GREIF
PRINTED PROSTHESES

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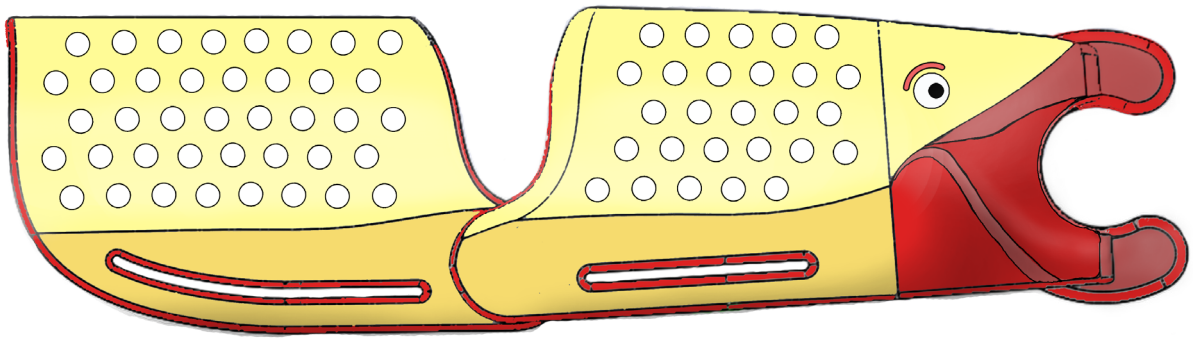
STUDENT PDF



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1. INTRODUCTION

The presented project “Hand Devices For Children” deals with a low cost, low tech activity specific hand prostheses for children of a certain age. The device is designed to allow acceptance and identification through function and aesthetics and is produced using rapid manufacturing techniques.

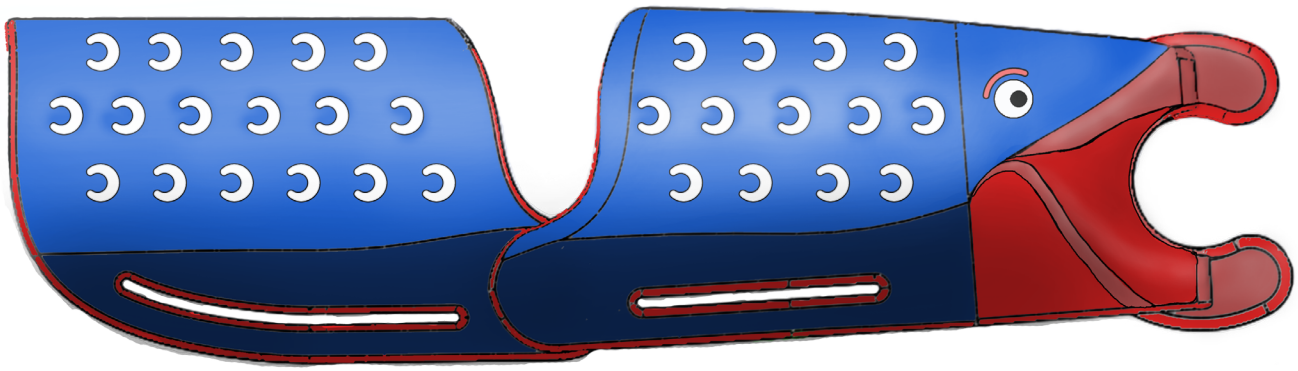
The problem formulation that was worked with is the following:

How does a children prostheses or device for the hand have to look, to work and be made to be affordable, socially accepted and identity endowing enough to be worn by a child or young adult of a certain age?

During the design process diverse methods were used, most important empirical research, drawing, modelling, questioning and prototyping.

The hypotheses that concluded of my research is the following: For children with upper limb loss, low cost, low tech activity specific devices can be of a great importance. These devices should be adaptable individually, functionally and aesthetically pleasant. Hand prostheses do not yet exist on the market in this form as only very new techniques as 3D printing and moulding allow their production.

The expected results of the project is a 3D printed prototype of a biking prostheses for children and several digital aesthetic designs, as well as a concept for a drawing prostheses including functional models and a graphical concept for a mere aesthetical prostheses.



2. PRELIMINARY SURVEY

As an introduction to the project, a manifesto was written, aiming to answer ethical and philosophical questions like the following:

Do we need a new human body?

How could this new body improve and affect our life?

Will we abandon our humanity?

Are we afraid of perfection through technology?

NEW HUMAN BODY MANIFESTO

1. *We need to extend the human body and mind – we need to design new cultural, medical-functional and emotional-cosmetically prosthetics.*

2. *We need to design prosthetics that educes the best in human and machine. We then have the chance to give dignity for example to old or so called "disabled" people.*

3. *People are not disabled – our environment is. We have to find new definitions for disability and ability.*

4. *Technology changes the way we think and feel. The design we use will affect our ability to think.*

5. *We have to deal with the conflict "machine beauty contra human beauty". We have to develop a new, an artificial kind of beauty.*

6. *We need better devices under our control – not the abolition of conscious control of our being. There is no need for devices that predict and replace human activity, but for systems and technologies that expand and enhance human possibility. We need to reassert our autonomy over technologies whenever and wherever we choose.*

7. *There are five steps on the way to create the new body which means the new human:*

    1. *Constructing the moving body*

    2. *Extending the thinking mind*

    3. *Adding artificial senses*

    4. *Defining the new appearance*

    5. *Direct interfacing of machines with human beings*

Working with this manifesto, I decided to use new technology such as rapid manufacturing in order to contribute to step one, constructing the moving body and for defining the new appearance.

The technical field I wanted to work in, the field of rapid manufacturing is in a phase of fast development, offering new techniques and materials every week. Geometries that could not be made with any other machine before allow to develop new products and applications. Using rapid manufacturing techniques, products can easily be parameterized and therefore individualized and personalized very economically – which is an essential argument for my work.

3D printing allows to work economically, with totally new geometries and and parametrizable results

AMNIOTIC BAND SYNDROM & UPPER LILMB LOSS

During my research, I quickly found a problem where this idea could have a relevant impact.

Amniotic Band Syndrom

Children with upper limb loss or congenital disorders often do not get prostheses until they reach a certain age due to high cost or, if they get them, they refuse to use their prostheses. The rejection and non – acceptance of hand prostheses, mostly caused by poor prostheses cosmesis (cosmetic improvements) is of course a highly interesting point for a designer.

Children prosthese with astonishing poor aesthetics

Many children do not benefit from prostheses during their daily life tasks in a technical way, as they have learned to solve most problems with their stump or remaining hand. Children find their prosthesis useful for specific activities, rather than for daily activities in general.

However, several surveys in the medical area show evidence that an upper limb amputations or loss causes severe functional disability and lower the patient's self body image, with severe psychological implications.[1] In comparison to able-bodied peers, withdrawn behaviour is significantly higher in children with loss of upper limb, social competence tends to be significantly lower, so do social activities. Children who are not using their prostheses show significantly more delinquent behaviour problems than fulltime users. These facts need to be considered differently between boys and girls.[2] A lower score on social functioning is especially shown in children aged 13 to 14 years.[3]

In the US, there are 32 500 children under 21 years that suffer from major paediatric amputation, with 5525 new cases each year, of which 3315 are congenital.[4]

1 http://jhs.sagepub.com/content/33/3/358 accessed 16.10.14
2 http://bvsalud.org/portal/resource/en/mdl- 16092464 accessed 16.10.14
3 http://bvsalud.org/portal/resource/en/mdl- 22289249 accessed 16.10.14
4 http://en.wikipedia.org/wiki/Prosthesis accessed 01.01.15

THREE CONCEPTS

Having found this problem, I started do develop different ideas that lead into three concepts.

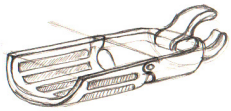
CONCEPT I

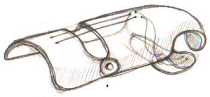
The first concept and the one I concentrated most on, is a device for biking. Important arguments to concentrate on this precise activity were on the one hand, that integration into a group of peers is apparently made easier by doing sports together and on the other hand, that a self confidence that is connected to the body always increases when doing sports.

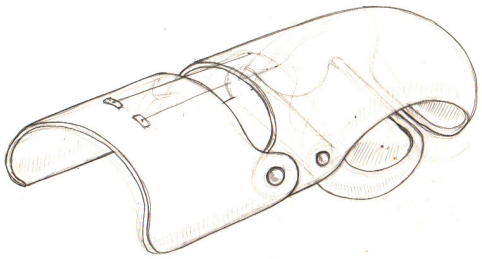
I made drawings, models, digital graphics and plan a 3D printed prototype for a hand prostheses that holds on to the steering with a simple mechanism.

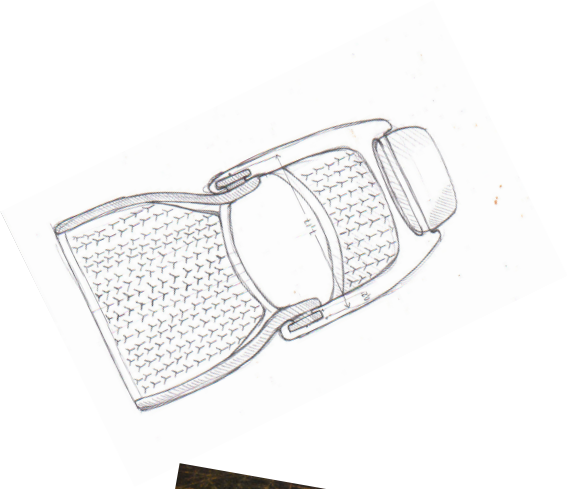
The drawings and digital graphics show the development of the general mechanical functions (two joints at wrist; two joints at the gripping mechanism) and details such as wholes for air and aesthetical approaches. The models show the attachment of the prostheses to the body, the proportion as well as the function. The 3D printed prototype will give a more clear and detailed view on how the final product will look and work like.

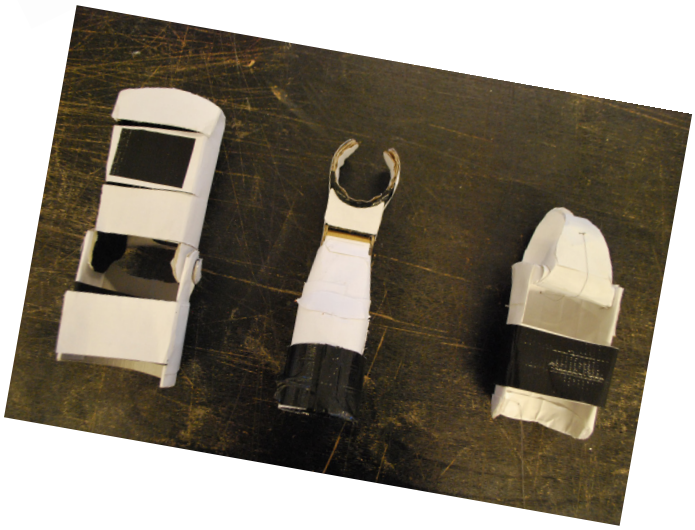
A printable biking device was developped, allowing to grip to the stearing using a simple and reliable mechanism. The prostheses contains a joint at the wrist in order to allow necessary movements when biking.

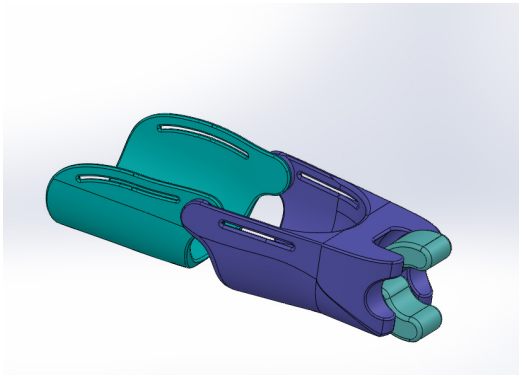


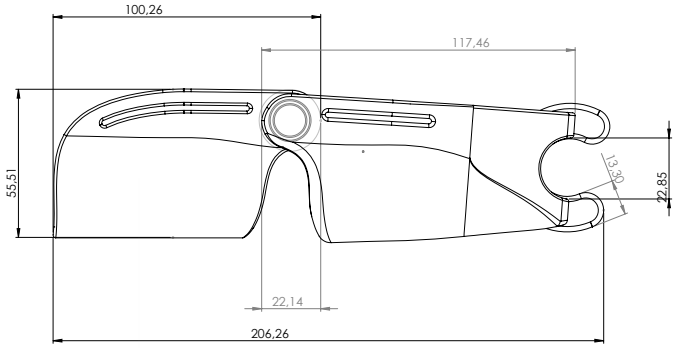


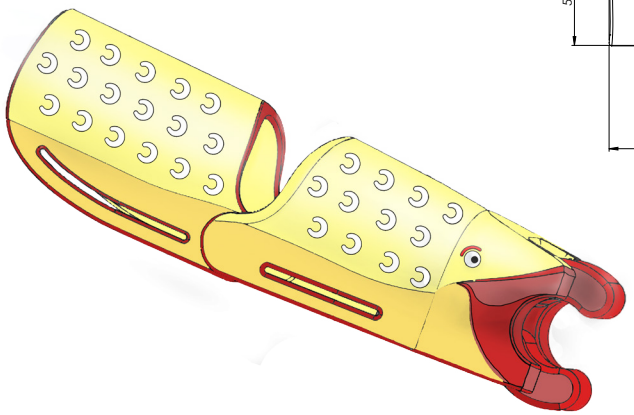


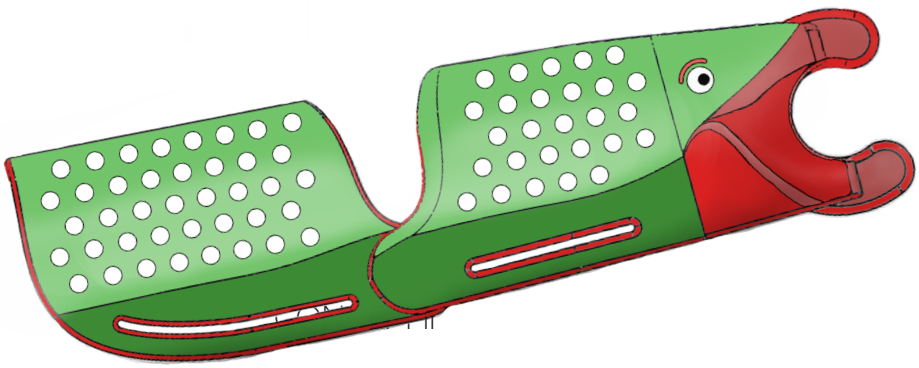












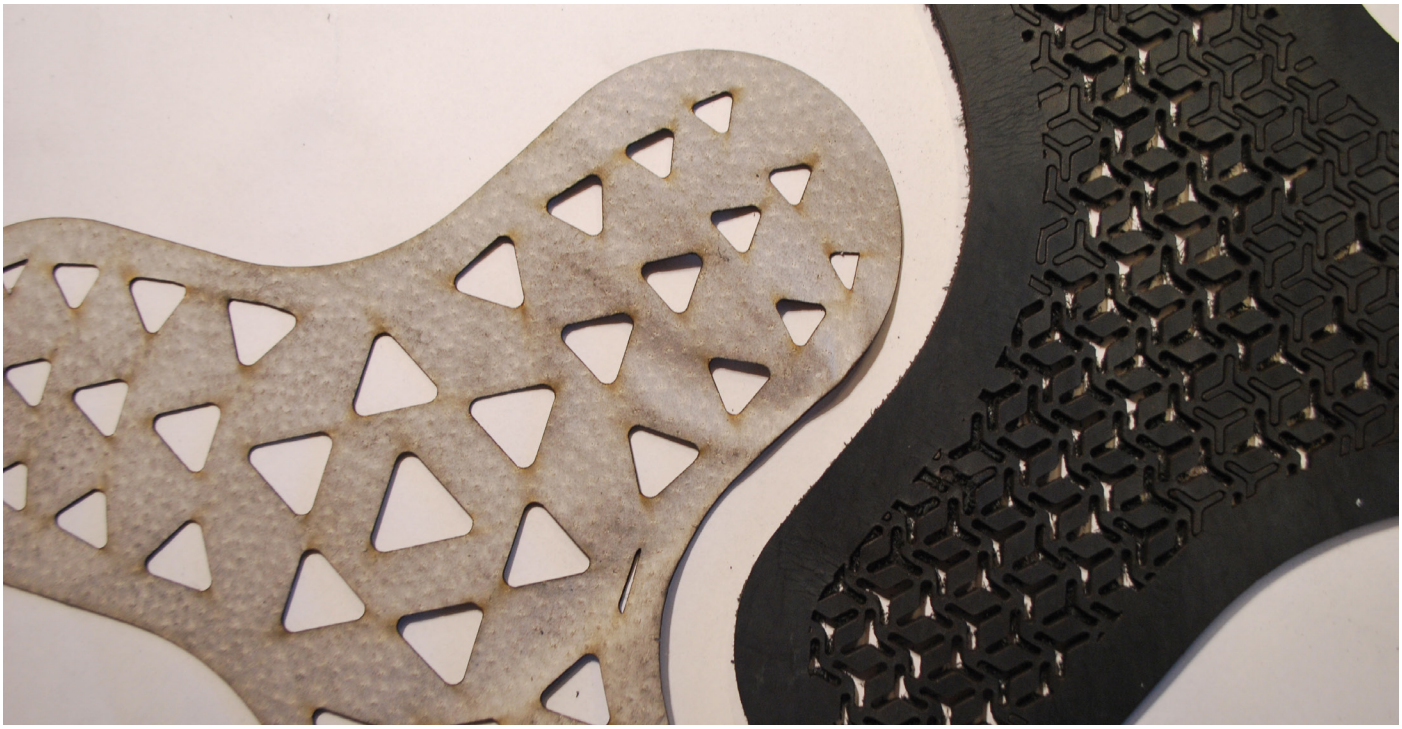
The second concept I worked on was a con-

cept for a drawing device. This idea was influenced by a picture I got sent from a mother whose son was born with the amniotic band syndrome.

were made as well as a lot of research on material. Different patterns were lasered into leather to find out more about possible solutions for air conditioning. As the developed drawing device has to be adapted very well to the individual stump, an orthopaedic plastic was chosen for the final product. To fasten the tool to the prostheses, different solutions were found and approved, including a 3D printed click mechanism and a Velcro solution.

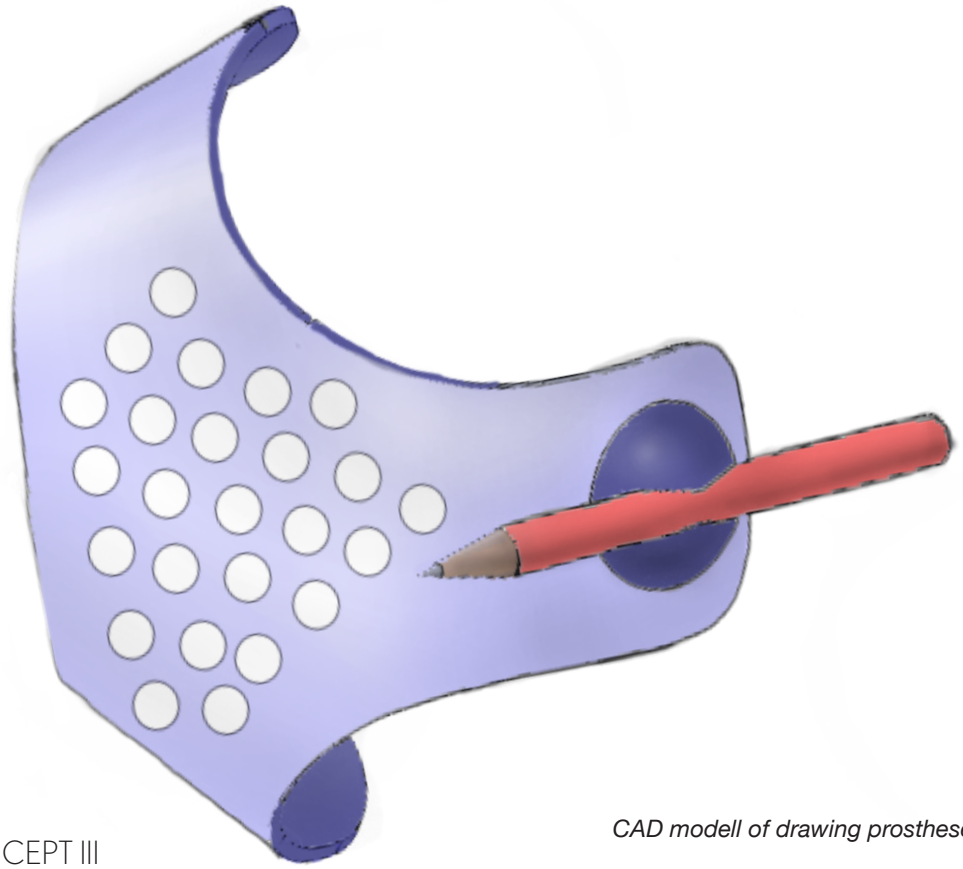
Child with amiotic band syndrom, using tape to fix pen

Orthopedical plaster, deformable at 40 degree



Pattern experiments, laser cuttet into leather

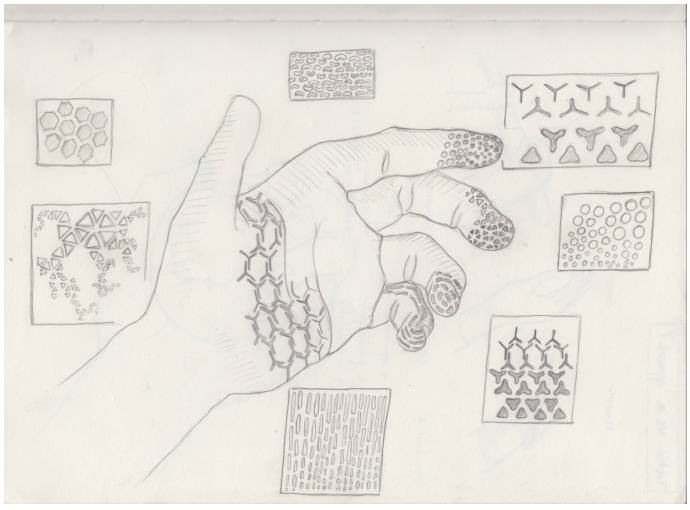
Again drawings, digital drawings and models



CAD modell of drawing prostheses out of aesthetic plaster

CONCEPT III

As a third concept, I designed a mere aesthetical solution for a prosthetic device, which resulted in several analogue and digital drawings and renderings. As I found out during my research, girls in the age of 12 till 14 years often use their prostheses for mere aesthetical reasons. With my third concept, I wanted to ask the question whether a prostheses which does not try to look like a normal hand but like something completely different could be accepted by affected girls.



First concept for an aesthetic prostheses

RESEARCH & QUESTIONNAIRES

As soon as my concepts where developed, I

tried to contact more families with children with upper limb losses. This proved to be quiet difficult, however, I reached only one more family that proved, by sending me the presented pictures, that my drawing concept made sense. Hereafter, I sadly could not use this contact very much, however, it confirmed my assumptions.

During the following process, I took part in a reading circle offered by the Co -Design department with “disability” as the leading theme to obtain a theoretical background. Taking part in these discussions, I learned to question the term “disability”. According to “Disability Theory” by Tobin Siebers[5], disability is “not a physical or mental defect but a cultural and minority identity”. Siebers demands to recognize disability as a social category, “capable of effecting social change”[6] and “subject to social control”. He emphasizes that it is a wrong assumption to think that every “disabled” person considers his or her disability as something negative, and wishes to be fixed or cured. The in the text illustrated ambivalence of disability made me aware of the complexity of the whole theme and opened up a huge and highly interesting research area, which, unfortunately, I could not investigate more intensive due to time reasons.

Furthermore, I learned a lot about how to approach a target group. In that way, I started to rethink my design process, in terms of questioning when and where it really starts and what different factors I have to consider when approaching a target group.

To integrate children into the aesthetical design process and the decisions being made concerning the appearance of the device, white gloves were given to young children between 3 and 7 years. The children were asked to colour the gloves with fabric pencil. Ideas and concepts such as designing animal like prostheses and using many different colours were generated.

White gloves were given to children and painted

There have been, of course, other approaches and projects dealing with the described prob-

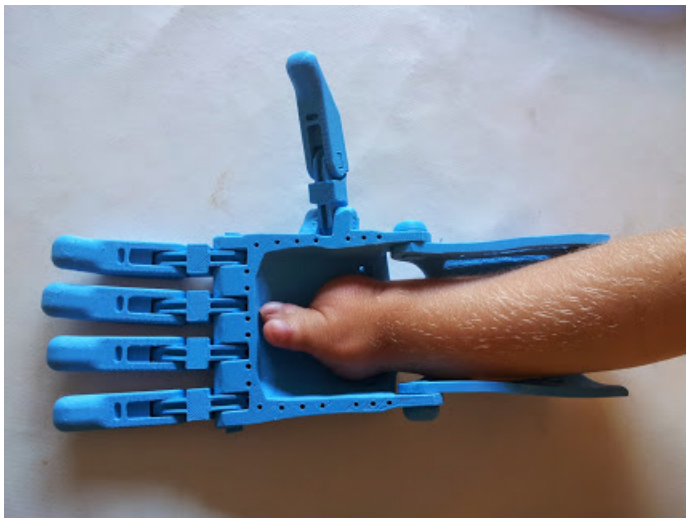
5 Sieber, Tobin: Disability Theory, University of Michigan, 2008; p.4
6 Sieber, Tobin: Disability Theory; p.4 and following

Results of the drawing experimtent

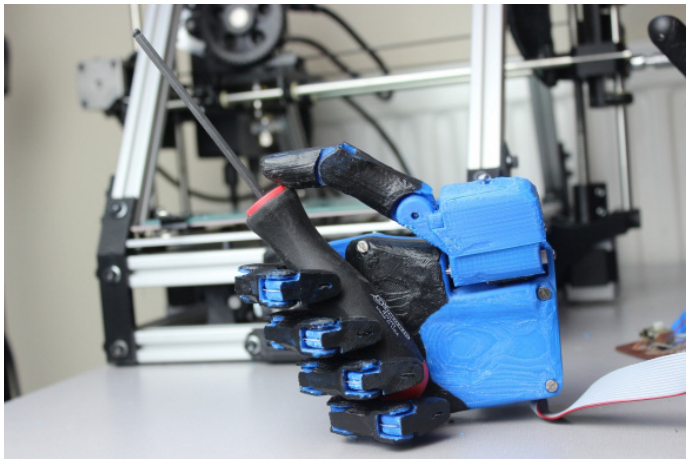
lem. The open source project “E-NABLE” uses very successful an international network of volunteers to develop 3D printed prostheses[7]. The knowledge about these 3D printed prostheses for children is collected in a blog and a Google+ site online. Different models of prostheses have been developed and a vtool for personalising them has been made. Many families participate in the project and the feedback is mostly positive, though these low – tech prostheses are far away from reaching the functions a professional medical prostheses can offer. However, as monitored in several surveys,[8] prostheses are often worn for mere cosmetically reasons. The appearance of the 3D printed prostheses seems to be very basic and technical, nevertheless interviewed children seem to accept them.

Lmbless boy with 3D printed prostheses

The “Open Hand Project” aims to develop a low cost myoelectric prostheses and has come already far on this attempt, however it is concentrating more on adults then on children [9]. The mentioned projects present of course further developed and often more complex solutions, however they barely treat the subject of activity specific devices.



3D printed prostheses, designed by E-NABLE



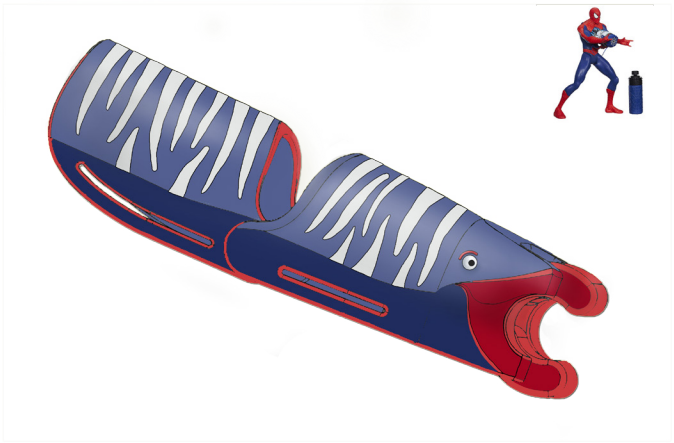
Printer used to develop prostheses, designed by the Open Hand Project

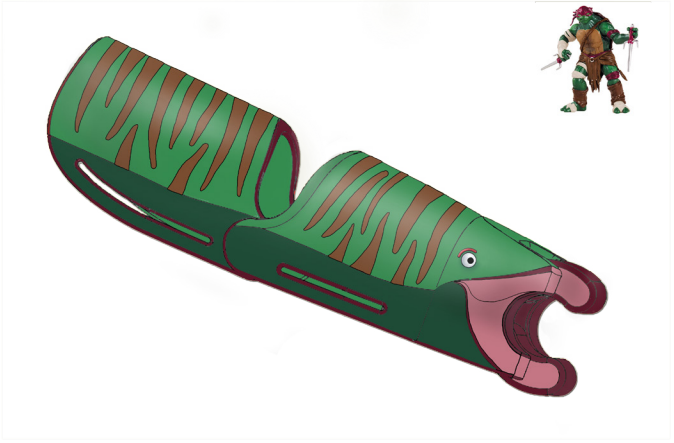
The aesthetics developed in my project have been directly influenced by the initial study.

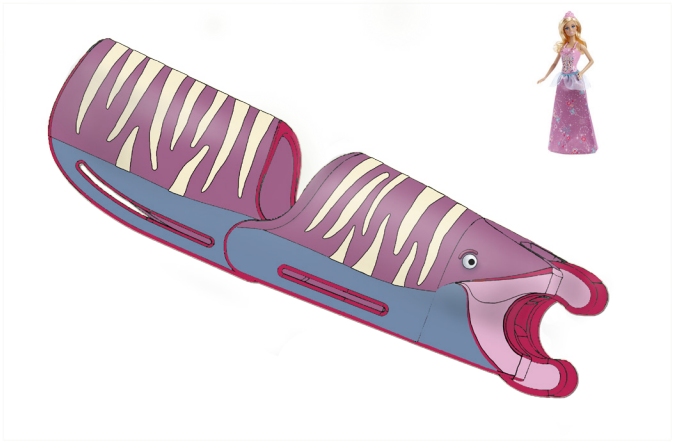
7 http://enablingthefuture.org, accessed 07.01.15
8 http://www.ncbi.nlm.nih.gov/ pubmed/23826203 accessed 16.10.14
9 http://www.openhandproject.org accessed 07.01.15

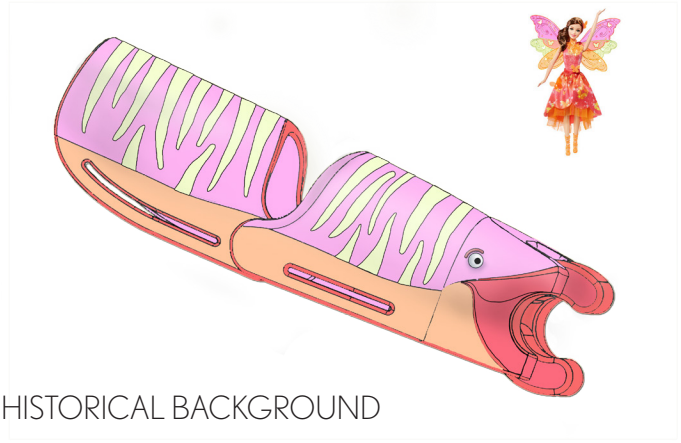
As a result of this study, I found out that the aesthetical appearance of a prosthetic device is often more important then the functions, especially to a child. It is for that reason, that research on current toy designs and on colour concepts was done to develop identity endowing designs.

Prostheses which look like animals or own a gender specific colour concepts were developed. “Male” and “female” colour concepts contradict my personal opinion. But as my design is for disabled children who often are disintegrated anyways, I decided that I would ask too much if I would expect a disabled boy to wear “girls” colours or vice versa.









Different color concepts, inspired by children toys

HISTORICAL BACKGROUND

To offer a deeper understanding of the project, I would like to give an historical background in the following:

Hand prostheses have been used for hundreds of years for technical needs as well as for cosmetical and the today existing prostheses are product of a long technical and manual evolution.

Götz von Berlichingen's prostheses

ses consisted of more then 200 parts, was agile and therefore represented an actual miracle back in that time.

Other than that, prosthetics remained quite basic in form during the middle ages. Debilitated knights would be fitted with prosthetics so they could hold up a shield. Outside of battle, only the wealthy were lucky enough to be fitted with a hand hook for daily function. During the Renaissance, which was a rebirth for the history pros- theses, prosthetics developed with the use of iron, steel, copper, and wood.

The first aluminium prostheses was made 1912 by the English aviator Macel Desoutter.

Already in 1920, Ferdinand Sauerbach, a German chirurgic, empowered his patients through a highly complex operation to control their prostheses with muscle power.

In the end of the 19th century, the American civil war advanced the development of prostheses. Many new mechanisms and material applications were made.

Other than that, during and after World War I only few innovations were made due to lack of technological advances.

Only after World War II, the U.S. government brokered a deal with military companies to improve prosthetic functions rather than that of weapons. This agreement paved the way to the development and production of modern prostheses.[10] [11]

A study from 2011 says that “voluntary opening prosthetic devices have not been improved since 1987”.[12]

Highteck versus Lowtech

Nevertheless, today technology has developed much further, myoelectric prostheses “offer the ultimate combination of function and natural appearance. Designed to mimic human anato-

10 http://www.amputee-coalition.org/inmotion/ nov_dec_07/ history_prosthetics.html accessed 16.10.14
11 http://en.wikipedia.org/wiki/Prosthesis accessed 16.10.14
12 http://www.rehab.research.va.gov/ jour/2012/494/pdf/ smit494.pdf accessed 16.10.14

my and motion, electronic components are the closest alternative to an anatomical hand or arm.“[13]

The functions of such a myoelectric hand are astonishing, and also the aesthetics are advanced, so that the prostheses are merely distinguishable from real hands in their appearance.

Examples for the up to date high tech myoelectric prostheses

3. ARGUMENTATION

The project “Hand Devices For Children” will result in a 3D printed prototype of a biking prostheses for children with different

13 http://www.ottobockus.com/prosthetics/in- fo-for-new-amputees/prosthetics-101/myoelec- tric-prosthetics-101/ accessed 16.10.14

aesthetic designs as well as a concept for a drawing prostheses including functional models and a graphical concept for a mere aesthetical prostheses.

perts in Co-Design, made many drawings and digital sketches, built models, integrated children into the process and I am about to finish a functional 3D printed prototype.

The gripping mechanism closes through pressure

CESS

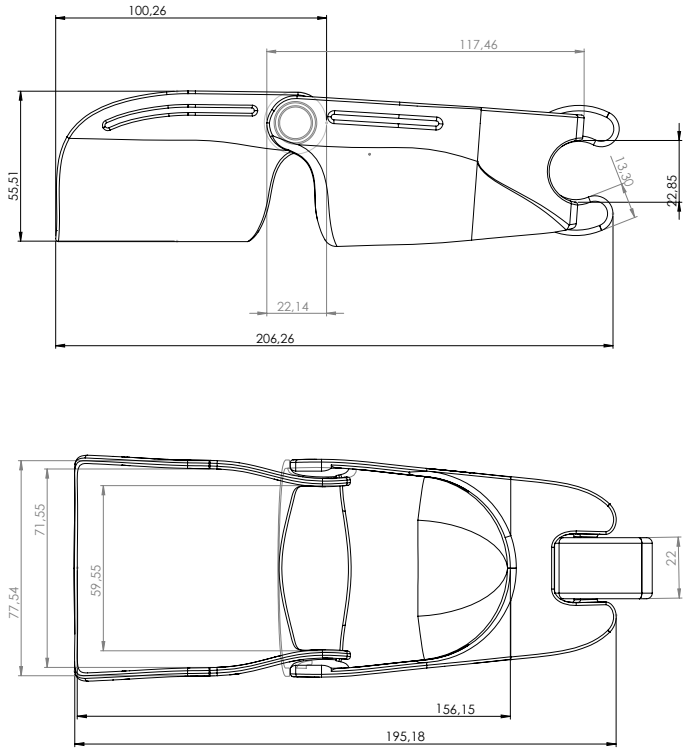
nt

reading circle about disability, spoke with ex-

decissions during my process. After creating a

lot of different ideas by researching and drawing, I had to get deeper into the several concepts and make the following decision.

For the bike prostheses, the mechanical solution, which had to allow a secure grip at the steering that could be loosened reliably at every time, was the most important challenge. A simple and secure mechanism was developed, furthermore material experiments were made. Hereafter, the attachment to the body had to be developed. A joint was added at the wrist to allow a better attachment. The prostheses can be fixed to the hand by using two sided Velcro, which also provides a comfortable fitting.



Technical drawings with measurements (mm)

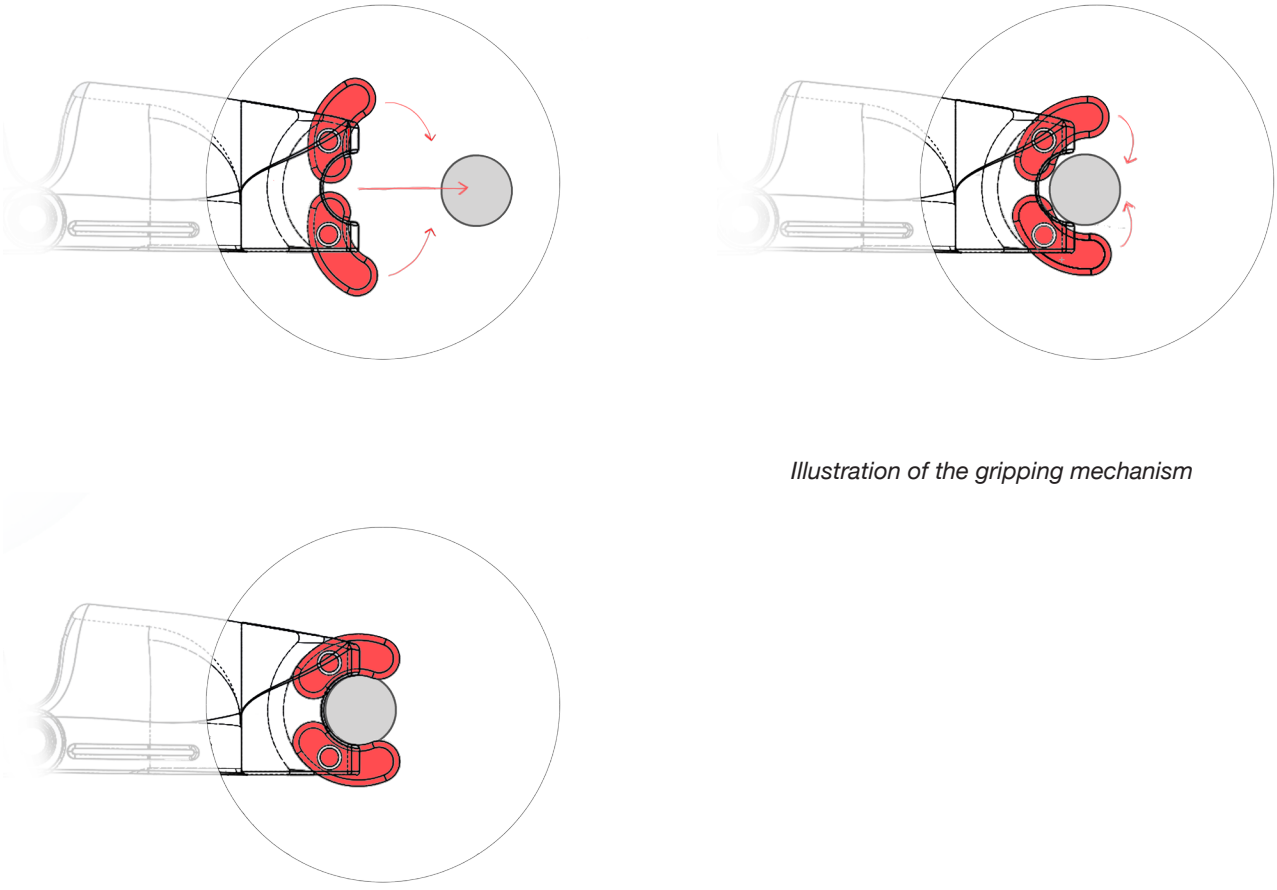
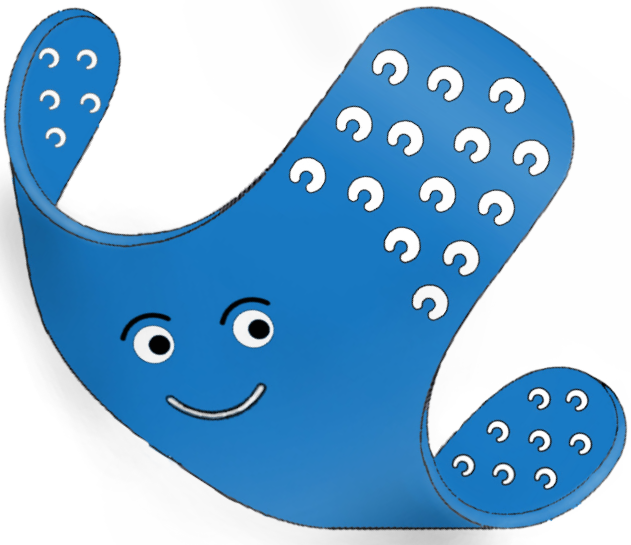


Illustration of the gripping mechanism

For the drawing prostheses patterns and ma-

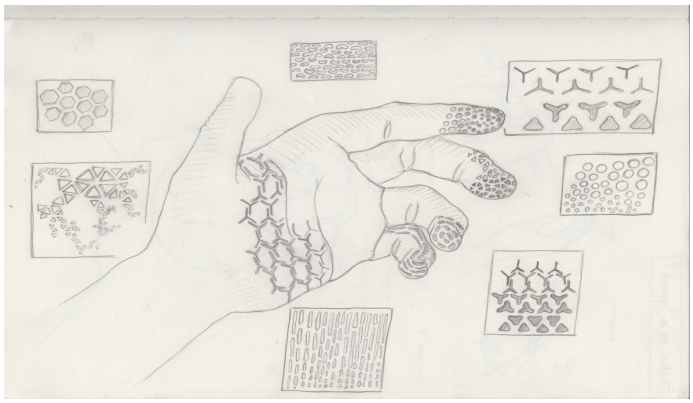
terials were in focus. As I wanted to work with material that could be fitted to the individual stump quick and easily, I decided to use thermoplastic orthopaedic plaster instead of 3D print. The device can be laser cut and then, heated to 40 degree, be easily adapted to the stump. The required tool, be it pen or fork, can be clicked into the holes in the material, which also serves as air conditioning, or, in a second design, be fastened with Velcro in the required position.

Orthopedic plaster



Digital drawing for drawing device

The design for the aesthetical device remained in an early state of drawings and digital graphics. An alternative kind of aesthetics was designed, that explicitly tried not to look like a hand, but as an prostheses of a new, unknown beauty that could be accepted as an aesthetical replacement.



In general, the foreseen method was accom-

plished. There are, however, a few choices that might not have been ideal.

The original program had aimed for more questionings and try outs with the target group in question. Unfortunately, children with the actual “disease” could not be reached for testing. For that reason, the technical try-outs had to be made by people with fully functional hands, which was possible to quiet a large content. However, the functional testing is a point of the project on which further research should be done.

Also, it would be of a great advantage to have better access to 3D printers and to do more functional models to really investigate the mechanics and functions better.

The project fulfilled its aim in the point of contributing to the development of low tech, low cost activity specific devices. Three different concepts have been developed, for one of them a functional model will have been made.

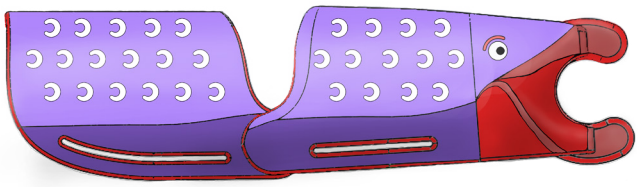
The connection between the problem and the solution is clearly visible: as problem, the non existence of low – cost, aesthetical pleasant devices for children has been questioned. The resulting solution consists in three concepts, three different kind of low-tech, low-cost devices.

Drawing experiment with children between 3 and 7 years

4. REFLECTION

During my project, I have gained experience and knowledge in different fields.

On the one hand, I learned a lot about prosthetic devices as they exist today. There are huge and amazing developments in this field, but at the same time enormous problems, especially concerning cost and aesthetics. I would not have thought that there is so much need in prosthetic development especially concerning devices for children and aesthetical design. Also, I would not have expected the aesthetical part to have such a great impact. The questions I asked myself, of how to develop a prostheses with certain criteria as explained above, was answered by developing the described models and prototypes.



Playful prostheses design in different colors

Concerning the professional field of design and its development, I have learned a lot in the conceptual and research area. As I have never before been working with a program and project report, it was a great experience for me to see how much influence a clearly structured and well researched program can have on a whole project. Also, it helped me questioning my project and its concept much more then I would have done normally in the beginning, which led, I am sure, to a different result.

The research within the area of prostheses was not always convenient, as it is quiet an actual theme, not many books and empirical sources are available about the latest developments, and the information accessible in the internet are not always reliable. At the same time, it is a very interesting and challenging task to research on a field that is changing so much just at the same time.

In terms of my development as a designer, I believe to have earned knowledge and experience in different areas. On the one hand, I have never before had such a long project with so little restrictions. This meant for me freedom and difficulties at the same time, as one has to be quiet consequent and structured while working. On the other hand, I have not before worked on so much digital drawings, so this is where I learned a lot during my project.

Furthermore, as this project was done during a stay abroad, I believe to have learned how to work in a new environment and how to cope with language barriers. I have also realised that it has a great impact on the own work whether machines and workshops are known and easily accessible or not.

Drawing experiment with children between 3 and 7 years

5. CONCLUSION

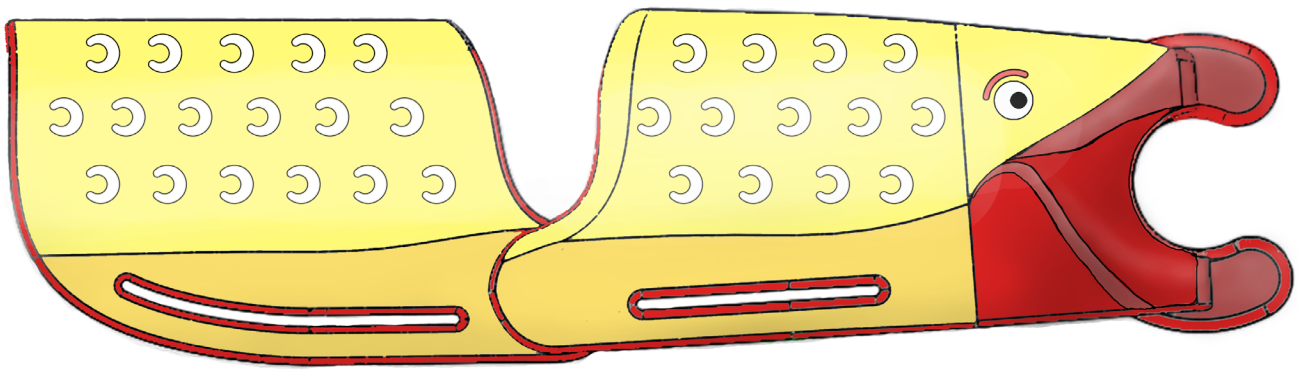
In the on hand project, it was my goal to design a prosthetic device for children of a certain age with upper limb loss or congenital disorder. The device was supposed to be affordable for a large group, to be aesthetical pleasant and functional. Due to the results of my research, it was designed for a specific situation, such as riding a bike, drawing or to serve as an aesthetic replacement.

My process on the way to the final design involved several weeks of research in the field of prosthetics and the new human body. After having finished research and having developed the general concept, I developed diverse ideas by sketching. Narrowing these ideas down, I decided to work on the three different concepts – a biking-, a drawing-, and an aesthetical prostheses. By doing more theoretical research, material research, functional models, more drawings, work with children and digital sketches, I succeeded to concretise my designs and to finally decide to set the focus during the last weeks on the biking prostheses.

During this project, I have learned to write a manifest, a program and a project report and therefore work much more conceptual and theoretical then I normally do. I realised that this provides the benefit of being able to work much more structured.

I consider my project as successful in the sense of having designed three different concepts as well as sketches, models and prototypes for hand devices and having gained a lot of knowledge in the particular field and hand prostheses for children an their production with rapid prototyping tools.

Further development would of course be possible and desirable. More functional tests, in particular with children from my target group would be helpful, as well as more development of the 3D printed models.



Playful prostheses design in different colors

6. BIBLIOGRAPHY

- http://www.amputee-coalition.org/inmotion/nov_dec_07/history_prosthetics.html accessed 16.10.14

- http://bvsalud.org/portal/resource/en/mdl-17549329 accessed 16.10.14

- http://bvsalud.org/portal/resource/en/mdl-16092464 accessed 16.10.14

- http://bvsalud.org/portal/resource/en/mdl-22289249 accessed

- http://enablingthefuture.org, accessed 07.01.1516.10.14

- http://en.wikipedia.org/wiki/Prosthesis accessed 01.01.15

- http://jhs.sagepub.com/content/33/3/358 accessed 16.10.14

- http://www.ncbi.nlm.nih.gov/ pubmed/23826203 accessed 16.10.14

- http://www.openhandproject.org accessed 07.01.15

- http://www.ottobockus.com/prosthetics/in- fo-for-new-amputees/prosthetics-101/myoelec- tric-prosthetics-101/ accessed 16.10.14

- http://www.rehab.research.va.gov/jour/2012/494/pdf/smit494.pdf accessed 16.10.14

- Sieber, Tobin: Disability Theory, University of Michigan, 2008