

Three glowing cubes are positioned around the central text. A red cube is in the top-left, a green cube is in the top-right, and a blue cube is in the bottom-right. They are all slightly out of focus, creating a sense of depth. The background is dark with some faint, thin lines.

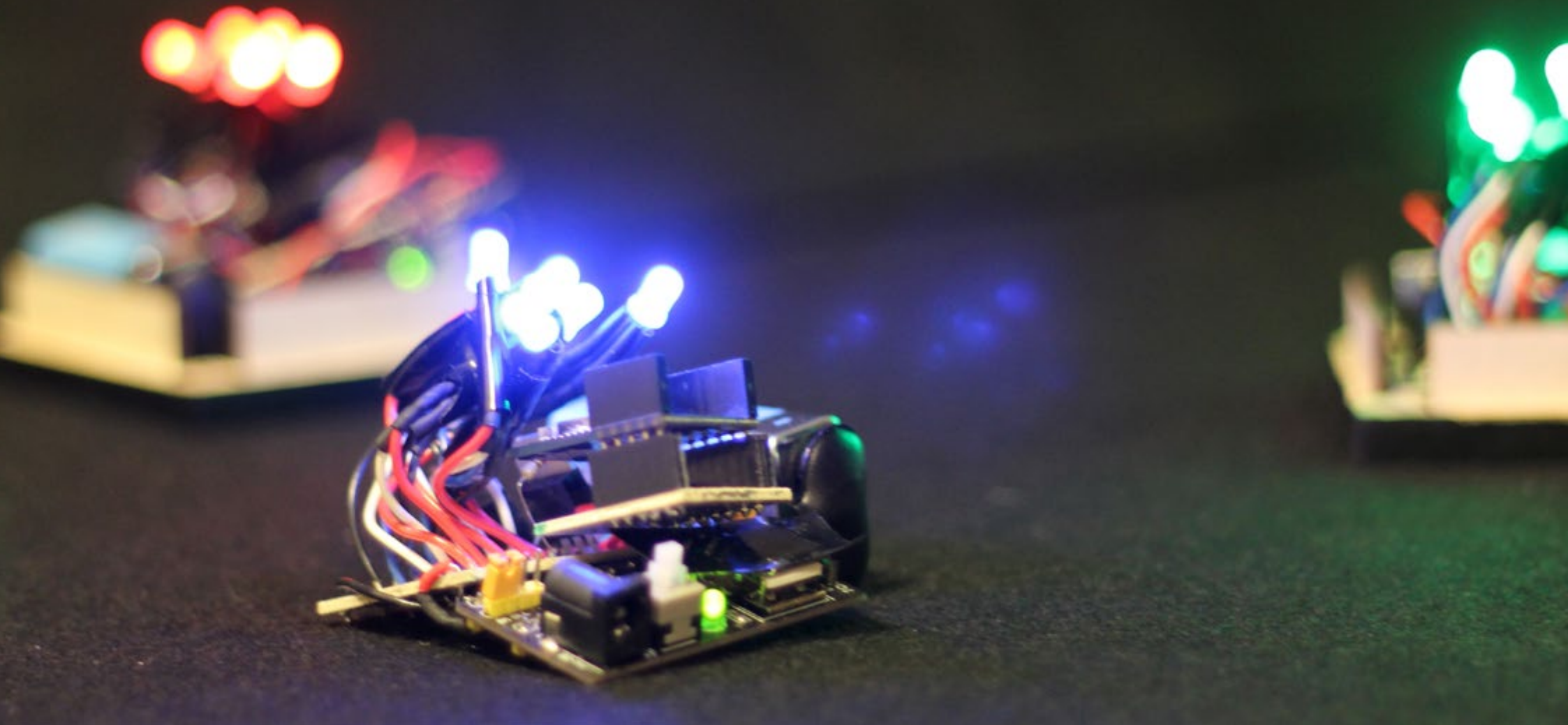
LEDs Blend

Report TDT4262
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PREFACE

The assignment, given by the director of Vitensenteret Arnfinn Rokne, was to make an interactive exhibit. The target group would be children between 4-14 years. The model should be educational while having depth. In this way, the model will not only catch attention, but it will keep the contestant entertained at the post ideally for more than two minutes.

Given the task above, we started putting our heads together. A couple of weeks later the concept was clear: 3 LED cubes representing colour mixing as it happens in visible light!

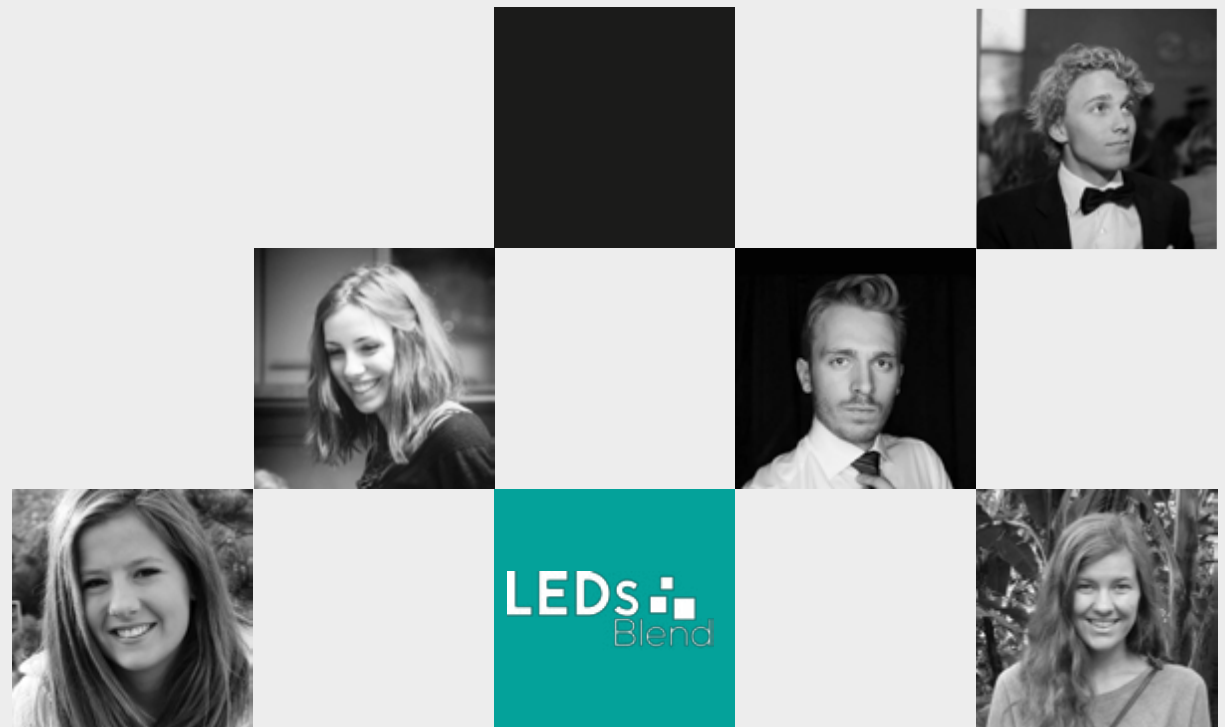


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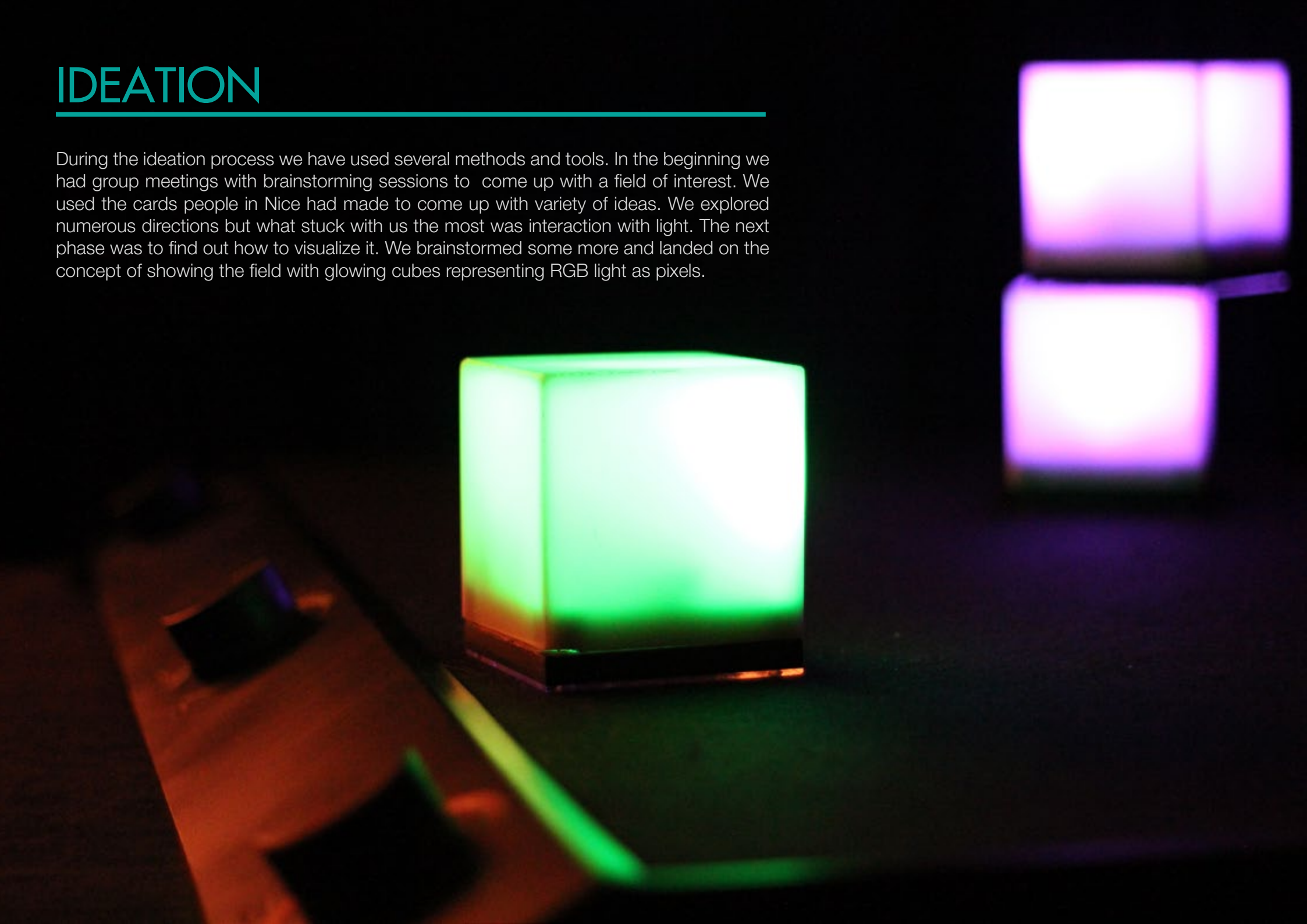
1. INTRODUCTION

This is a report for the final assignment for the course TDT4262, Prototyping Interactive Media. We are five students: Sigurd Kalvik, Ane Otterlei, Nora Skarre, Herman Slyngstadli and Gergana Tatarova. Here we will explain our design process including decisions we have made and a presentation of the finished product model.

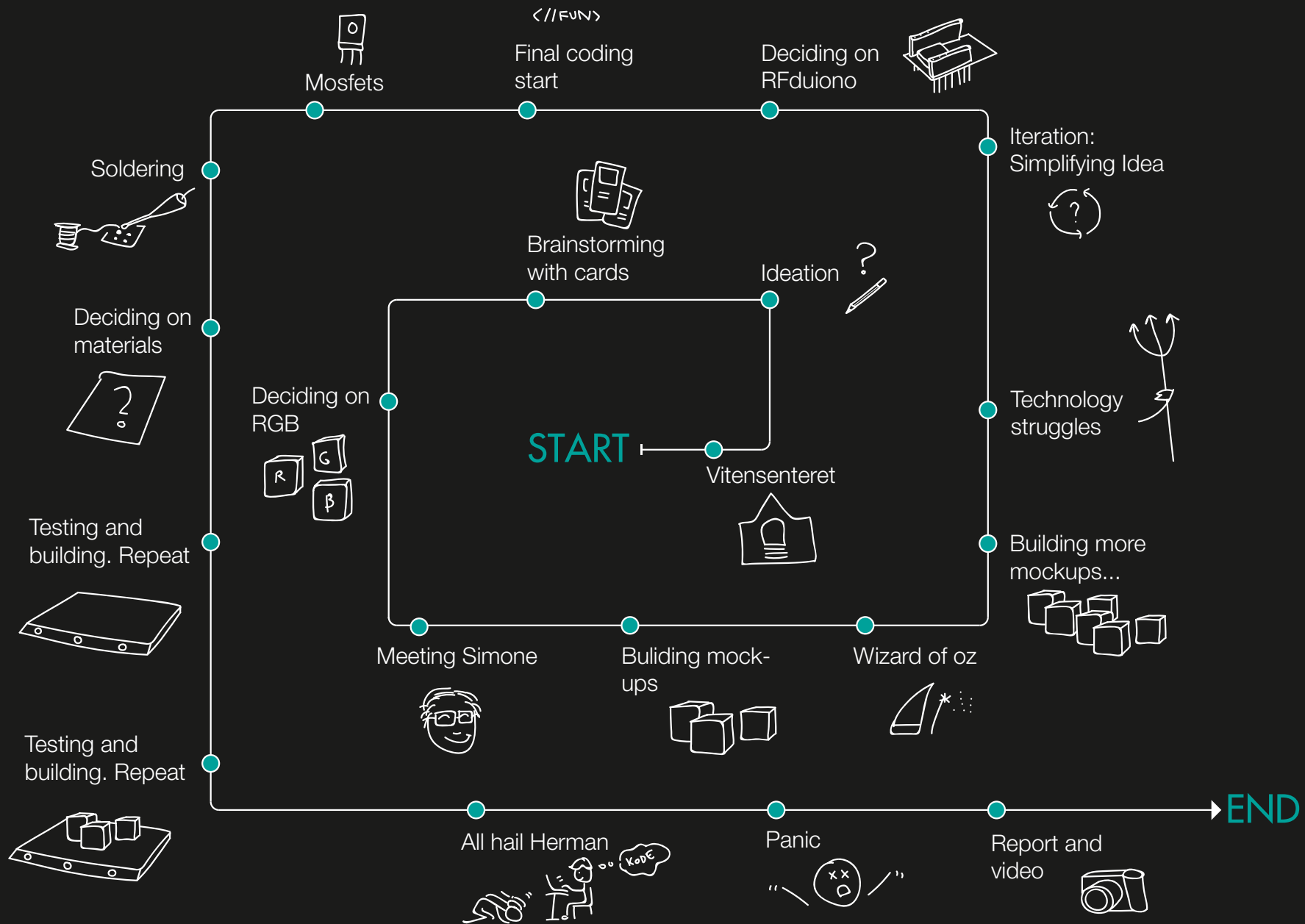


IDEATION

During the ideation process we have used several methods and tools. In the beginning we had group meetings with brainstorming sessions to come up with a field of interest. We used the cards people in Nice had made to come up with variety of ideas. We explored numerous directions but what stuck with us the most was interaction with light. The next phase was to find out how to visualize it. We brainstormed some more and landed on the concept of showing the field with glowing cubes representing RGB light as pixels.



2.1. TIMELINE



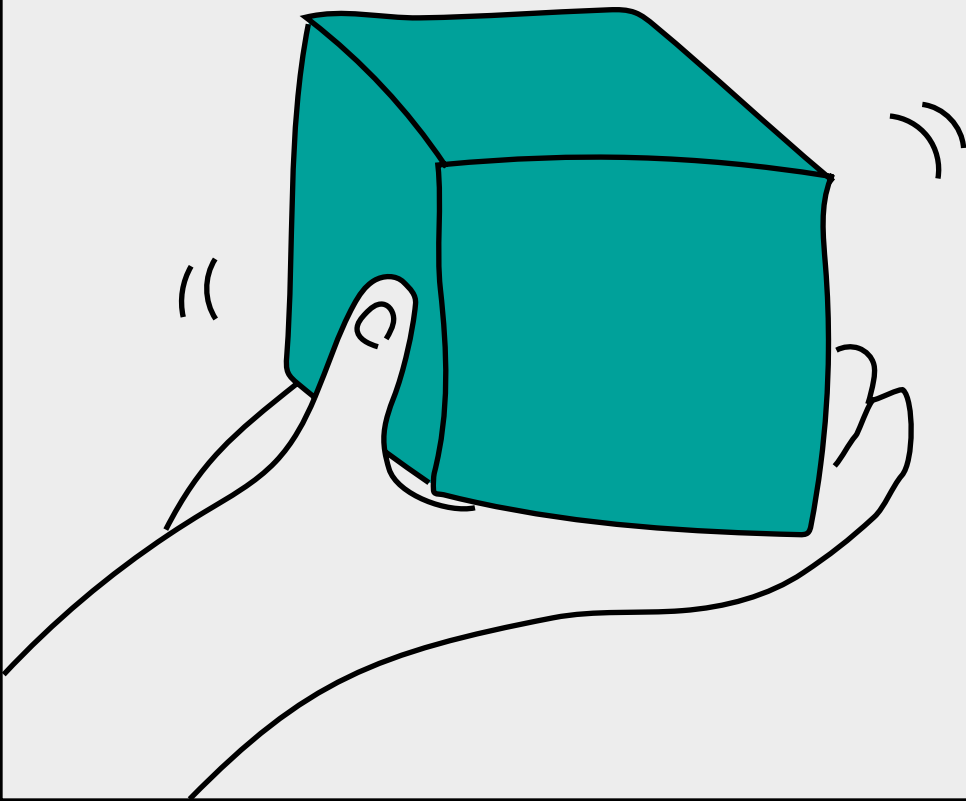
3. INITIAL CONCEPT

The initial idea was to make glowing cubes representing RGB that interacted with both the user and each other.

We wanted to teach children about light, and how you can mix RGB light to make a broad spectrum of coloured light just by adjusting the intensity of each colour.

The cubes would ideally glow smoothly on every surface and not have any bottom or top.

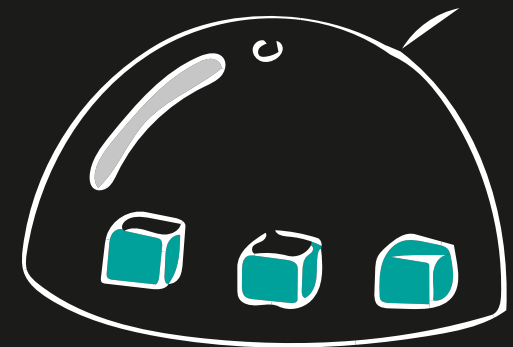
1. Cubes vibrate when lifted



2. Pipette for colour picking



3. "Dome" for colour blending



4. Scanner for colour picking



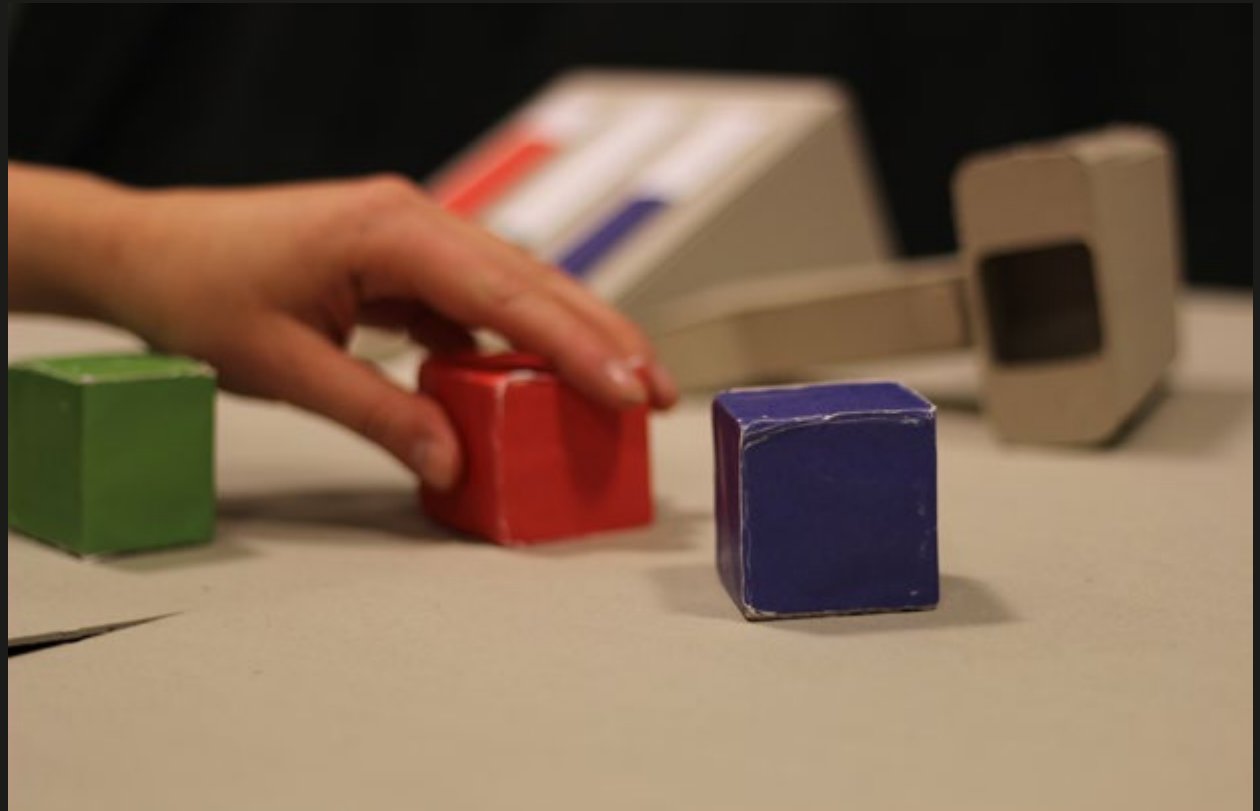
4. WIZARD OF OZ

We did a quick mock-up for our Wizard of Oz test. It included a big piece of cardboard as the table surface, three cubes in RGB, a control panel for the adjustment of their intensity and a colour picker.

The idea was to have three cubes on a table that the user could move around and when the cubes collided they blend their colours. With the control panel, the user could adjust the intensity of each cube and experiment how this creates variety of colours. To add an extra dimension to the concept, a colour picker was also included so that the user could explore the room and pick a colour that will display on the cubes.

The Wizard test's feedback made us realize our concept was a bit too complex to grasp. People got a bit confused and their focus was not where we wanted it to be. They did not even realize at first that the cubes were movable, because there was so many other things going on with the buttons and the scanner.

We had to clean up our idea and make it more intuitive - the colour picker/scanner had to go. Additionally the control panel had to be re-designed and reduced in size. After all, the main attraction of the product was the RGB cubes. It is also worth to say that the wizard test was a bit hard to conduct because we did not have any electronics and had to simulate the colour changes with pieces of coloured paper, which did not always seem credible.



5. FINAL CONCEPT

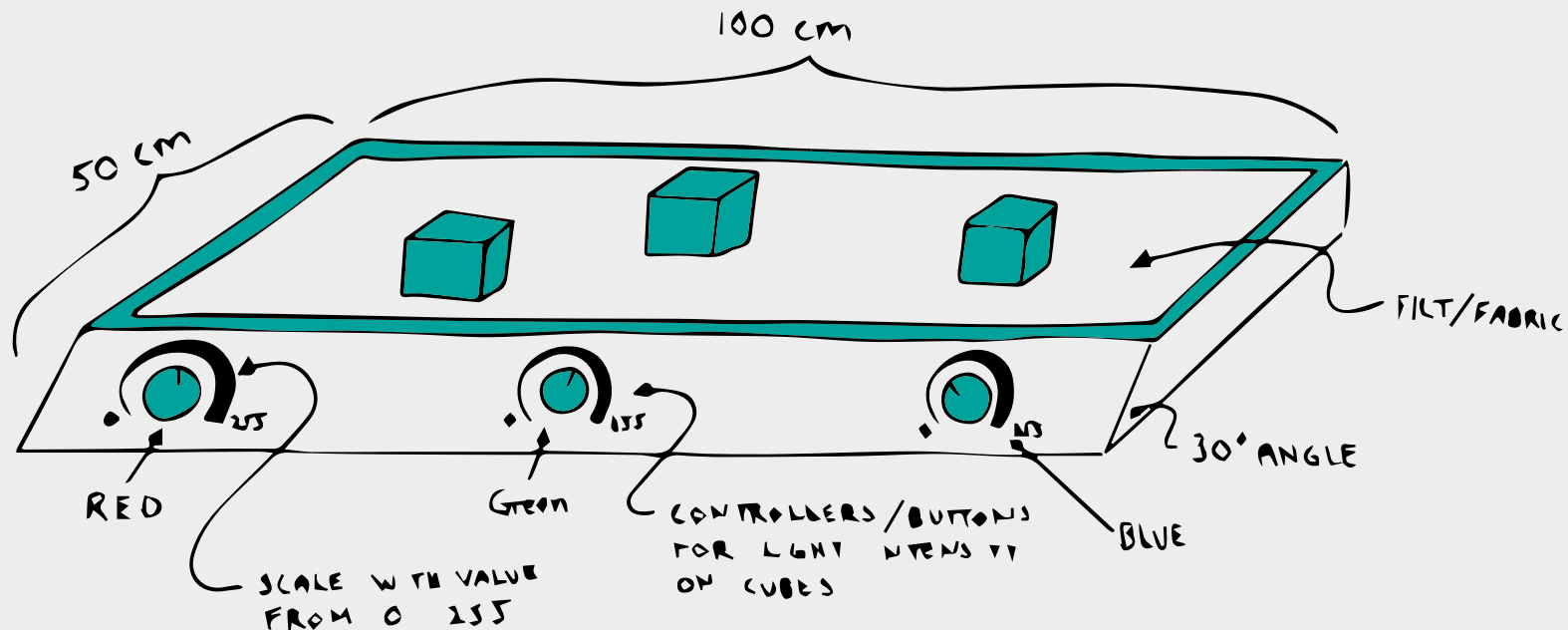
The idea of the cubes is to teach children about light and colours and how every colour could be made by mixing red, green and blue. In the computers, the component values are often stored as integer numbers in the range 0 to 255. This concept is also used in displays, as pixels. A display has several million pixels, where every single pixel is a combination of red, green and

blue light that can be combined to every colour. This is something we wanted to show by making the light sources come from cubes, similarly to the squared pixels.

Each cube represent their own colour. One for red, one for green and one for blue. The cubes interact with each other and with people playing

with them. They communicate wirelessly to sense when close to each other to blend their colours.

The cubes are placed on a custom made table which has a surface of filt on the top plate. On the front panel there are three potmeter buttons that range from 0-255 and controls the intensity of light in each cube.



6. ROAD FROM CONCEPT TO PRODUCT

6.1

FINDING THE RIGHT SENSORS

Finding the right sensors to get the cubes communicate wirelessly with each other turned out to be rather difficult. The first idea was to implement the tiles from Nice in the cubes. We had a meeting with Simone and he explained us how we possibly could make this work. The tiles were also small so it seemed to be a good option. The problem, however, was that the delivery time was about two months, and we could not wait that long, so we decided on using RFduinos and program everything from scratch.

We also spent a lot of time researching and testing out different sensors for achieving communication between the cubes. Some alternatives we looked further into were NFC, Hall-effect, motion sensors and IR sensors. However, there were difficulties with them all. The NFC and Hall-effect sensors demanded too much accuracy for the cubes to sense each other, as well as the NFC scanner is quite large. If we had used the IR-sensor it would have to be on the outside of the cubes, which would interfere with the smooth surface we had planned, and block light spreading.

Eventually we found out that the RFduinos we were planning on using had a built in bluetooth function which we could make use of, and so we did.

6.2

ELECTRONICS

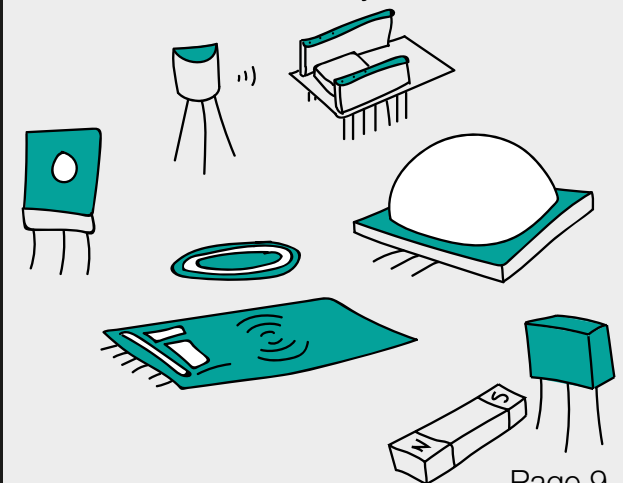
In order to achieve our goal we had to make the cubes communicate wirelessly between each other and the control panel. This required the use of multiple RFduinos which had to constantly transfer string of information between each other. Each cube has an RFduino and multiple LEDs for consistent light. In order to power them we needed to use MOSFETS which not only let us connect and power as many LED as we want but use just 3 PWM pins.

We figured out how a set up using N-type MOSFETS and common cathode LEDs works. But it turned out that the LEDs we had to use were common anode ones and required P-type MOSFETS which are much less common and due to the RFduino we needed ones that run on 3.3V. We got the right MOSFETS and learned the physics around them to understand how to connect

them. Besides some confusion regarding the `digitalWrite(Red, HIGH)` meaning red off, everything turned out well.

Regarding the power situation, we had ordered Li-Ion 3.7 rechargeable battery. These were supposed to power the RFduinos and the LEDs, while making it easy to charge the cubes with a micro USB. Unfortunately the voltage difference wasn't enough to drive the MOSFETs and the LEDs were barely lighting up when we tried this setup. So we needed 3.3V for the RFduino and 5V for a nice bright light. Therefore, the power divider YwRobot came into the equation to give power the way we needed it from only one 9V battery.

At the control table we have 3 potmeters used for controlling the values of Red, Green and Blue intensity from the user.



6.3 CODING

After we found that the RFduino was our best option for communication between the cubes, we had to figure out how to make the setup.

Usually there's a master and slaves. But in order for all the cubes to know where the others are we needed all of them to be masers somehow and since there cannot be more than one master at a time we had to switch roles. This was rather difficult and not quite as previously explored as we hoped.

Not only did they have to switch roles, the master had to send out a string of information (all the cubes positions and current roles) before handing in its mastery to the next cube. We used the exact same code for the three cubes!

We programmed a fourth RFduino to control RGB intensity. This fourth RFduino created a lot of problems for us, as every time we used it, the values it sent bugged the connection between the cubes. This might possibly be a hardware problem as the RFduinos can only output power to three ports at the same time.



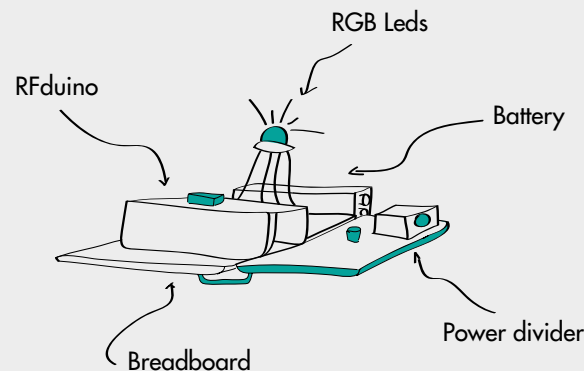
6.4 SOLDERING

After we found a setup that worked (See Fritzing attached), we had to solder a smaller and more robust version.

The design had to be small enough to fit in a cube with a size that a child could use. It was also important to put the RFduino in the middle of our setup, so that the bluetooth signal would have a constant radius.

We were all relatively new to soldering and it was fun to learn that cool skill. We were failing a bit in the beginning but then we also learnt to check the circuits in a logical manner and find our mistakes.

After a while, we were able to fit everything quite tightly constantly coming up with better arrangements. We also had to modify the power board, so it fitted better with the other parts, as well as it got smaller. We were pretty happy with the results!



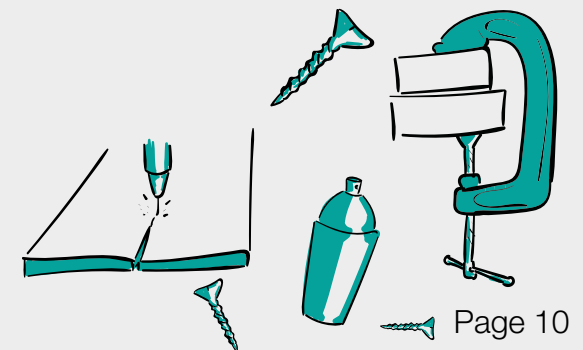
6.5 TABLE

We built the table in 6mm MDF by laser cutting, gluing and painting.

After testing the dimensions in real life we decided to go a bit bigger than we expected initially - more exactly 100 cm x 50 cm. This way it is inviting for more people to participate.

The process of building the table was pretty straight forward – laser cutting the pieces, gluing them together, covering the table plate in felt and painting the surfaces black. The front plate has a 30 degree angle and is also the “control panel” where the buttons for adjusting light intensity are.

They were also lasercut and intentionally placed far from each other to promote interactivity.



6.6 CUBE

We wanted to find a proper semi transparent material that spreads light well. We started experimenting with acrylic, which we laser cut and polished with sandpaper to get a frosted surface. This did not spread the lights very well so we found another material, a polycarbonate called lexan.

This, however, was not suited for the laser but we cut it by hand, put it together and found out that the light spread very well. It seemed to be the best option for us, but then we started thinking in the direction of vacuum forming transparent plastic and lacquering the inner surface.

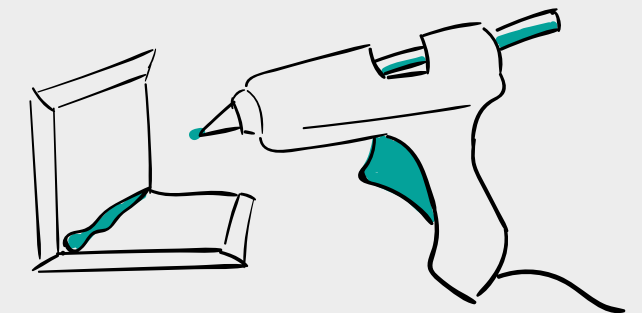
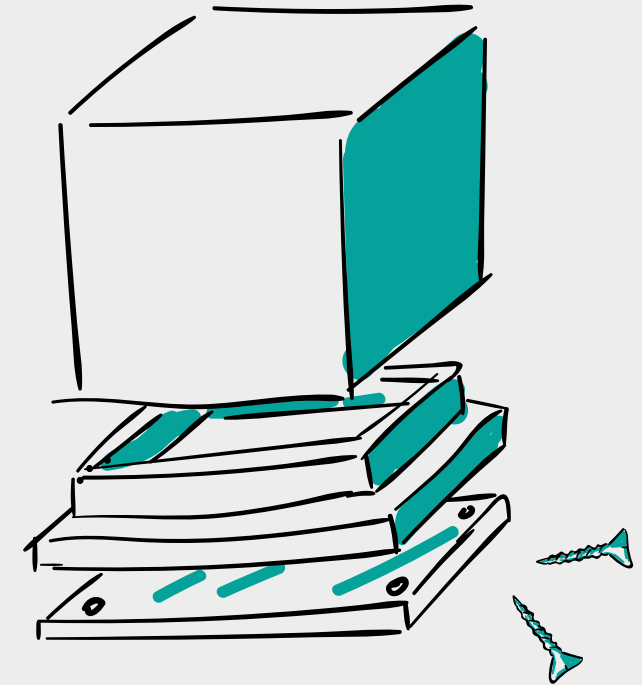
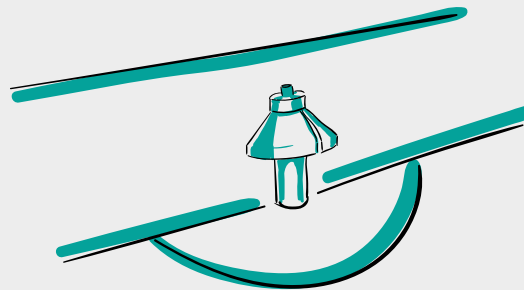
Because of difficulties in the technical area, we decided that the cubes also were going to have a bottom in laser cut plywood which all electronics would be attached to. This would give us the possibility of disabling the cubes to change batteries. A vacuum formed cube now seemed to be a good option since it gives one open side and the rest closed with a smooth and solid finish. However, this did not turn out the way we pictured, and we decided to give the former idea another chance.

Since the lexan material we ordered did not arrive in time, we made the cubes out of another semi transparent plastic material.

This was neither suited for the laser nor the vacuum former, so we had to cut it out by hand and use the router table to get edges in a 45 degree angle. We glued the pieces together and sand papered the edges carefully. The result was amazing.

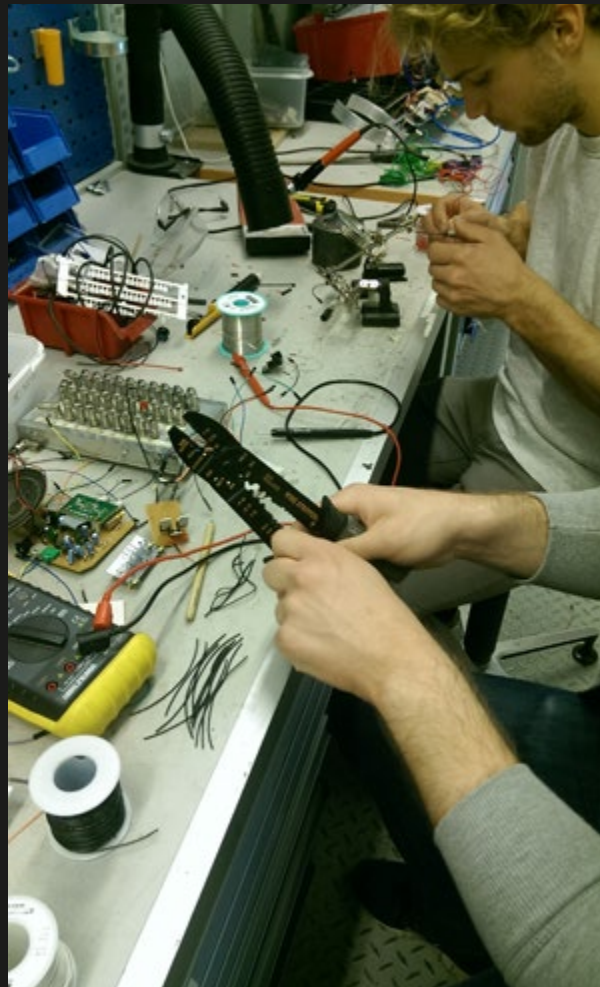
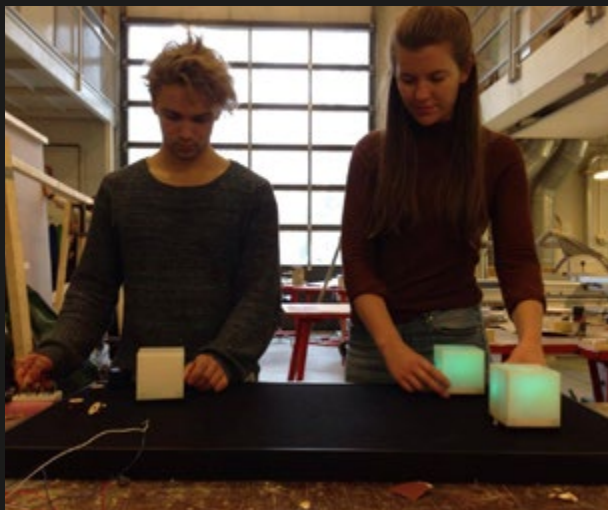
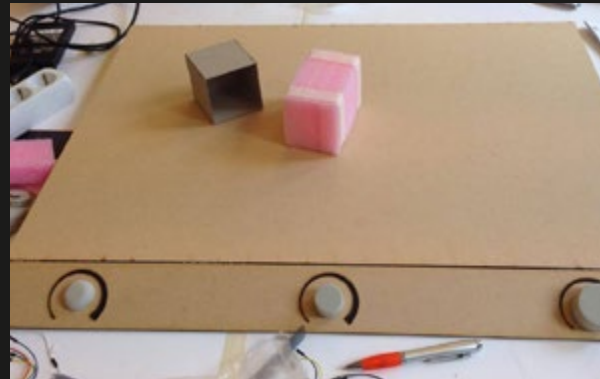
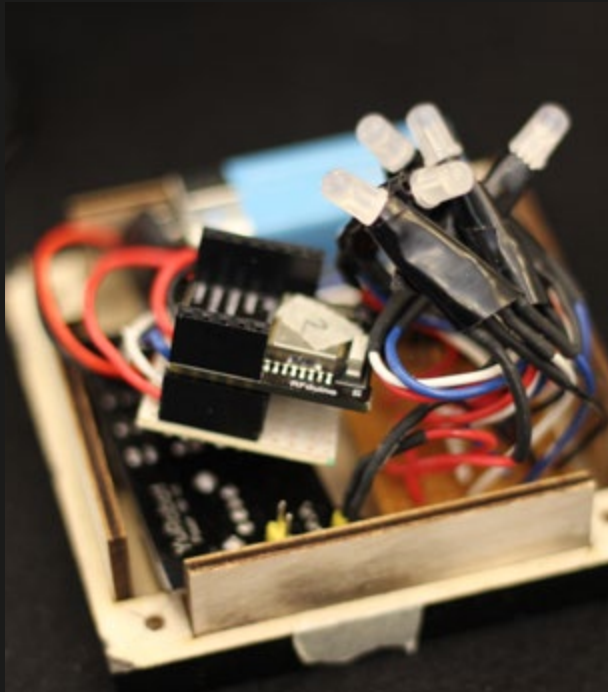
We made the bottom of the cubes out of laser cut plywood which we lacquered in black to match the table. We also laser cut some small squares that we glued on to the edges of the plastic parts which we then assembled on to the bottom of the plywood.

The very bottom has a plastic part in 2 mm acryl which we laser cut and assembled on in the same way. This plastic makes the cubes glide well on the felt surface on the table.



6.7

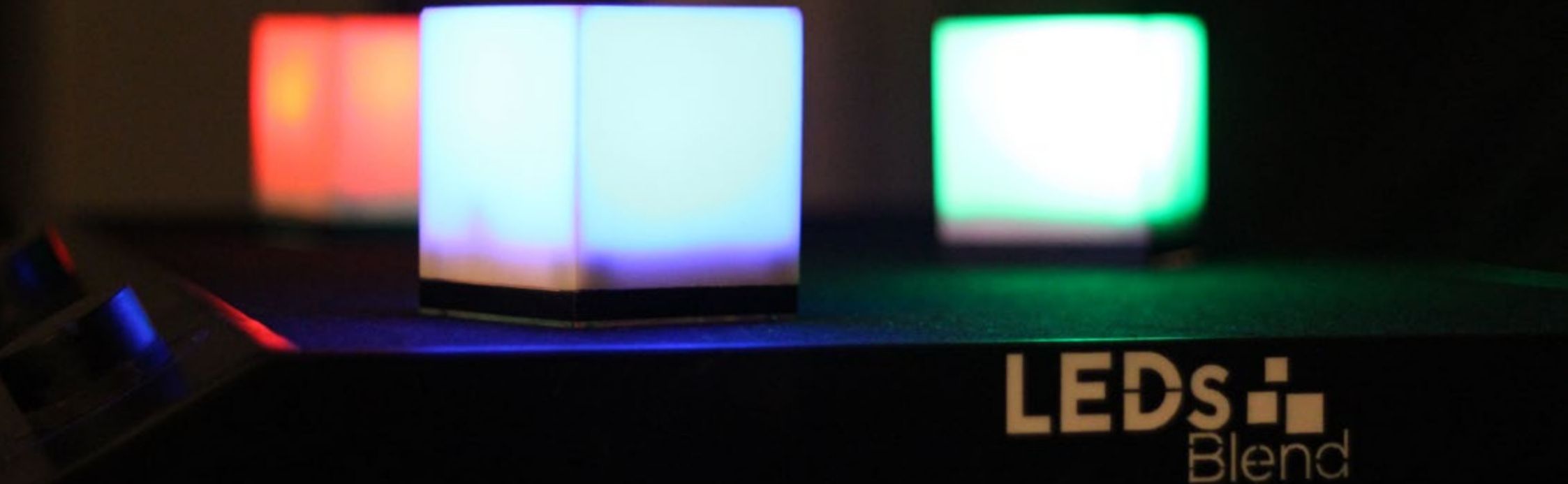
SOME PHOTOS

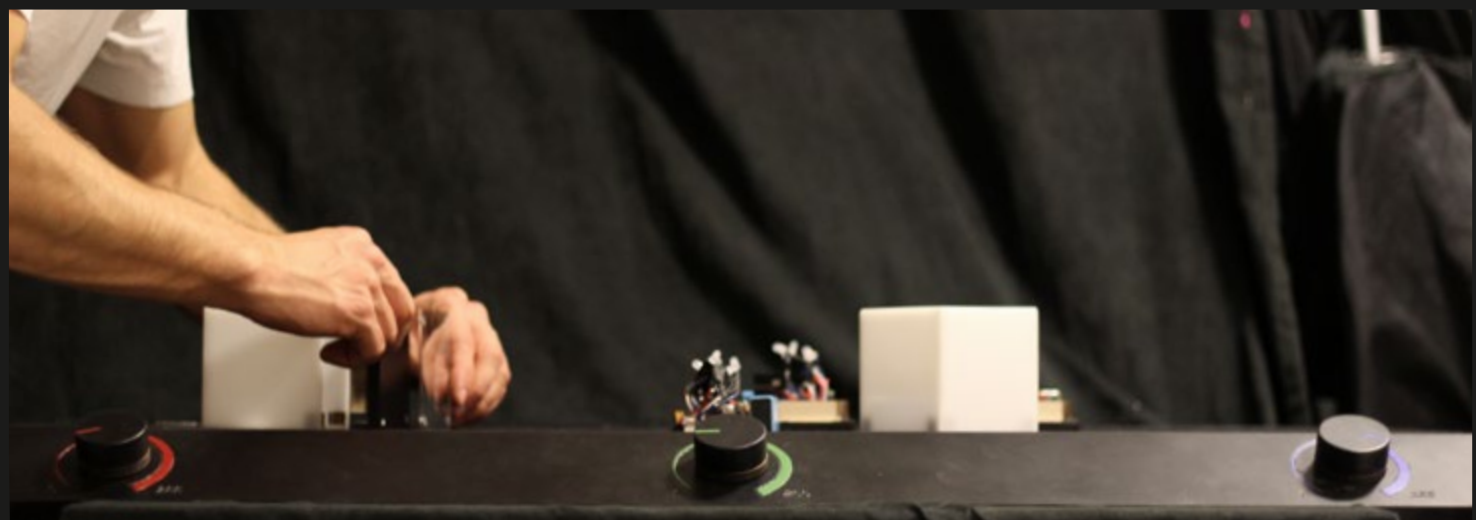
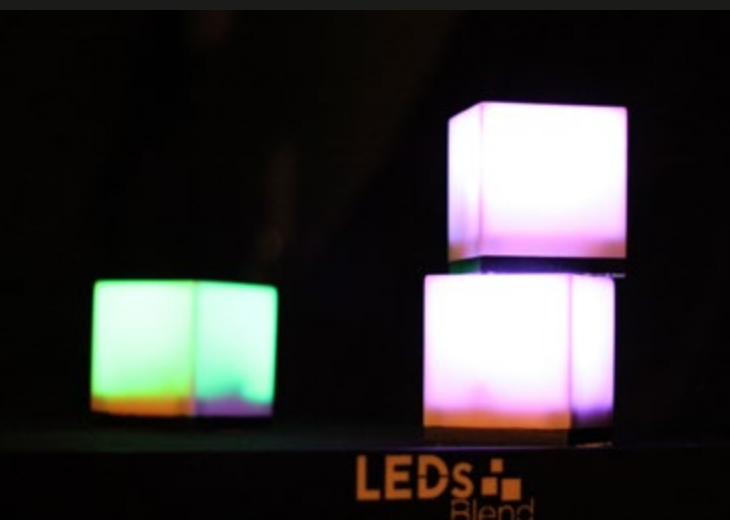
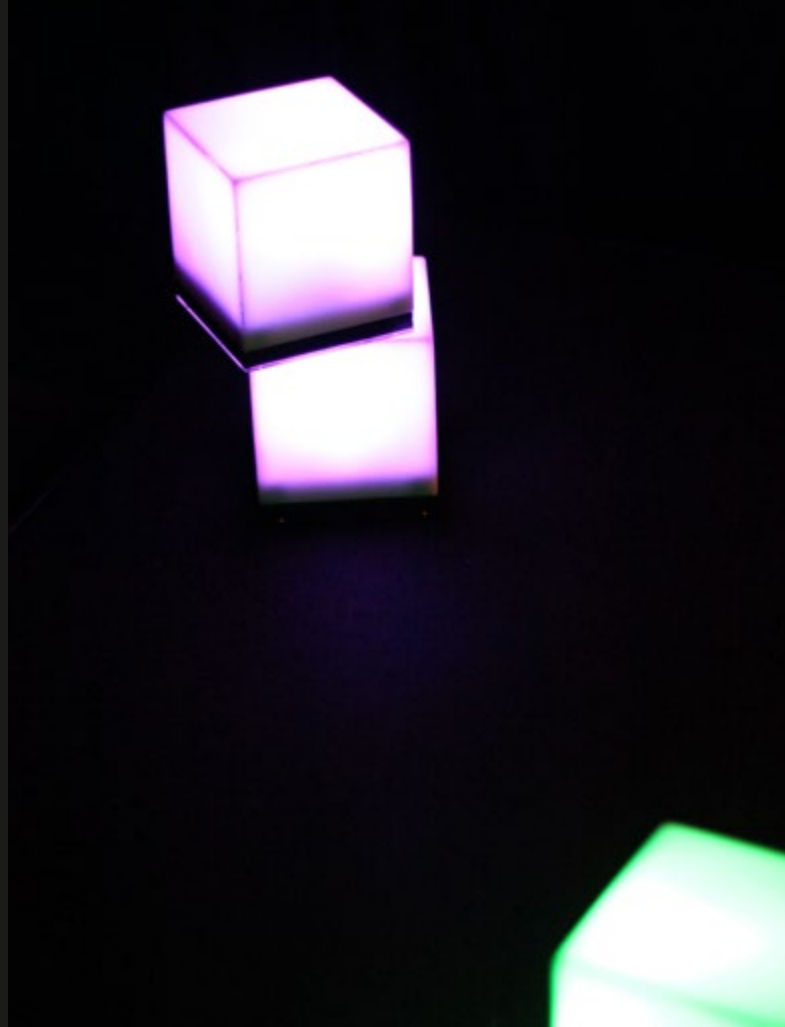
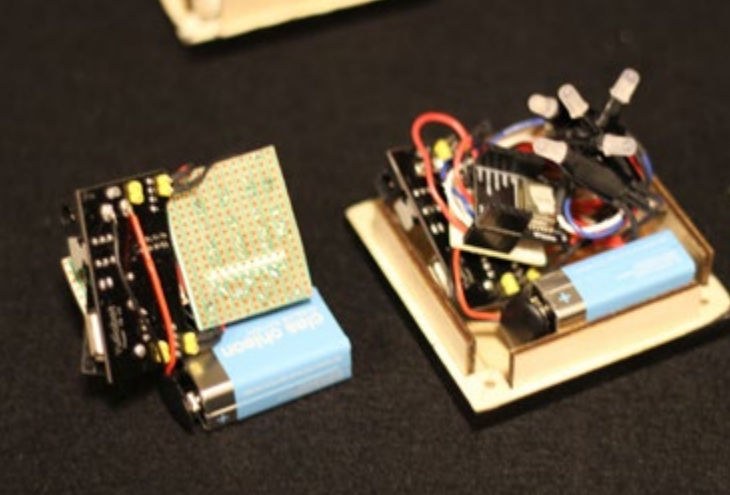


7. RESULT

We encountered a few difficulties the last day before delivery when the potmeter buttons for the control panel would not work properly. We lost a lot of hours trying to fix it, but it would not co-operate, so we ended up with the buttons being there as a reminder of the potential for future development of the product.

However, the result without the buttons is still amazing. We played with the cubes and watched them switch between many beautiful colours. It turned out to be a really entertaining product, and we believe that it will be a hit among children!





8. EPILOGUE

After a lot of late nights and uncertainty regarding if the code would work or not we can now safely say that we are satisfied with the results. We managed not only to make the cubes light up and communicate wirelessly with each other but also to make them respond to external movements and adjustments on buttons from the contestants. The result is a great exhibition not only for children, but for adults as well. It is an interesting and funny way to teach children about lights and colours, and we believe that it is a great idea with promising potential for further development, because after all, it is only a prototype.

If we have had more time on the prototype we would have worked more on making the code more stable and maybe found another communication channel between the cubes that don't get interfered by wifi and other signals. Additionally it would have

been nice to include a battery that could charge, and also to make a charger output that you could reach from outside of the cube. The LEDs on the cubes could also have been stronger to give even more light, and the absolute dream would have been to have a cube without a bottom or top, but smooth and evenly glowing surfaces on all six sides. Another idea that would have been fun to commit is to make the buttons and scales on the control panel to light up in the respective colours.

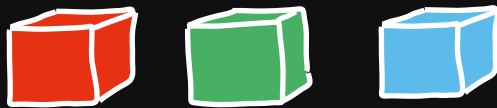
Otherwise, we have learned a couple of things throughout this whole process. Firstly, things take time. Soldering, mock-ups, prototyping and building etc. Things that seem to be well planned and straight forward actually take more time than we originally think they will. Also, ordering components and material demands planning, because the delivery

time can vary a lot. We experienced this from not getting our plastic material in time and having to go for a substitute material instead. Substitutional plans in fact turned out to be a clever thing on several areas, because changing a part of our concept into including a bottom in the construction of the cube made things a lot easier for us.

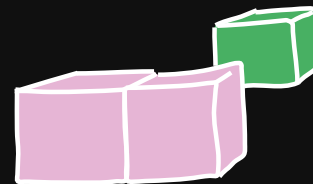
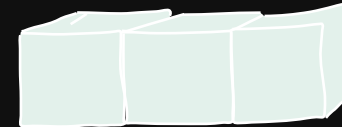
It has also been important and useful for us to work a lot in three dimensions and not only sketching on paper. As quickly as we got the ideas we made mock-ups to test the sizes and feelings it gave. During the process we have also divided the tasks among us so that we all have done things we were more or less good at from before. This has made things more efficient, but for the learning process we could have challenged each other a bit more on the stuff we are bad at.

LEDs Blend

This is the
red, green and blue cubes.



Or mix them all!



Push them together and
mix two colors