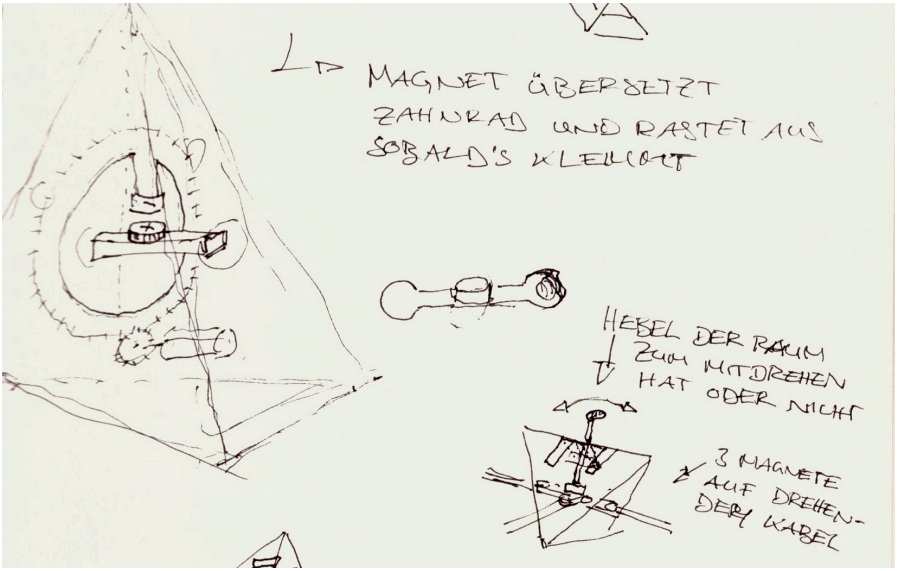

TETRA WEARABLE?
GROSSE HOHLE BLÖCKE ZUM ANZIEHEN?
TOUCHY MATERIAL: WEICH, STOFFIG, LEDER-ARTIG.
KLETTVERSCHLUSS
Writing sometimes felt like talking to myself but it looked a lot cooler and allowed to remember I had to give up.
SIMULATION!
AUTARKE BLOCKS
EIN SET AUS 12 TEILEN
JEDES HAT EIN "UNTEN", DAS FIX AUSGERICHTET IST;
DIES LÄSST IMMER NOCH ALLE KOMBINATIONSMÖGLICHKEITEN OFFEN, UND ZUGLEICH MIT SICHERHEIT BESTIMMEN WIE DIE FIGUR AUSSIEHT.
3 IDENTISCHE SEITEN, (ABER ANDERE KANTE ALS DIESE)
GRUNDSEITE
4 EINZELTEILE SIND FARBIG
SIE "ZAPPELN" IN DER SIMULATION
KÖNNEN SIE SICH FORTBEWEGEN?
GENIALE LOGIK!
....oder?
+4. STELLE FÜR ON/OFF BELEGUNG
1. TEIL FIX AUSGERICHTET!
WENN ALLE TEILE SO GEBAUT WERDEN, KANN ICH
ALLEINE ANHAND DER VERBINDUNGEN (1, 2, 3) FESTSTELLEN UM WELCHE FIGUR ES SICH HANDELT!
...alles andere vergessen?

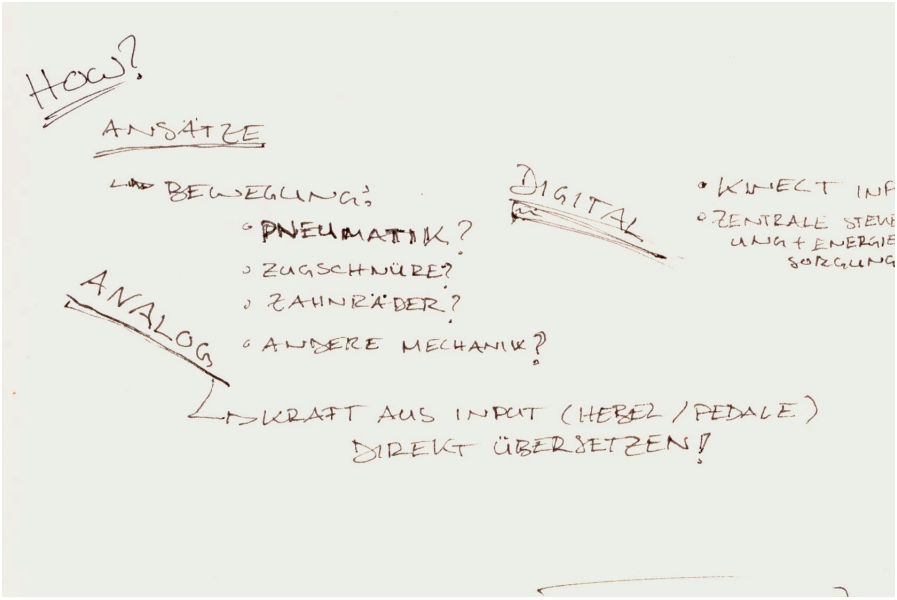


Sometimes 2D-writing was not enough. I drew on my prototypes to understand the geometric limitations of connecting them.



The quickest (and dirtiest) way of getting a tetrahedron to move.


MAGNET ÜBERSETZT ZAHNRAD UND RASTET AUS SOBALD'S KLEICHT
HEBEL DER RAUM ZUM MITDREHEN HAT ODER NICHT
3 MAGNETE AUF DREHENDER WÄBEL


How?
ANSÄTZE
BEWEGUNG:
PNEUMATIK?
ZUGSCHNÜRE?
ZAHNRÄDER?
ANDERE MECHANIK?
DIGITAL
ANALOG
KRAFT AUS INPUT (HEBEL / PEDALE) DIREKT ÜBERSETZEN!

HAIL THE FAIL

The process of developing and testing possible realisation of my master plan was as interesting as it was fun. But despite the amount and quality of time I spent working out the perfect way to go, I did not get much closer to my actual destination. It took a lot of time and effort to admit to myself I failed in two critical ways:

- Many of my ideas – even those which proofed to work – were technically very demanding. It would have taken all my time and skill to realise them nicely; however they would have remained "peanuts" to specialised engineers, or programmers. I wanted to focus on interaction not on technology.

- I was so fascinated in simulated evolutions that I did not question how people would experience the outcome. Would they really do, play and learn as I expected? And more important: Would they have fun and feel like discovering something new by themselves?

It was very hard to give up plans I have worked on passionately for so long. In retrospective it was the best thing to do. This I will remember.

EXPERIENCE DESIGN(ING)

TAKE THE FUN SERIOUSLY

What was I doing? My course of action was pragmatic, full of interesting insights and fun. But it did not get me to a realistic result.

Looking back I realised: This course of action I took would not get me to the experience I was looking for. But the joy I had going this way, was exactly the feeling I wanted to create for others! To create delightful moments in playing with tetrahedrons I had to enjoy discovering and give up preconceptions myself – just as I wanted people to do it.

This approach allowed me to research very personal experiences of joyful self-making (at the expense of objectivity – it was only possible towards my own perception of joy). Some of them – such as the passion in perfect geometries – I adapted to other people too and influenced my final design.

THE RULES

To set the new strategy clear to myself and others, I tried to define three simple and punchy guidelines to remember:

PLAY LIKE A CHILD!

My aim is to enjoy playing - finding a way to design it for others is secondary at this stage.

EXPERIENCE, DON'T EXPECT

Do things before you decide how, why, and what for exactly. Keep a "blank mind" until you observed, tested and made sense of whatever you do. But make sure you DO.

LET THE SOLUTION CREATE A PROBLEM

Dive into an immersive process where your own perception of the moment exceeds the rational perspective. A playing child can see a wooden spoon as a magic wand. I need to do so to.

These principles are not very different from what I did in the process so far (and in many other creative processes before). However, defining them consciously gave me more control and insights about my intuitive design process.

THE FLOW

From this point on my course of action got into a dynamic flow of intuitive doing and reacting on observation without expectation. To describe it I will -from here on - focus on a thread along crucial events that had an impact on my final creation. Since this path is pretty complex already I will blurr out other lines I have followed meanwhile.

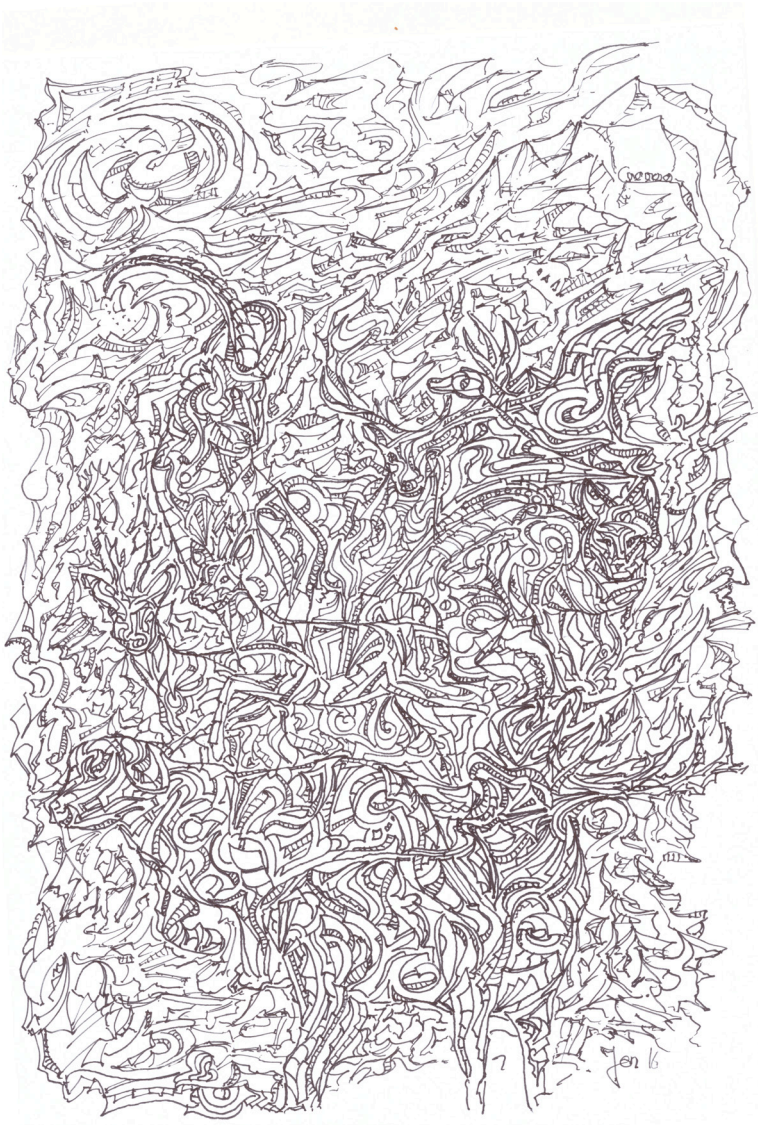


Image: Letting things happen became part of the strategy – as also visible in my sketchbooks.

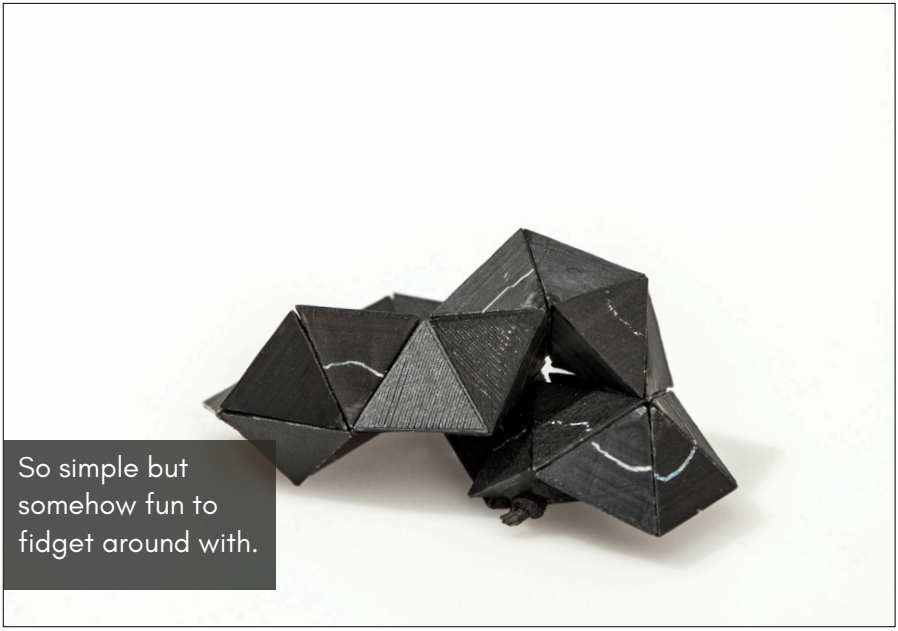
TETRATRACK

PICK IT UP

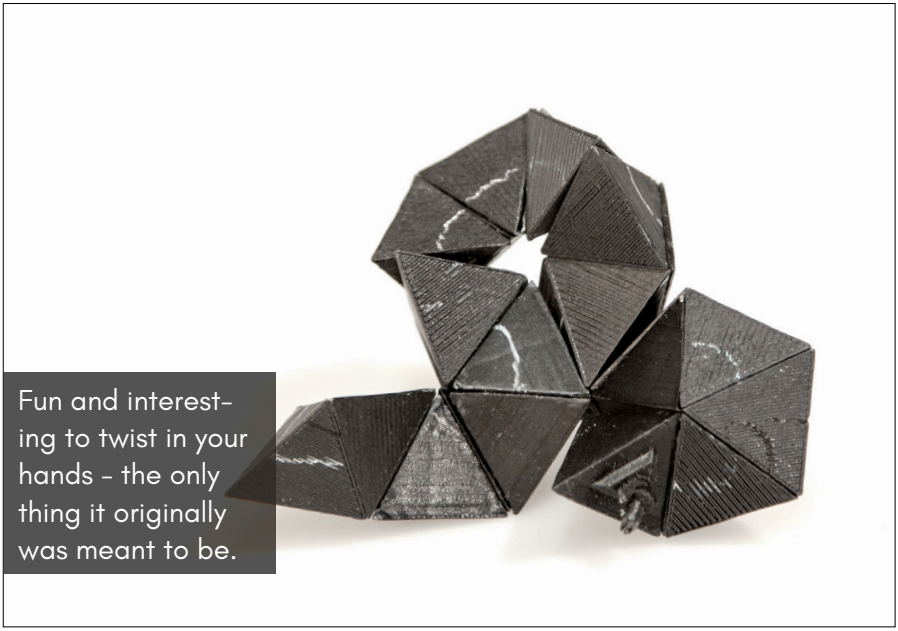
If actions lead to questions and questions provoke action, it does not matter where you begin.

I started off my new strategy with picking up and playfully rediscovering what I had built so far. Among tetrahedrons of all kind, the "Tetratrack" I made long before this project (see research) was the most fun to play with.

Trying to put elements of a puzzle to it I drew white lines along the sides. Most people intuitively tried to turn bricks so that the line did not break and thereby recovered "hidden figures" I precomposed.



So simple but somehow fun to fidget around with.



Fun and interesting to twist in your hands – the only thing it originally was meant to be.

A PERFECT CIRCLE?

ERROR: THE RADIUS OF A PROTON

Playing with the "Tetratrack" triggered thoughts that entraped me with theoretical research again. There was more to it than I thought.

Can a chain of tetrahedrons build a circle that closes perfectly? This mathematical question[1] was raised by Steinhaus in 1958. Two years later S. Swierczkowski[2] announced: No. But admitted limitations to his theory (see citation next page).

Over 50 years later the story continued: Stan Wagon[3] started to challenge the theory with the help a digitally connected community. In collaboration with others he managed to get the error of the equality down to the radius of a proton.

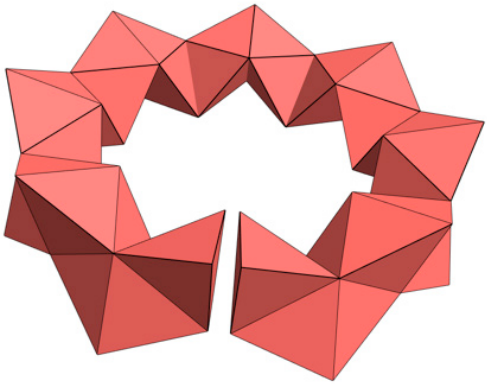
Meanwhile designer Brian Hayes picked up the challenge through playing with "Geomag" toys and finally contributed by 3d-printed models of Wagons calculations.

[1]Steinhaus, H. "Problème 175", Coll. Math. 4 (1956-1957), p. 243.

[2]S. Swierczkowski, Looking Astern, unpublished memoir p. 191:15.

[3] Elgersma, Michael and Wagon, Stan "The Quadrahelix: A Nearly Perfect Loop of Tetrahedra", 52 B10 (Primary) 51 N20, 11 J25 (Secondary) Nov. 6, 2016.

Img. 20: Wagon, Stan, "A tetrahedral chain challenge", (20. 03. 2017). http://community.wolfram.com/groups/-/m/t/143090.



"[...]it still may happen that all observations and measurements indicate that these two pyramids do have a sidewall in common.

This would not contradict the mathematical result; it would only illustrate the obvious fact that no measurement is 100% accurate.
So, a new problem is born..."

S. Swierczkowski

Is there any number of bricks that would close the gap? Possibly yes, said r S. Swierczkowski 1960 unless he proofed the opposite. Illustration of the problem by Stan Wagon.

TETRAHELIX

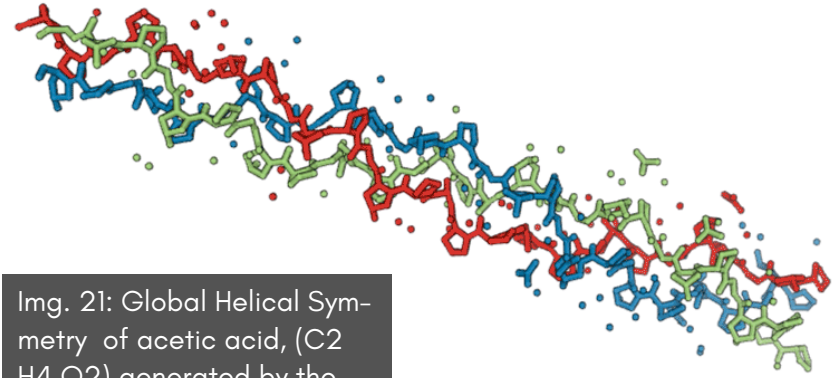
GET IT STRAIGHT

Reseraching the mathematical background of tetrahedral chains I picked up the shape of a perfectly straight chain of tetrahedrons. The"tetrahelix" is often found in biological structures such as protein chains.

HELIX CHALLENGE

Instead of letting people search for predefined arrangements (white line) I now challenged them with symmetry. Assembling a perfect tetrahelix from a 13-bricks chain took most people about 4-6 minutes and raised a lot of ambition. And satisfaction when achieved. Personally I got better and better at it but I still had to focus a lot and build up brick by brick. It was almost impossible to set one angle right without adjusting all the others in the line.

Img. 21: Research Collaboratory for Structural Bioinformatics, "Global Helical Symmetry " of acetic acid, (02. 04. 2017). http://www.rcsb.org/pdb/pv/pv.do?pdbid=1CAG&bionumber=1.



Img. 21: Global Helical Symmetry of acetic acid, (C2 H4 O2) generated by the Research Collaboratory for Structural Bioinformatics.

The Tetratrack in perfect tetrahelix arrangement.

PROPERTIES EVOLVE THROUGH CONDITIONS

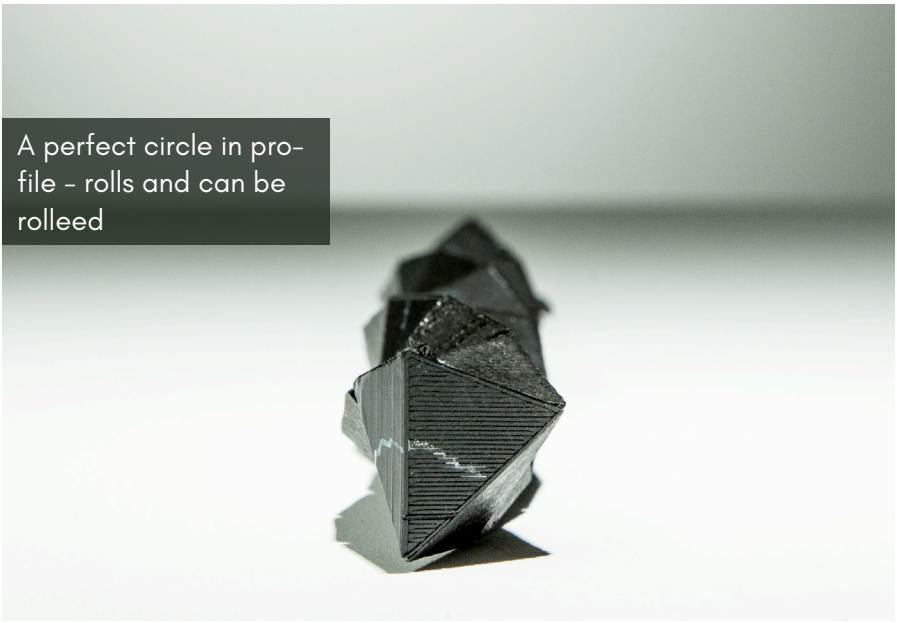
HELIX THAT ROLLS...

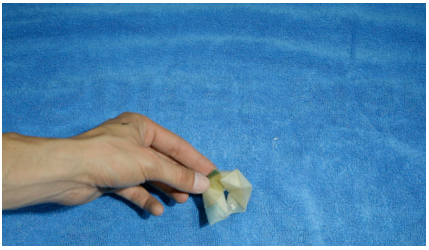
Taking tetrahelixes to further play I realised they were rolling surprisingly well on flat ground. Research quickly proofed what I thought: An irrational set-off angle between tetrahedrons add up to a perfectly round profile.

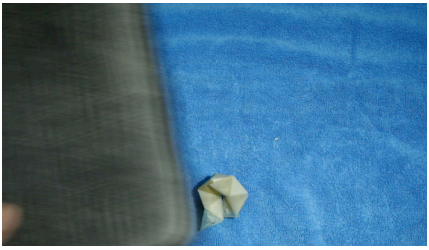
ROLL THAT HELIX!

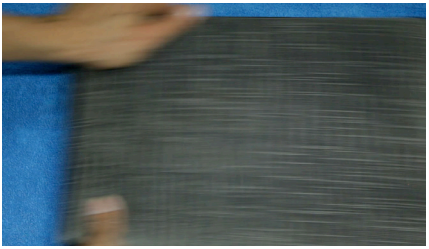
Still having evolutionary thoughts in the back of my head, I inverted this finding above into a theory of self assembly:
If a tetrahelixes do well in rolling conditions, rolling dynamics should evolve helix arrangement in reverse.

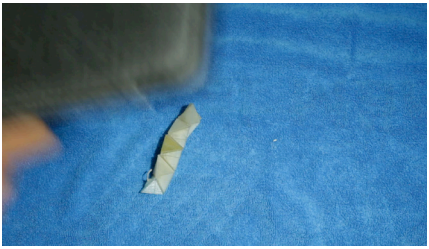
I quickly put this thesis to test and could proof that rolling the chain between flat surfaces forced a tetrahelix. Sometimes this worked even quicker than (untrained) humans could do by intention.


A perfect circle in pro-
file - rolls and can be
rolleed









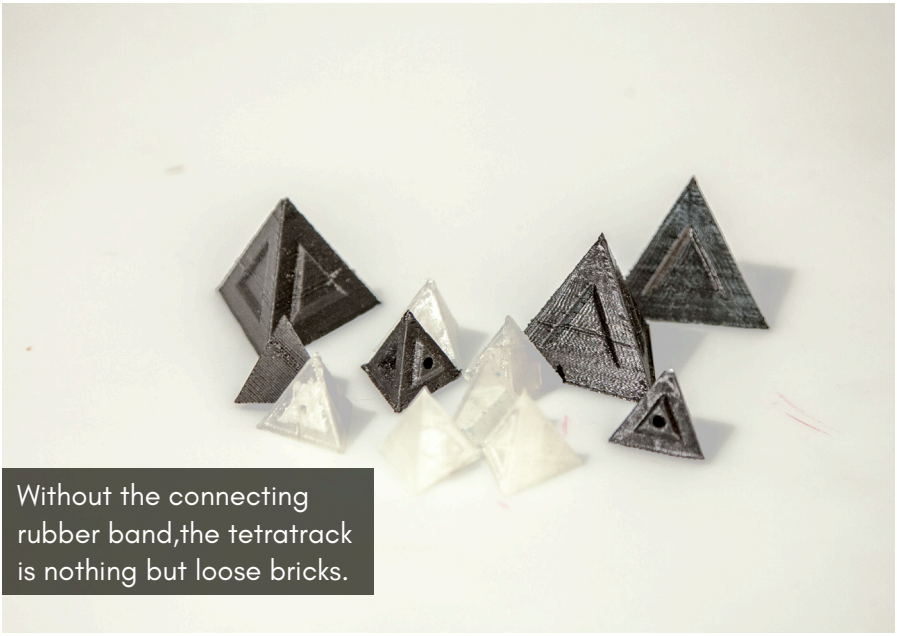
FREE ASSEMBLY?

LOOSE THE CHAINS!

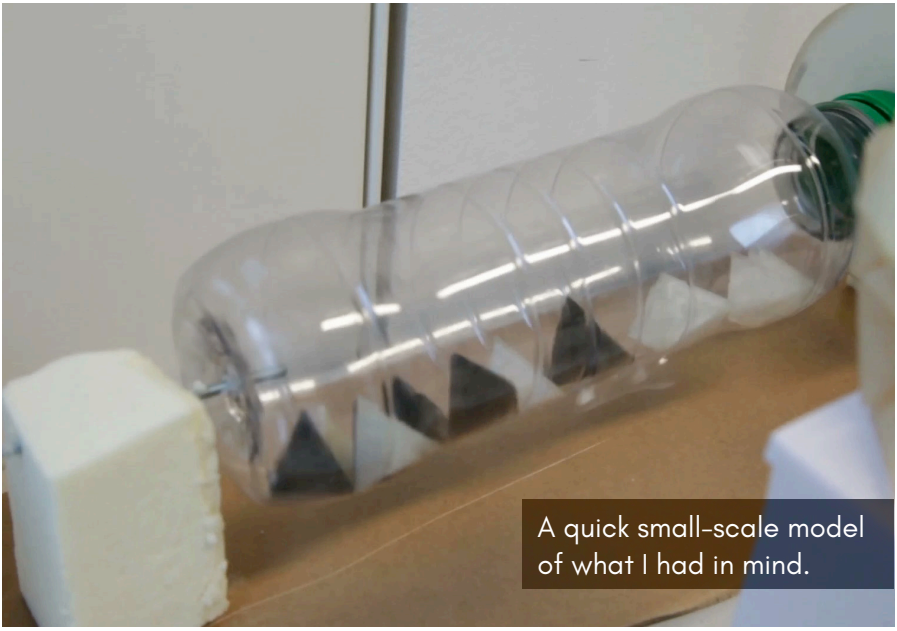
Based on my own findings and those of others (see research) I derived another thesis from the observed self arranging property of the Tetratrack:

In a "rolling condition" loose bricks that randomly connect with each another and fall off through impact would assemble to a tetrahelix too. For the same reason as the bound chain of tetrahedrons does: As long as it is in any other assembly than a perfect helix, bricks will stand out and be knocked off when rolling until they connect at the right link.

With no final intention what to make out of this theory in case it worked, I decided to put it to trial anyway.



Without the connecting rubber band,the tetratrack is nothing but loose bricks.



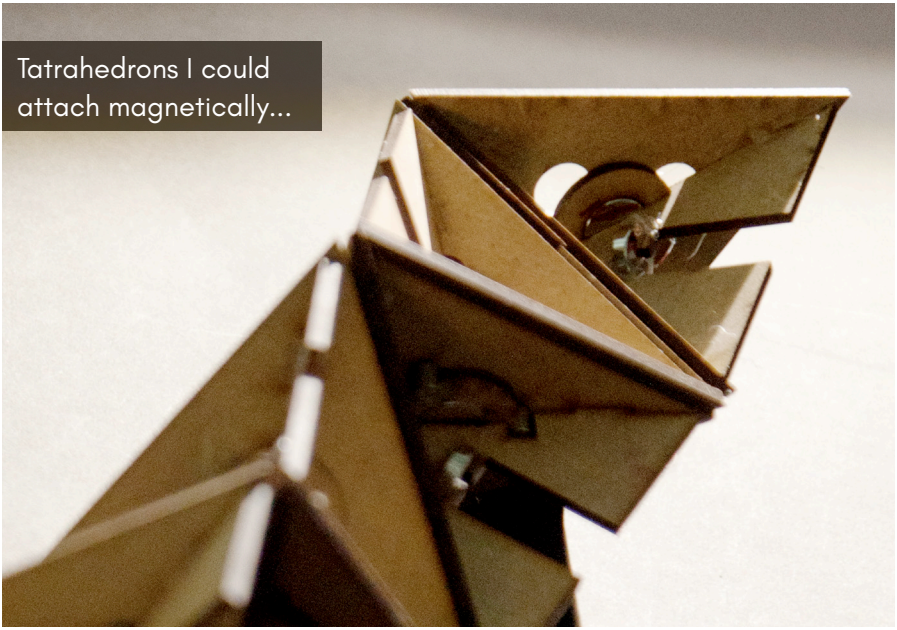
A quick small-scale model of what I had in mind.

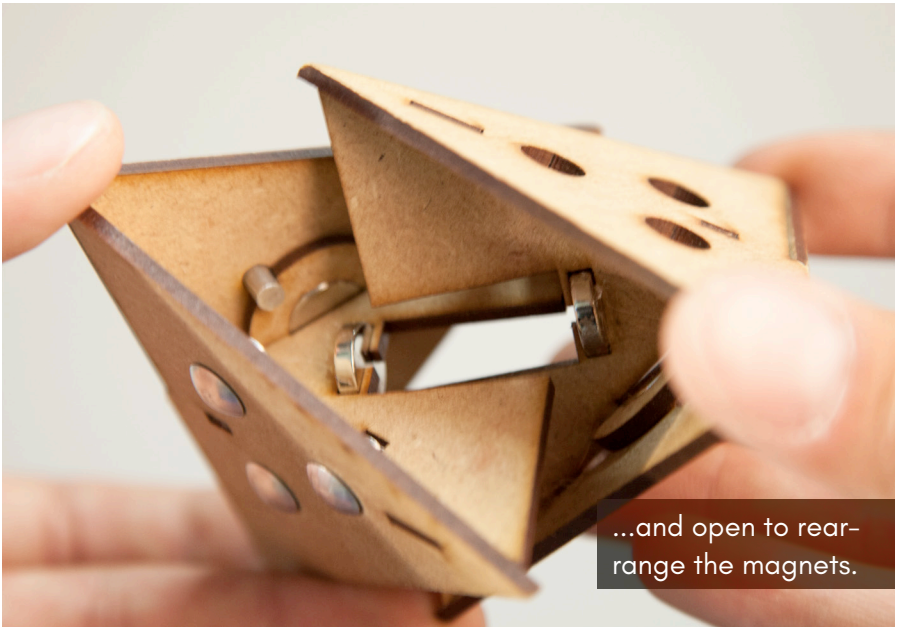
BUILDING BRICKS

A MATTER OF MAGNETS

There are different technical and conceptual ways of building bricks that temporarely attache and fall of at a certain threshold of force: velcro, lego, locking mechanisms, sticky liquids and many other thing could provide this quality. Some of them attach to anything, some only to each another and most have positive and negative sides that reject equals.
Like many others on this field of experiments I went with magnets, because they do not (significantly) wear off their attraction polarity gives more options on determining assembly. Arranging positive and negative poles on each brick will affect the assembly as a whole. Furthermore they have something very appealing when put together: You can feel their intention and get a confirming “snap!” when they are supposed to connect.

However, attachment is not the only thing to be considered. Bricks also had to remain in the angle they where put together. In addition to magnets I sometimes to locked rotation mechanically through wholes and knops that fit in in only three directions.


Tatrahedrons I could attach magnetically...


...and open to rear-range the magnets.

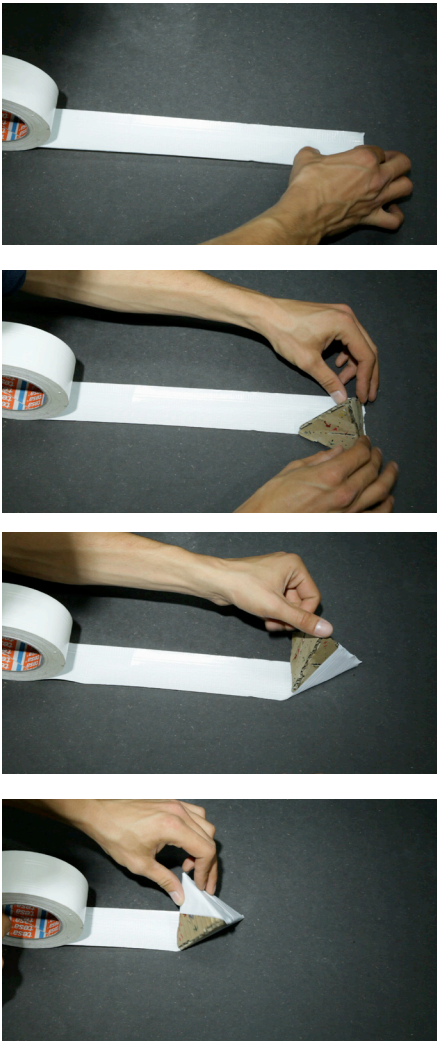
WRAP IT UP!

When constructing and building I kept being very pragmatic at putting thoughts to action. But in contrast to my action on the "master plan" I now stayed free from fixed intention: I allowed myself to spontanously try out ad-hoc ideas that rose from problems they did not even solve. Since I was searching experiences of joy, it being interesting or just fun was reason enough to do.

The most essential of these trials occured when I built magnetic cardboard-prototypes for self assembly: To prevent the sharp edges from destruction in the assembly, I tried to wrap them with tape. Not being a fan of laborious work, I wondered if there was any way to fully cover all sides and edges of a tetrahedron without cutting the tape into four triangles.

Doing before thinking I just started wrapping from a random corner on. To me this was very exciting: Each side I managed to cover, felt like a milestone - the moment when I crossed an area double like a wall I ran into. After two "walls" and restarts I crossed the finishing line: I managed to wrap a tetrahedron with a single, straight strip of tape!

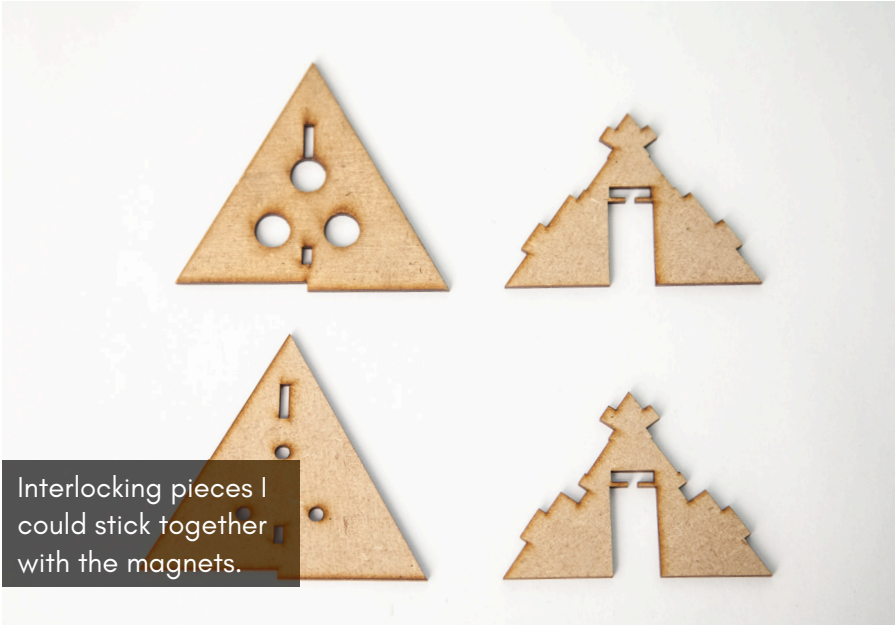
This might not seem as exciting to the reader as it was to me. Thus it is a good example of immersion into a world of self-made sense and relevance based on my own action at that moment.



Wrapping 8 split sides of the tetrahedron.

FROM 2-D TO 3-D

In the whole process of development I based construction on flat surfaces that folded up and interlocked to tetrahedrons. This way I could quickly test ideas with hand-cut cardboard and directly transfer successful blueprints to lasercut MDF and plywood. Although it was quite tricky taking all the uneven angles into account when calculating the offset of material thickness, this was an efficient and effective way to go: It was faster but also demanding more consideration toward construction than 3D-printing. This helped keeping a constant flow of thoughts, trial, error and recreation.



Interlocking pieces I could stick together with the magnets.

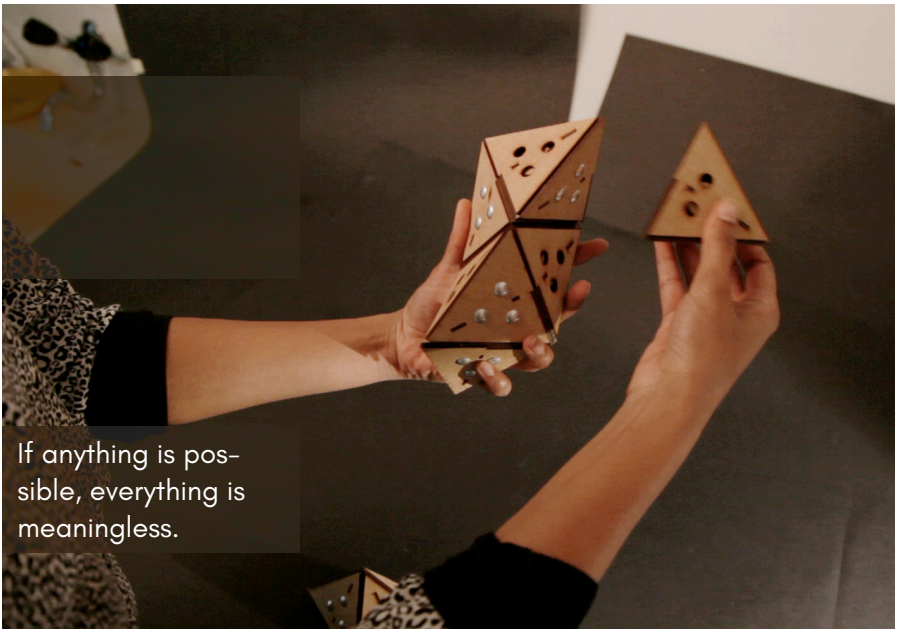
Lasercutting MDF.

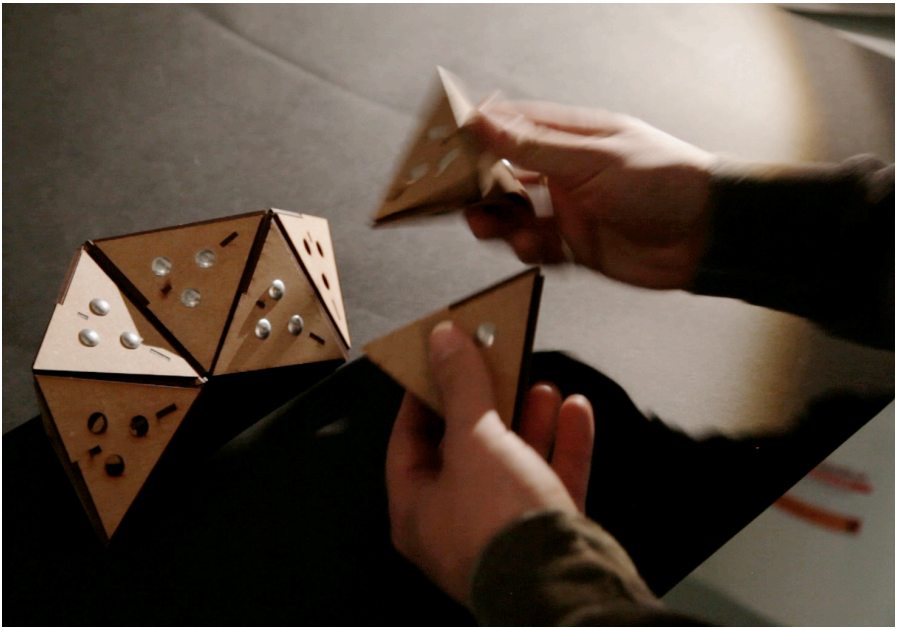
WHAT YOU DO WITH IT

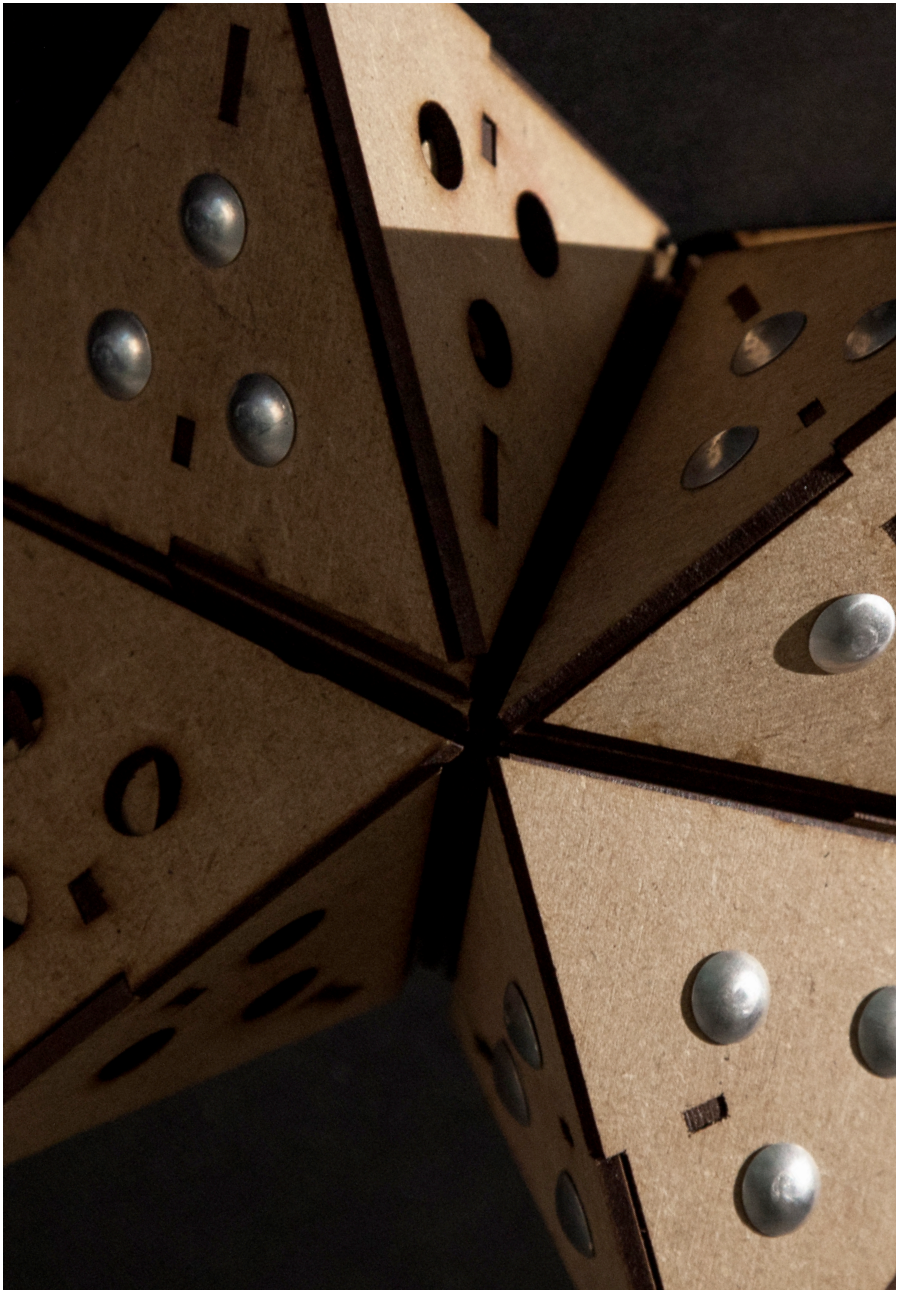
HELIX BY HAND

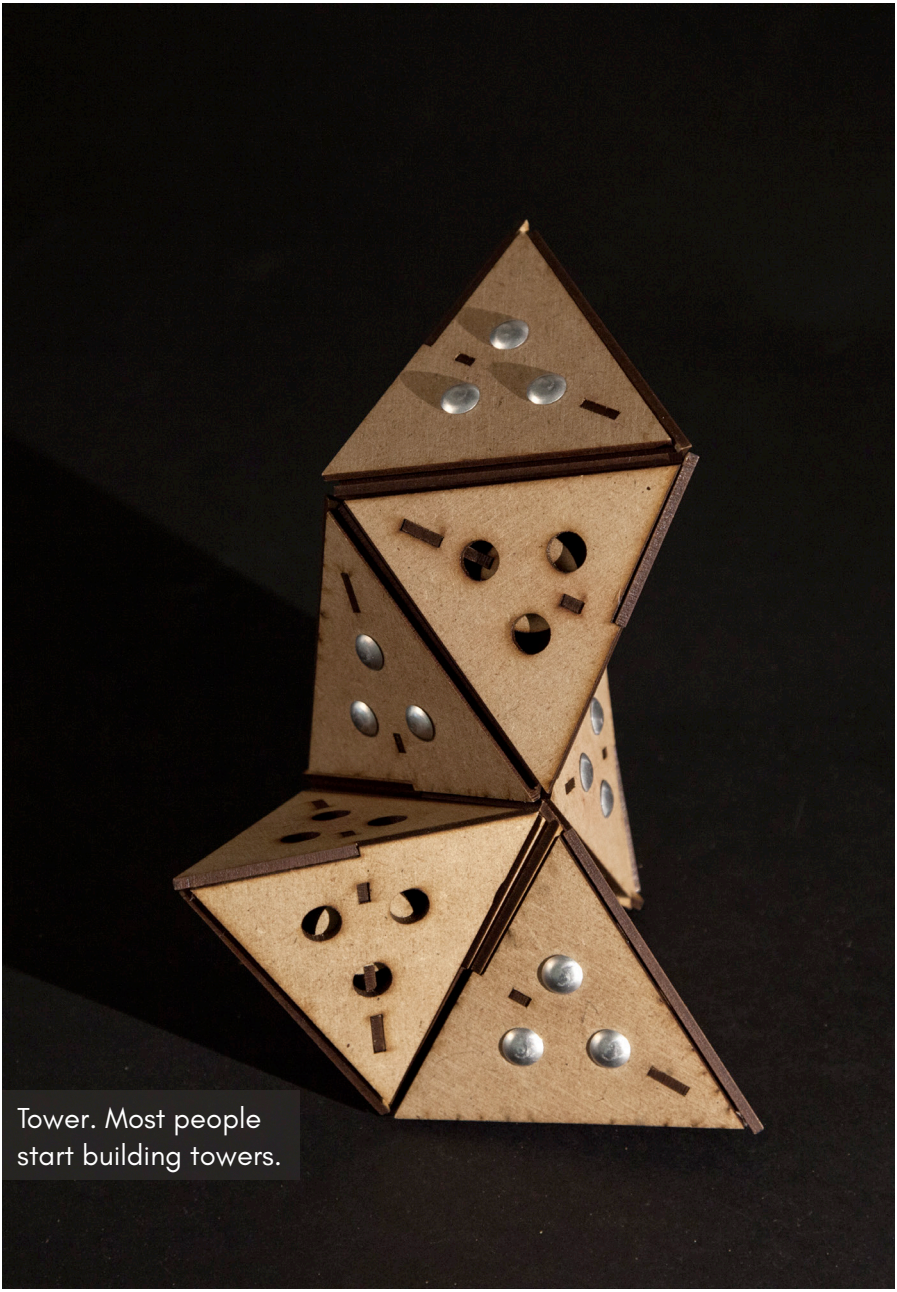
It was not part of the concept but an obvious reaction: Always before I could test any self-assembling qualities of the bricks I had built, me (and people around me) started playing with them by hand.

Interestingly, with loose bricks challenging people with the construction of a tetrahelix (see "Helix Challenge") was not fun anymore: Without the restriction of an interlinking chain the difficulty of unfamiliar rotation angles fell away. The problem was so small, its solution became almost obsolete and meaningless.


If anything is pos-
sible, everything is
meaningless.







Tower. Most people start building towers.

LIKE LEGO?

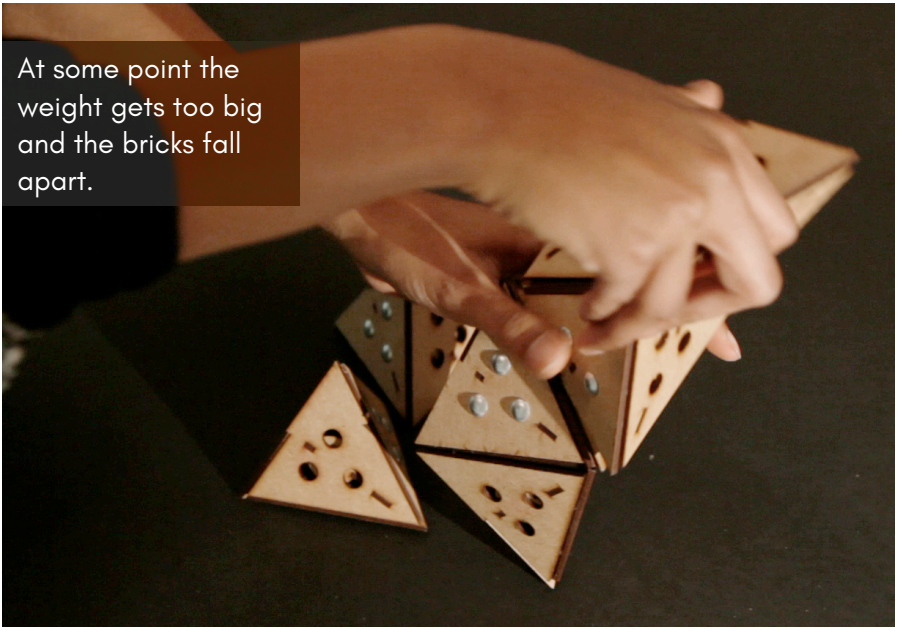
Observing the play with loose tetrahedrons, one could assemble in any possible way, confirmed an assumption I during my research (see "Building Systems"):

The fact one could make anything of a medium does not necessarily raise his intention to do so. Such medium is not creating new things and sense, it is only allowing to realise them.

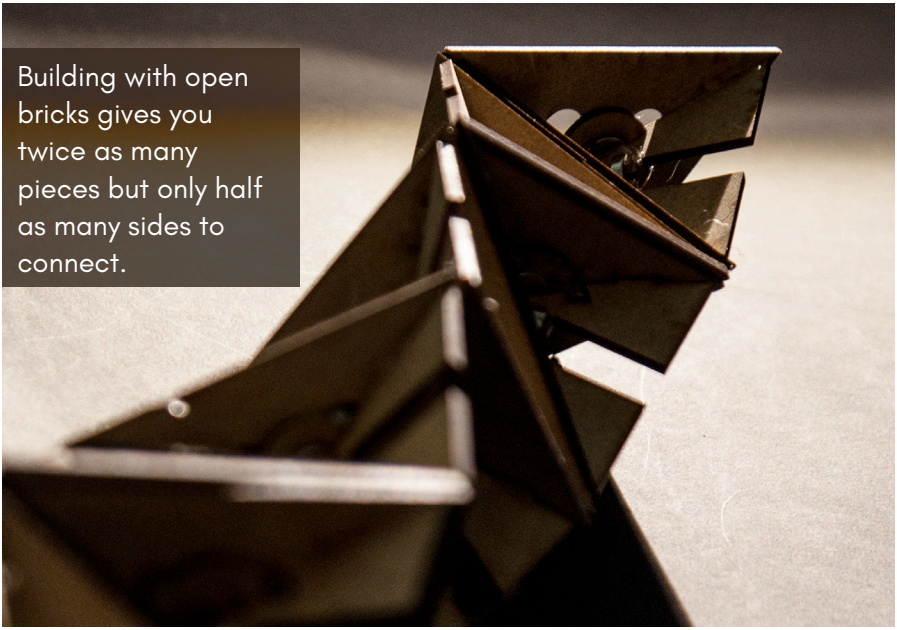
In this regard Lego and my similar principle of free building tetrahedrons only let those experience the joy of self-making who are able to do so anyway. Like children (therefore Lego could be seen as "too difficult" for most adults).

BUILDING ~~WITH~~ TETRAHEDRONS

Trying to draw conclusion from the suspected downsides of bricks for human intended assembly, I realised that my process of building the tetrahedrons themselves was actually more interesting than building with them once they where complete. Something to keep in mind...



At some point the weight gets too big and the bricks fall apart.



Building with open bricks gives you twice as many pieces but only half as many sides to connect.

SELF ASSEMBLING TETRAHELIX

THE RIGHT RANDOMNESS

In order to test if the built magnetic tetrahedrons would self-assemble in a specific way, I had to create a "randomiser" providing dynamics that rotated around a central axis.
To see how things are happening I constructed a tube of plexiglass to put the bricks inside.
First I just pushed the tube with a broom through the atelier, then I spun it on skateboard wheels before I let it roll down a lorry ramp. Not much happened - the bricks where gliding along the plexi-glass surface, neither turning nor reassembling. I helped this by adding rubberbands to the tubes surface to give it a grip on its content.
Another variable of randomness to set was the speed and consistency of rotation. I started controlling and observing with a setup to spin the tube with an electric drill.

With the help of gravity: Rotating the “randomizer”.

Controlling the variable of rotation speed.

FRAGILE CREATURES

The thesis, loose magnetic bricks in rotating randomness would assemble into a tetrahelix, was hard to proof with certainty. My observation suggested there were many tendencies towards this. However in none of the experiments conducted tetrahelixes remained in an assembly of more than 5 bricks. Trying out different types of brick-construction, led me to the following assumptions:

- If magnets and angle-locking mechanisms were too weak, the tetrahelix' weight tears it apart soon as it exceeds 5-6 bricks.

- If connections were too strong, the bricks tend to cluster up into asymmetric chunks that do not break apart anymore.

Under constantly high speed, bricks often formed flat, wheels of 5-6 pieces that rolled vertically. Stopping rotation caused them to tip to the side and break apart when rotating again.

Assemblies like this one quickly broke apart.

Inverse: Roll the underground on the object.

STABILE “WOBBLERS”

To test “long term effects” I started spinning the tube with tetrahedrons for periods of 5 and more minutes non-stop. To my surprise a new arrangement of assembly seemed to occur and remain remarkably often: Two “wheels” (as described) joined in an angle of 90° (eye measurement). This way they could not tilt over anymore when stopped. Together they built the side profile of a cross, but always tilted half of the original wheel along the rotation axis. This allowed them to roll without hitting corners and made them resistant towards further rotative dynamics.

A very resistant and well-rolling assembly. for the sake of simplicity I called them “Wobblers”.

REFLECT & REDIRECT

TWO SYSTEMS OF ASSEMBLY

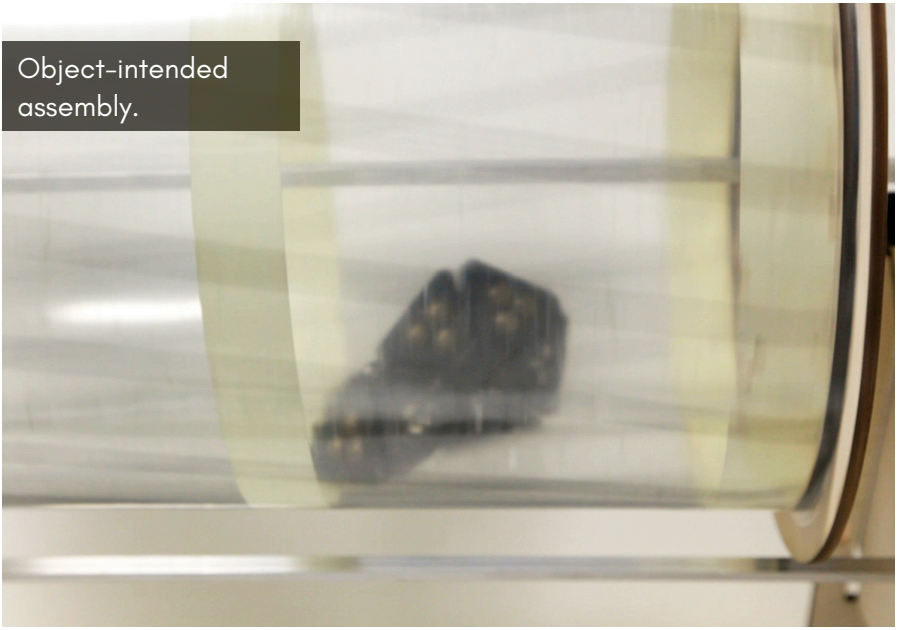
After jumping into an immersive flow of creation I stepped back to overview the situation from a distance. What was this all about?

I went off to discover the joy of building with tetrahedrons and explored two opposite principles of systems: Bricks that worked like tools for realising human intent and building compartments with a designed intent for assembly. The first was expecting too much from people, the second would not allow them to complete what was made by others.

As discussed in my thesis, many designs of self-making tend to become hybrids: They combine designed elements with the right amount of blank space for the users own creation. The two extremes I had explored practically could be projected onto the cases discussed in the thesis:

Systems like Lego demand a high amount of human intend: Everything is possible but requires creativity but does not necessarily initiate it. In contrast, IKEA has to guarantee (by law) a perfect assembly of compartments under certain conditions. Therefore the manual gives as little options for self-making as a self-assembling systems.

Human-intended assembly.



Object-intended assembly.

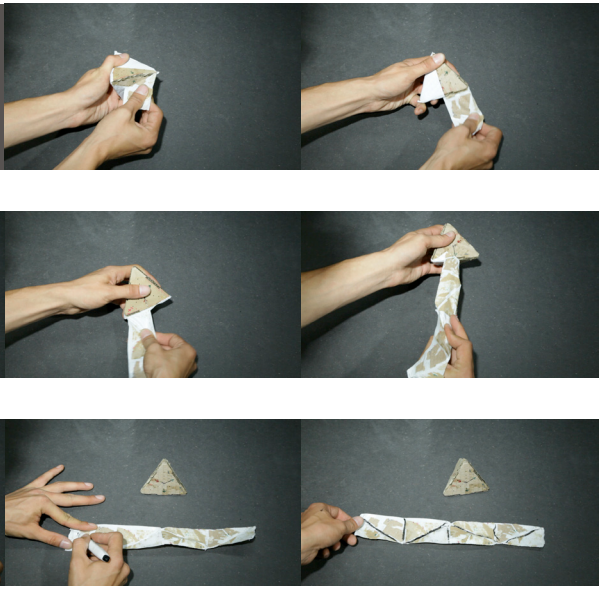
"HEUREKAEDRON!"

Thinking of personal highlight within the whole process I remembered the moment I managed to perfectly wrap a tetrahedron in a strip of tape. Being very honest: THIS was really great.
Was there any way I could invert the path to such joyful discovery, just like I did with the rolling of tetrahelixes?

UNWRAP - AN IDEA!

So far I described all influences towards my final concept – the moment of the ideas ignition however remains mysterious (even to my own perception). In context of all research, experiments, the present situation and the way I got into it, it just seemed like the most obvious thing to do at this point.

Unwraping the tape to tracing the geometry.



1) I tore off the tape from the cardboard tetrahedron:
The prototye's sides and corners left marks on the tape.

2) I traced the geometry of this "unfolded blueprint" and cut the shapes out of cardboard.

3) I stuck the cardboard segments back onto an identical strip of tape in exactly the same arrangement.

The result was a strip of tape with hard surfaces and corners that potentially folded up to a closed tetrahedron.

GIVE IT INTENTION!

Knowing the object and its affordance I could now turn the flat strip with carboard shapes on it into a tetrahedron. But as quickly turned out, no one else managed to follow my steps.

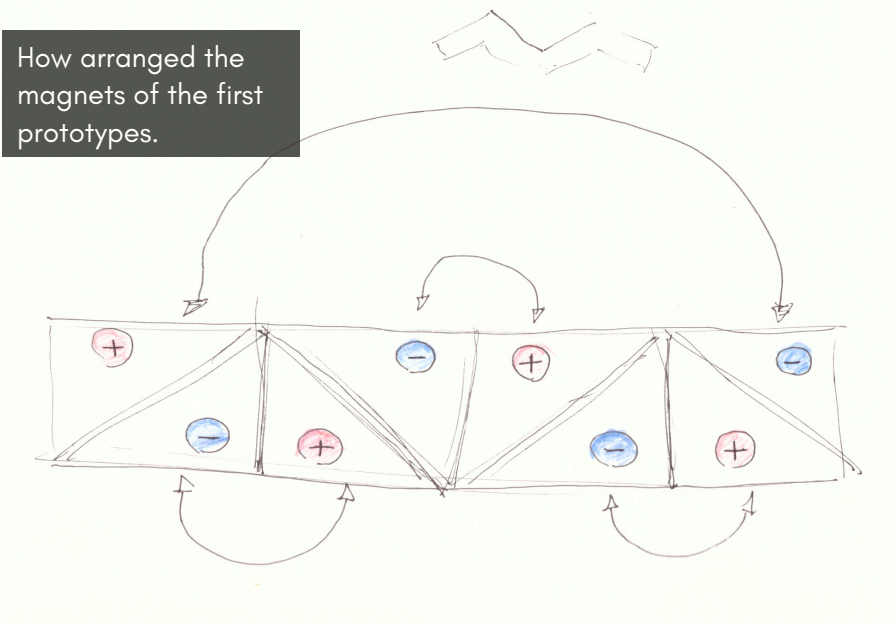
So I backtracked my traces of my own action again: I added magnets to help holding sides together and reduce the chance of “wrong” assembly by 50% (equals reject).

THIS WOOD DO IT

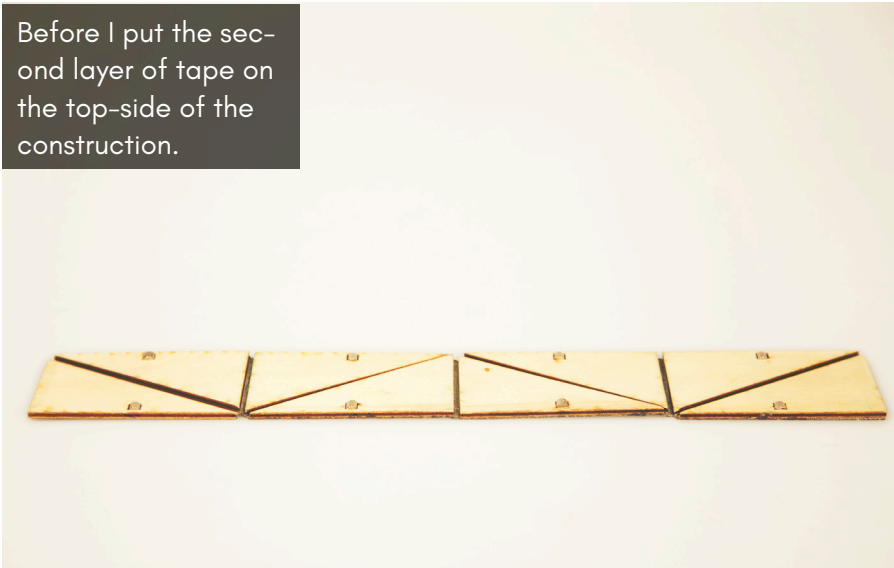
As before I chose to quickly transfer my cardboard blueprints to lasercut pylwood (MDF i considered as too heavy and they took longer to cut). Plywood plates made the tape strip thicker and allowed putting magnets inside. They also improved how the edges stuck together along the narrow sides.

I arranged the compartements in a certain distance to each another and put tape on the wooden plate before I cut it. After wards I took off the tape and all cutout elements remained stuck onto it in perfect arrangement.

How arranged the magnets of the first prototypes.



Before I put the second layer of tape on the top-side of the construction.

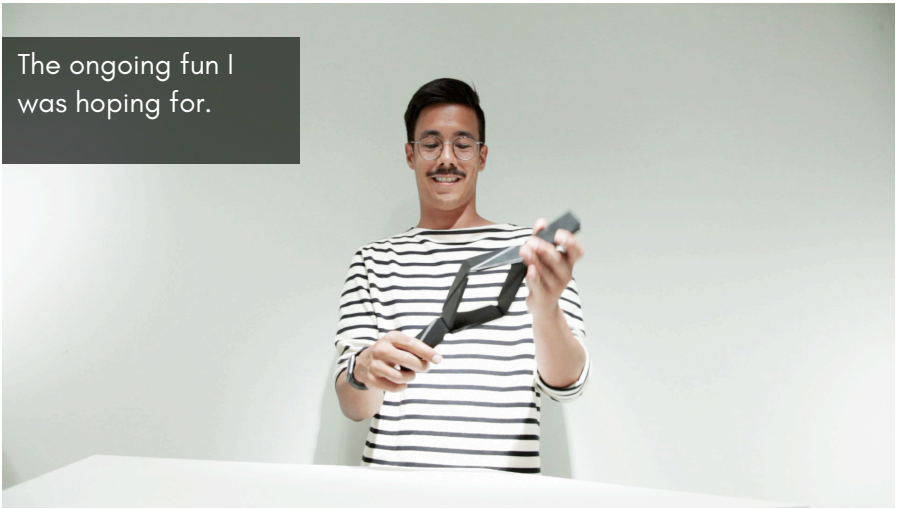


TWO DIMENSIONS OF PLAY

A LITTLE DELIGHT

With magnets a well balanced solution seemed to be found: First-time users usually spent about 1-3 minutes to figure out how to folt a tetrahedron of the strip. In addition they reacted to the magnets by figuring out this object had a certain affordance they had not found yet. It forced them to trial without clear intention. Once the tetrahedorn suddenly closed with a snap, a grin on many faces said they enjoyed their achievement this (provoking a smile on my face in consequence). Most users also understood that "This was it" and they had found the solution - the perfect symmetry and the "clap" when closing the last gap where confirming their action. Nonetheless they kept on playing and many of them had a second moment of delightful discovery when they found out they could fold the whole structure inside out.


The little moment of joy
I was trying to bring


The ongoing fun I
was hoping for.

THE MORE THE MERRIER?

So far I have created a single object that provided a little joy in little time. What happens if I combine many of those to a bigger system?
To my surprise this worked in the best way I could imagine:
The number of possible “stable”, “symmetrical” or (anyhow “right”) configurations seemed to grow exponentially with every building element I added to the assembly. However, this quickly caused chaos: with more than 6 stips usually lost controll and overview of the construction.

Another thing I quickly found out about the system: Everything you could build out of a smaller number of bricks, you could replicate on big scale with a larger number of compertements.

Intermediate prototypes.

USER TESTING

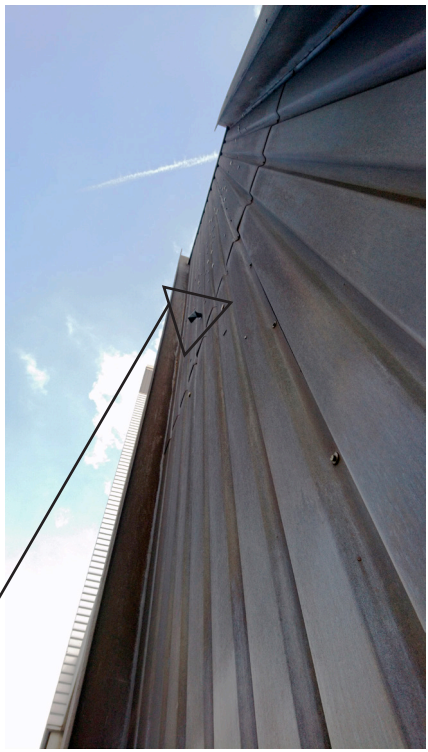
To me it was alway great fun observing how people reacted to the prototypes. Therefore I always kept at least one of them on me and gave it to anyone on every possible occasion (never it was so easy to explain what I study).

Most reactions were positive, some overwhelming: People wanted to keep the prototype, one even offered to buy it. Nonetheless there is some downsides I detected:

- Due to plywoods thickness the gap between wood plates needed to perfectly fit the offset of the tetrahedral angles. Otherwise solids folded up sideways or not at all

- The stripes tended to stick together flat-to-flat or folded up, building to compact blocks one could barely open again.

- They need to be even more resistant to the physical impact of play than I thought.



Not all prototypes came back from user testing. One remained stuck on a metal wall far out of reach.

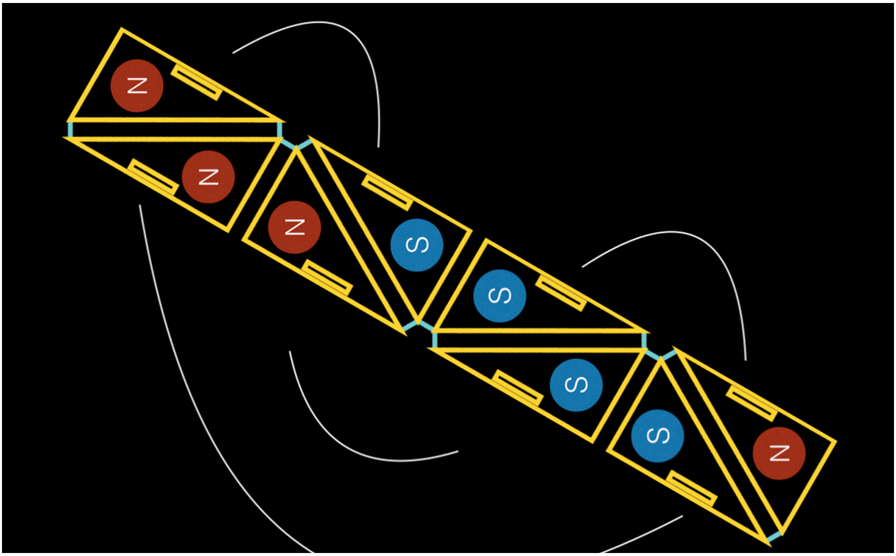
THE LOGIC BEHIND

Trying to solve the problems I found evaluation, I started rearranging the order of magnets. Thereby I found a solution that still allowed single bricks to form tetrahedrons but to some degree prevented compartments from folding up and clustering into blocks. Testing this arrangement, I realised it changed the logic of the whole system in a very interesting way: Two pieces could still be connected (with perfect alignment) but only one out of four possible orientations worked. Two of them looked exactly the same. This was game-changing in two ways:

- It made building by plan much harder. Not anything could be constructed which made it more interesting and challenging to find out what was possible. Therefore assemblies that "worked" (stable/closed/even) often turned out very symmetric. They looked "right" without definition - there is more "solutions" than a single person can find.

- Since the magnetic arrangement was asymmetric but invisible, players where often forced search the right orientation by trial and error. This was an important element of concept and design to the experience. Furthermore it conformed the rules I had set up for myself: "do before you know", "Don't expect...", "Let the solution shift the problem". This seemed right.

Although it did not fully prevent the original problem, the new magnet arrangement specified two crucial principles of the interaction. As I added two more magnets to the construction later on, I followed the logic I had defined at this point.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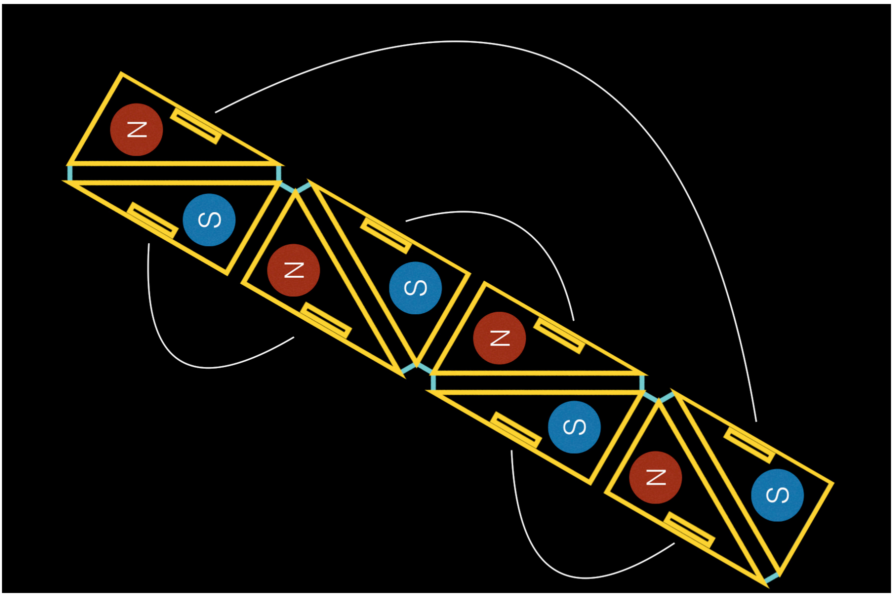
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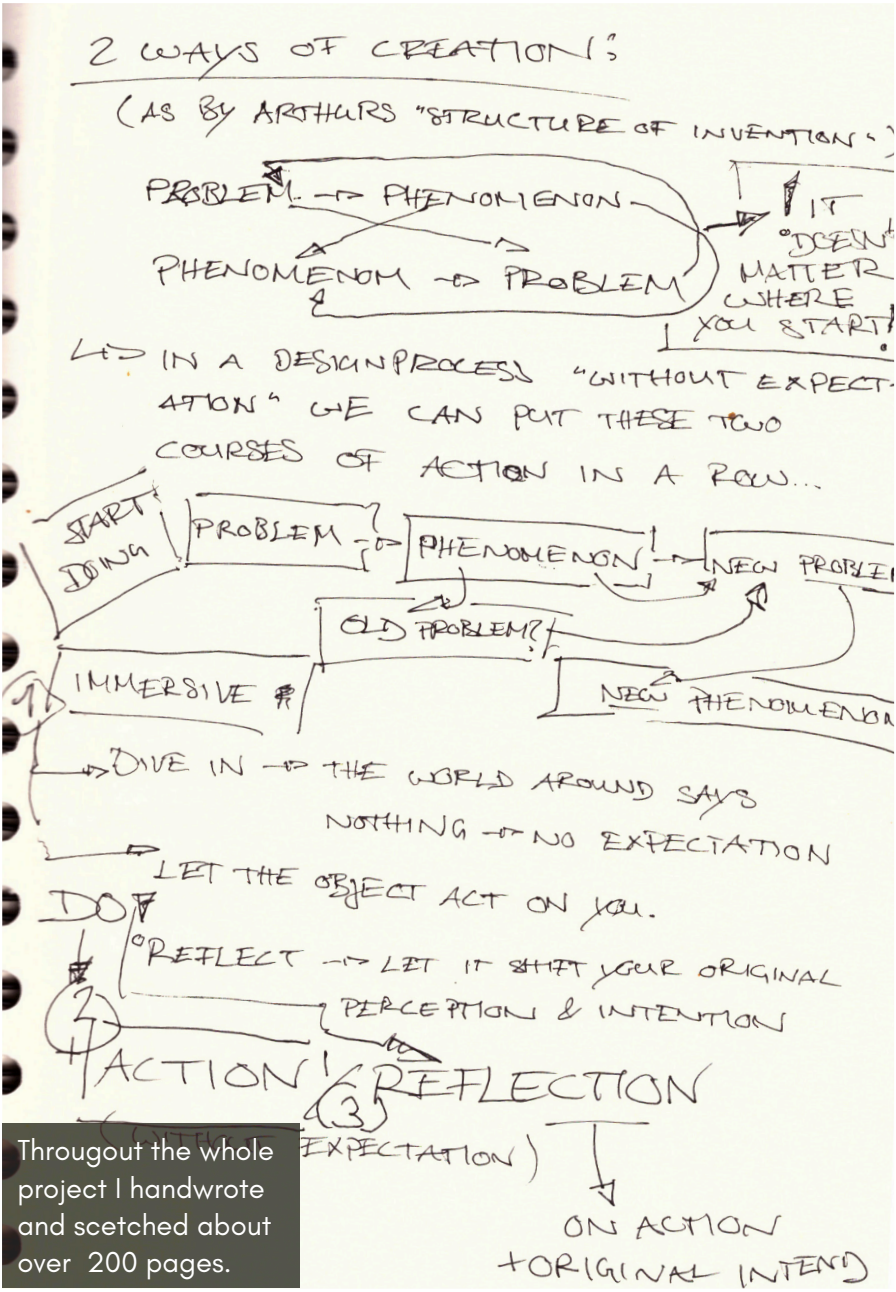
REFINE & SHARPEN

MEANING-LESS

Since sometimes there was little aimed intention (by strategy) in my process of creation, I often had to look back and get a clear mind on the course and result of my action. Observing how people played and what they thought of the building system helped a lot specifying what I had built here myself.

The question “what is it for?” remained a tricky one: Any indication of use and sense would give preconception and thereby loose potential for self-made sense. I dealt with this contradiction by making it part of the concept: In terms of obvious use and sense the system should seeks to appear as blank and empty as possible. If things were not awfully hard to describe otherwise, I would have prefered not even calling it a “building system”.



Througout the whole project I handwrote and scetched about over 200 pages.

NAME AN ANONYMOUS

I took the idea of meaninglessness further the naming of the project. For the following reasons I chose “Tambas-Char” to be the title:

Except the 6’000 people speaking Rumantsch Vallader no one knows “Tambas-Char” means “creative tinkering and handcrafting” in this idiom of the language. Unlike many of my friends I do not even speak it myself. Listening to them, I enjoyed making up the meaning of words I heard by myself. There I saw an inspiring analogy to my concept: Not having or knowing things is the ideal condition (or even requirement) for self-making them. So even though there is a specific meaning behind, “Tambas-Char” remains blank for self-made sense to anyone (except my friends). Best case people would learn the expressions meaning without words - just through experiencing the prototype and making their own sense of what they are doing.

https://www.srf.ch/radio-srf-3/highlights/allegra-rumantschs/facts-figures-zur-romanischen-sprache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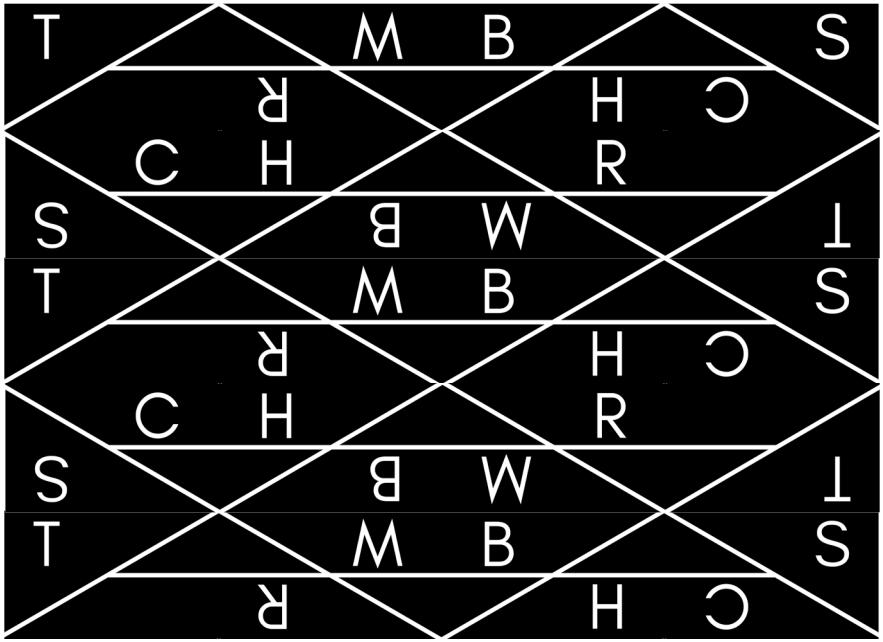
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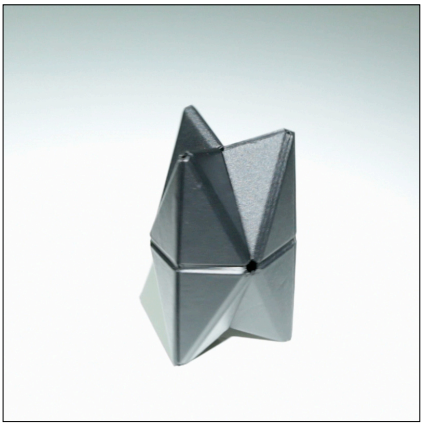
FROM QUICK & DIRTY TO SLICK & WORTHY

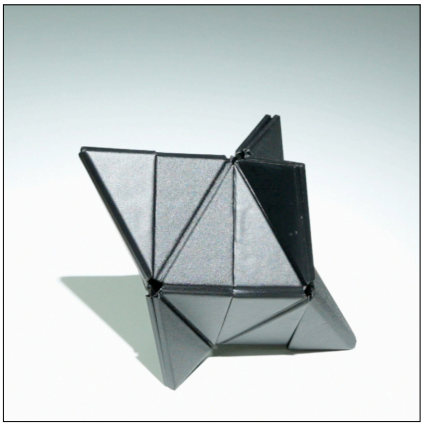
QUANTITY & QUALITY

In development I mainly just used material that was available and "satisficing" to build my prototypes. This often raised new problems but - as mentioned - those were part of my strategy. Remember: I would have never got to my final concept if the "Gaffa Tape" I wrapped my first prototype with was wide enough to cover full sides of the cardboard-tetrahedron.

But for my final prototype I decided to go one step further than a functional protoype: I wanted an ideal prototypes. Playing with it was saying more than a film, thesis and documentation could ever describe - the experience of the object needed to be the highlight of the project.

However to a certain degree the experience of playing was more dependent on quantity of building elements than on their quality. Thus it was important to keep construction quick, affordable and suitable for mass production.





Materia thickness is a critical point to consider (I found out with this prototype).

CONSTANT IMPROVEMENT

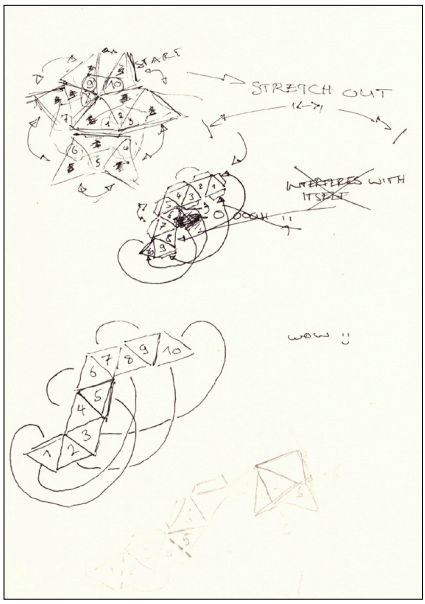
Even though I had built over 30 prototypes of Tambas-Char so far none of them looked the same. There were several elements I constantly improved:

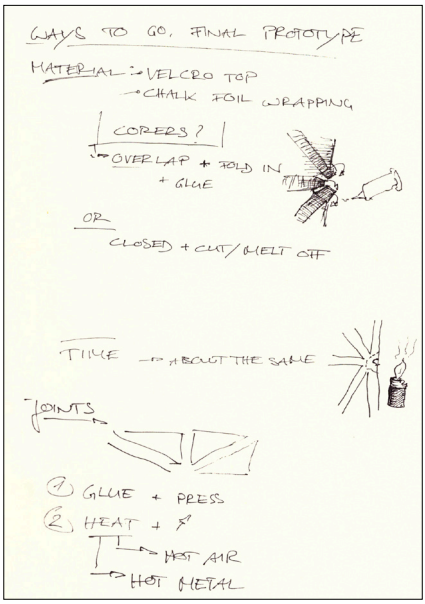
- Closing the tape: To make the construction resistant to the impacts of play, the surface could not have any gaps or overlappings of tape that could open. I moved the seam from the center, to the edges and finally to the side of he built-in plates.

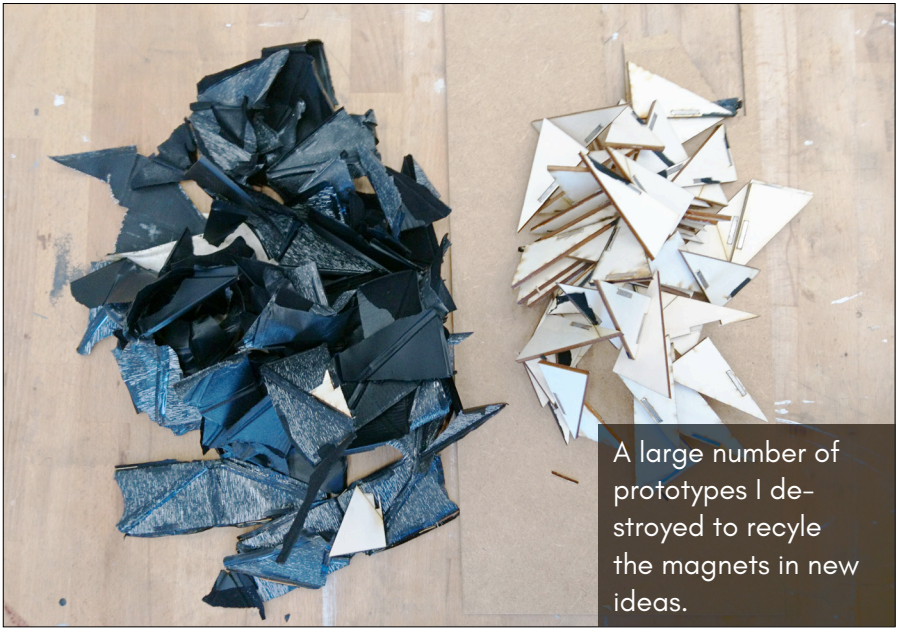
- Edge distance: As mentioned before, the distance right between the solids is crucial. Anyway I had to adapt the result of my calculations to reality by trial and error.

- Magnet force: To save time and money testing different magnets, I adjusted their force by moving their position towards each another. They had to be stable enough to build but not too hard to be taken apart.

- Corners: The most tricky thing, was sealing the corners of the (potential) tetrahedron, since bending caused an offset of the inner and outer tape. I tried pressing, glueing, cutting and melting. The best solution was cutting them to the right angle and folding them in.







A large number of prototypes I destroyed to recyle the magnets in new ideas.

FINAL PROTOTYPE

MATERIAL WORLD

Most important to me was the materials touch, sound and durability. Further it had to be available, affordable in sufficient amounts and easy to be implemented in the production process developed so far. The following options I tested in both construction and play:

Gaffa tape:

+ Worked perfectly throughout the process.

- Too narrow - to make as little seams possible.

Vinyl foil:

+ Is cheap and available in large format

- Looks and feels cheap in any format

- Too thin to cover the structure of wood and magnets

- Rips apart when swinging around forcefully

Book binding leash:

+ Very nice look and feel

- Not hard enough on corners - they loose the snapping sound

- Neither flexible nor durable enough for impulsive playing

- Not self adhesive

Tent-repairing textiles:

+ Resistant
+ Textile touch
- Too expensive

Chalkboard textile:

+ Surface to paint and write on.
+ Nice, rough touch but got sticky when no chalk on it
- Hard to bend over edges
- Impossible to seal with itself
- Became and stayed very smelly when lasercut

Chalkboard foil:

+ Surface to paint and write on
+ Slick touch but texture with grip.
+ Very nice sound when clapping
- So thin the structure of wood and magnets beneath was visible
- Not resistant enough towards repetitive movements

Velcro foil

+ Smooth and elegant look that smoothened bumps.
+ Easy to work with: melt- and foldable.
+ Resistant
+ 95% of users loved the material
- However two people described it as so unpleasant, they could barely touch it. What a pity but I had to take this serious.


The original:gaffa tape was my first choice.


Is and looks cheap: Vinyl foil.

Not strong enough:
Book-binders leash.

Velours: Elegant but
“untouchable” to
some people.

SELF-MADE SOLUTIONS

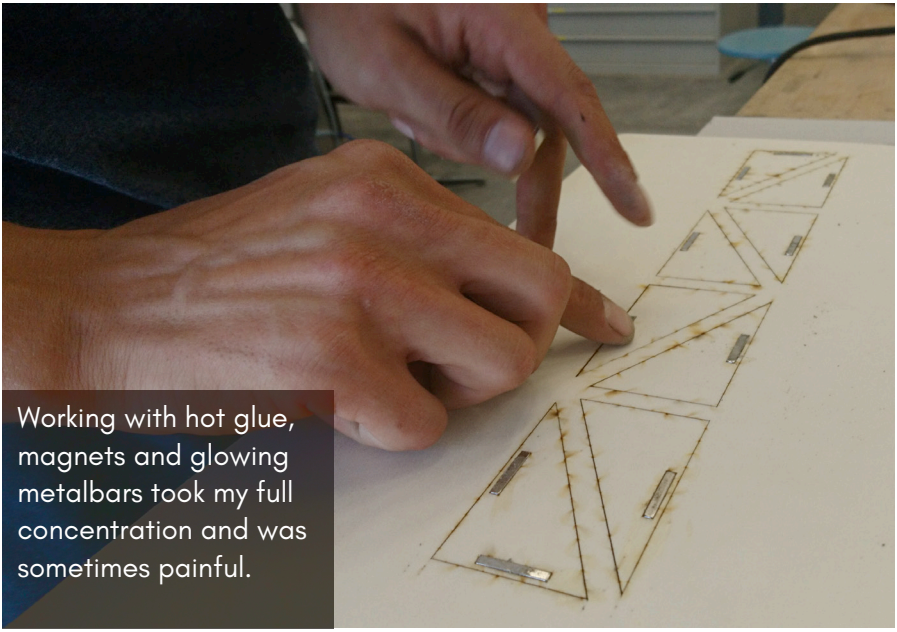
As I run out of options for material I started experimenting with what I had found so far: I sanded, varnished, melted, glued and even burned surfaces in order to improve their quality for production and play.

The final solution was combining two foils of complementary quality: The velour foil provided strength, weight and fleeciness underneath whilst chalkboard foil on to made it rewritable, easy to clean, sealable and pleasant for everyone to touch.

With heated air I slightly melted materials before I pressed edges into shape with a lasercut form and a wood hammer. Holding a hot metal bar close, the magnets pulled the prototype towards and thereby sealed the overlapping foil on the narrow sides.

Using three different blueprints for wood, top and bottom layer I covered the edges only with thin chalkboard foil to give snapping compartments a conspicuous sound.

Finding and making the perfect material myself was a joy.

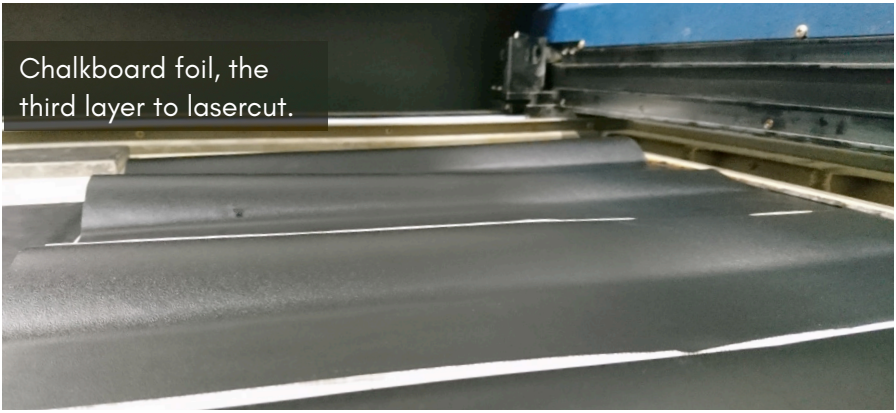


Working with hot glue, magnets and glowing metalbars took my full concentration and was sometimes painful.

MASS PRODUCTION

With every prototype I built, I took production time and resources into account: Every brick had to be produced identically, in little time and without waist of mental or physical resources.

This challenge often draged me into further thinking about construction and new solutions (of which sometimes I did not even see the problem beforehand). Often I ended up with very complex constructions which I could simply once I had proven the concept.



Chalkboard foil, the third layer to lasercut.

No worries, the material inbetween the cutouts wont be waisted.

Systematic building system building...

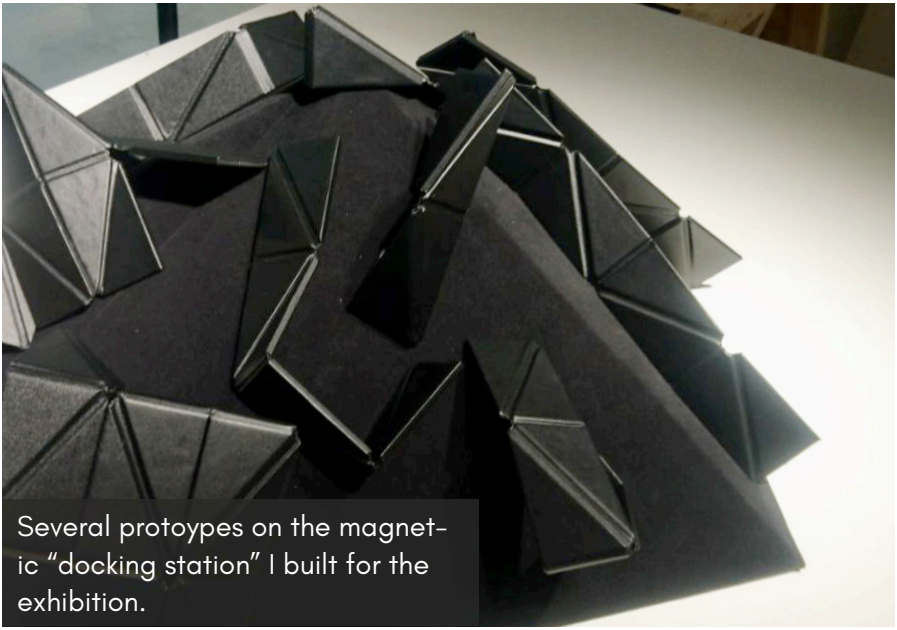
A SELFMADE THING & SENSE

THE RESULT

At the very beginning of this project I set myself specific requirements for the system that I planed to build and how it is experienced (see project proposal: "The system should..." / "The audience/should...").

Looking back at presentation slides and notes was a delightful surprise: Despite the rather impuslive, jumpy and chaotic course of action I took, Tambas-Char seemed to meet all targets set. This was remarkable in context a of design process that specifically involved "loosing track" in many regards. I think it highlights the importance of those moments I was looking back, reflecting my action and redirecting it.

Further I defined certain aims towards the project as a whole ("my project should..."). As most important I considered the last statement that I put on this list; and even though the answer is not certain at the time I write this I can already say that I achieved 50% of it for sure!



Several protoypes on the magnetic "docking station" I built for the exhibition.

THE EXPERIENCE

Looking back I am happy to call this one of the most intense, exciting and pleasurable experiences I have ever had designing as a professional. It is hard and maybe unprecise to analyse this, but there is ceraitnly many valuable lessons and memories I want to take on to my future doing.
In many regards it has been a constant balancing of inner and outer intentions: Being confident enough to realise your own vision without ignoring what others say, following your guts without shutting your eyes, take off in fantasy and get groundet by reality. I would not say I did this for the first time. But the consciousness, joy and intensity I did it with had enormous impact on the development of both product and process of my own design.

Sometimes I neither I fully controlled nor fully understood what happened. But I fully enjoyed. Just as like this image happened.

THANKS!

Having such an exciting experience, fully elaborate prototypes and so valueable insights about my own design process in the end would not have been possible withouth the help of great people around me:
First of all I want to thank my academic mentors Karmen Franinović and Luke Franzke for letting my find and choose my very individual way of action. Their advice and backup was crucial to the confidence I needed to risk going my own way.

Likewise the support of my family was an essential source of motivation and encouragement. Opposing to this, much thank goes to Nicola Tissi for testing my confidence and prototypes to the limit and without mercy. He further was involved in production and construction of exhibited object and visual material.

Further Barbara Bucher and Jessica Asante deserve thanks for enduring their housemate's creative escalations and providing kitchen tools for prototyping. Finally I want to thank all my friends from Scuol for coming up with a name for my product and going out with a guy obsessed with tetrahedrons.

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Img. 9: Tibbits, Skylar, et al., “Aerial Assembly”. (08. 02. 2017). http://www.selfassemblylab.net/AerialAssemblies.php.

Img. 10: Tibbits, Skylar, “Fluid Assembly Furniture“, (08. 02. 2017). http://www.selfassemblylab.net/FluidAssemblyFurniture.php.

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