BSc Thesis
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An assignment for Conrad Electronic

Making Makers

How STEM kits can help in taking the first steps

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Abstract

STEM kits are teaching their users technological or scientific phenomena, with the goal to allow them to use that knowledge to repair, improve, and make with anything around them. Sadly, that goal is not commonly reached. This research set out to find why by interviewing makers and zeros in order to find out which obstacles the zeros perceive and which aids help the makers in an attempt to find ways to remove those obstacles. One solution was to leave room for experimentation and thought in instructions, this method has been implemented with an existing STEM kit and discussed with experts in an expert interview. Though the implementation is not perfect, it is promising. The methods Conrad is advised to attempt to use are the aforementioned instruction improvement, setting up a knowledge sharing platform and promoting it in STEM kits, and each STEM kit showing which level of experience is expected to be necessary in order to successfully use it.

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1 Introduction

1.1 problem statement

In the past, people would often repair or improve their own possessions and equipment. Nowadays, that sort of activity is left to professionals. (Dougherty, 2012) But people have a certain need to use objects in more ways than just consumption. This need has brought forth the maker movement, in which technology enthousiasts create new things by playing with technology.

Conrad Electronic holds great value to the maker movement, as makers and people who want to become makers are their primary target groups. This is why the company sells STEM kits (Science, Technology, Engineering, Mathematics). These kits teach the user a certain technological or scientific phenomenon by letting them build an object which makes use of that. For instance: the user learns how LED lighting works by building a “magic lamp”. The goal behind teaching people these phenomena is to allow them to use that knowledge in order to build or improve things in their surroundings. Sadly, practice learns that only few users actually do so. The goal of this project is to find out why and give Conrad advice on how STEM kits can be improved in order to urge more people to start making.

1.2 Common terms

Maker

According to Dougherty (2012) everyone is a maker, from the cook who prepares meals to the child who plays with its LEGO. In this project, the term maker will be used specifically for those people who use their skills and knowledge to improve existing objects and create new ones.

Zero

In this project, the term zero describes a person who desires to become a maker but does not yet apply their knowledge and skills to play with the world.

STEM education

Science, Technology, Engineering, and Mathematics (STEM) education is a way of learning that subconsciously teaches a principle in one or more of these four domains by letting the student or user put together a project based on that principle. For instance: they can learn how the lever principle works from a set that lets them build a catapult.

Affordance

Affordance is a term used to describe what an object tells the user to do with it. For instance, a chair affords to be sat on.

1.3 Goal

The 21st century skills for Learning direct at creativity & innovation and critical thinking & problem solving.[1] The aim of this project is to design a STEM kit which affords the users to use its materials to improve these skills by trying out and learning new things, by playing with and improving the space they live in. To do so, a serious effort will be made to research what is necessary to help a zero become a maker and how that can be supplied by STEM kits.

1.4 Research Question

It has been briefly named in the previous paragraph, the research question of this graduation project will be: What is necessary to help a zero become a maker and how can that be supplied by STEM kits? In order to find an answer to this research question, it has been divided into four sub questions:

1. What allows makers to build the things they want to?
2. What stops zeros from building the things they want to?
3. What is necessary to help zeros become makers?

1 https://www.aeseducation.com/career-readiness/what-are-21st-century-skills

4. How can findings from subquestion three be applied in STEM kits?

1.5 Research Outline

Several steps have to be taken to reach these findings. In the following chapter, an analysis of the current state of relevant knowledge and products is given to understand the background of this research. In chapter 3, the method by which the research question will be answered will be further explained. In chapter 4, the ideation phase, thought processes of makers and those who aspire to be makers will be compared in order to find the differences and how those can be overcome. First, makers will be interviewed about their making processes. Second, aspiring makers will be interviewed about what stops them from creating their ideas. Then, the findings of these interviews will produce multiple combinations which can help zeros take the steps to become makers. In the next step, the combinations need to be applied in or together with STEM kits, and should therefore adhere to certain requirements. After this, the four sub questions have been answered, but it is necessary to test whether the found answers are useful. Therefore, in chapter 5, specification, the requirements will be set for an implementation of found ideas in chapter 4. Then, in chapter 6, realization, the implementation is performed and discussed with two experts in expert interviews. In chapter 7, the results of these interviews are displayed and in chapter 8, evaluation, they will be discussed. In chapter 9, a conclusion will be drawn after a short summary of the research before that and the conclusion will be evaluated to see if it functions as an answer to the research question. And finally, in the 10th chapter, the discussion and future recommendations can be found, detailing what should be kept in mind while reading this paper and how to continue the research.

2 Analysis

In this chapter, all background information gathered will be set out. It contains the learnings of a University of Twente Masters' course about tinkering and helping others to tinker, which is closely related to making. After that, there is an indexation on currently existing STEM kits and products or services that help people become makers. Furthermore, since curiosity is a main reason of making, there is a literature review of curiosity and how constructions can be changed to spark it. And finally, there is information about the client, Conrad Electronic, and their vision.

2.1 Mastering Tinkering

From the master's course Mastering Tinkering[2], several empiric and scientific findings about the concept of tinkering have been learnt.
Materials were reviewed on their tinkerability on several criteria gained from a group brainstorm, these were: Interoperability, ease of use, preciousness, necessary level of instruction, iteration time, low threshold - high ceiling, affordance. An overview can be seen in appendix B.
The process of tinkering contains six parts, each important to start the process and keep it going. The steps can be seen in image 1.

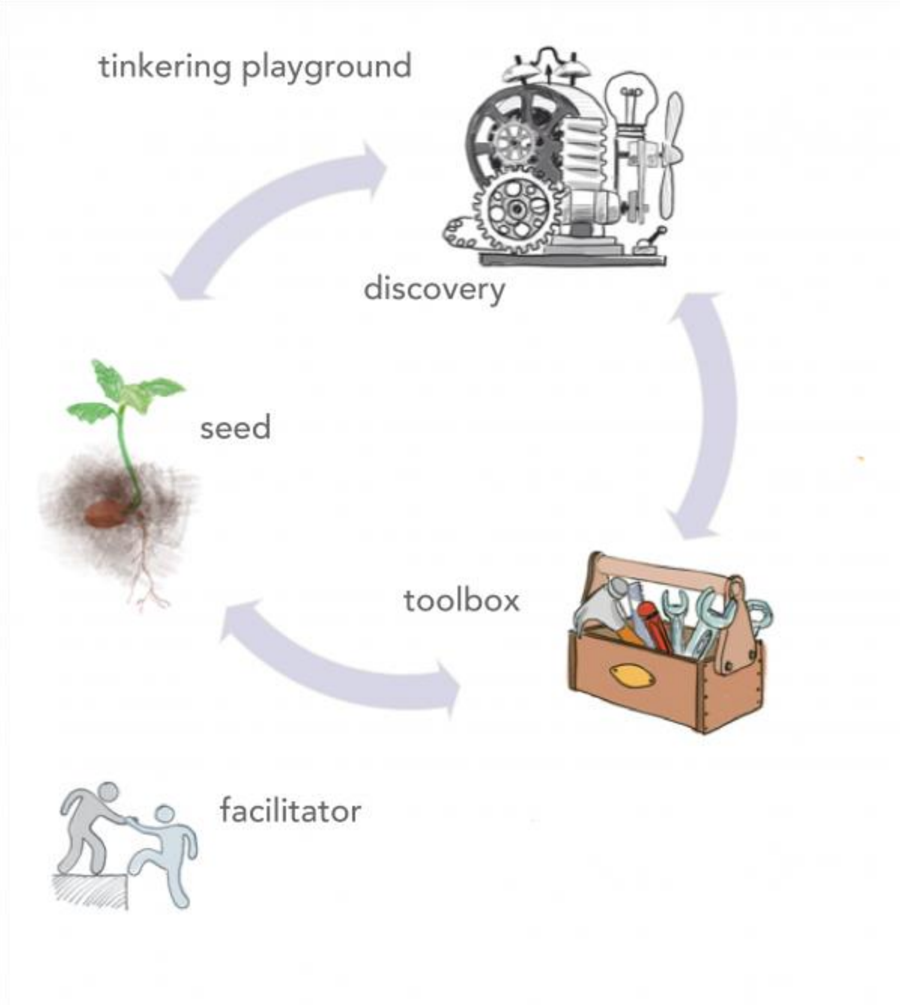

Image 1: the process of tinkering, as described in Mastering Tinkering.[3]

2 Osiris course code: 201800228
3 Source: http://wiki.edwindertien.nl/doku.php?id=education:masteringtinkering:01_method

1. Playground

An environment where the tinkerer feels safe, everything is allowed, creativity and curiosity are stimulated, and failure is nothing more than an experiment with an interesting outcome. That would be the ideal tinkering playground. In order to help someone tinker, the environment should be

2. Toolbox

The things that will be used to set goals and put objects together. The toolbox can contain literal tools, such as screwdrivers or a soldering iron; but also materials, physical, and virtual ones: from LEGO blocks and microprocessors to Excel and Photoshop. Finally, the toolbox contains what the tinkerer brings to the table, their skills, knowledge, and passions.

3. Seed

The seed is something that inspires the tinkerer to start tinkering, to grow out the seed into a tree of possibilities. A seed can be an exercise, an open goal; it can also be a new material or a concept.

4. Discovery

The tinkerer decides their goals, in order to discover the possibilities of what they are working with. What do they aim to achieve? It does not necessarily matter if they do achieve that goal, because the process will be full of discoveries and maybe one of those side discoveries is much more interesting. By self-defining their goals, the tinkerer really becomes an attached owner of the results and the discoveries.

5. Process

The process starts at the seed and uses the toolbox to discover, after every discovery and a little reflection on what happened, the process starts its loop again until the tinkerer is satisfied. In order to achieve this loop of iterations, the tinkerer should keep working with their hands and iterate as much as possible. Working with their hands keeps the tinkerer from getting into dry materials and keeps the iteration process going. Many iterations allows for trial and error, improving the results over time and learning from every mistake along the way.

6. Facilitation

Facilitators are often experienced tinkerers who design the session and are physically present. They set the mood, provide or help identify a seed. Facilitators set a low threshold and a high ceiling, keep the flow, and stimulate reflection; to let failures not be problems, only chances to learn. They provide scaffolding in order to get the process started and going in the right directions.

A kit can provide or influence three of these things: the toolbox, a seed, and facilitation. The toolbox can be enriched with materials and tools the kit provides. Seeds could be delivered and the kit can provide instructions on how to identify a seed. Facilitation is more difficult, since it might prove difficult to provide a live facilitator with the kit; facilitation can be delivered by manner of instructions. The hypothesis is these instructions need to contain explanation of the necessity of failure and reflection, and a few exercises as scaffolding to get started with new materials. Furthermore, these instructions should be designed with aim towards sparking curiosity and allowing tinkering. Out of these terms, seed and process will frequently return in the thesis.

2.2 State of the art

Based on the reviewed existing products and services in the fields of STEM education and maker movement, there appear to be six different types available:

1. Kits providing materials, such as Creative Technology’s own Protobox.
2. Kits with precise instructions, such as most AREXX kits.
3. Kits providing challenges, such as Sciencebuddies
4. Products affording to use other things creatively, such as Makedo
5. Challenges to creative use, such as the McGyver challenge
6. Examples of creative use, such as 5 minute crafts videos

The list of all reviewed products can be found in Appendix A. In this chapter, each category will be reviewed on its manner and level of instructions, and how well it affords the user to tinker.

2.2.1 Category 1: Kits providing materials

These kits are the component boxes and tool deliveries, they deliver materials and tools. The can usually very well be used together, but it is just as easy to use parts in one project, and other parts in another.

Instructions are either not present or generalistic, since the kit mostly provides materials to be used outside of the kit.

Tinkerability is usually high, since the materials are all ‘spare parts’, none directly have a purpose within the kit.

2.2.2 Category 2: Kits with precise instructions

These kits are the most standard type of kit, providing materials and instructions for one specific project. Kits whose results can be enriched by adding more kits, such as Makeblock mBot, usually fall into this category as well, since each kit has their own set of instructions. Instructions are usually very specific. Describing in detail what should be done. This is usually enriched with drawings or images showing what should be done. Sometimes, the instructions are not in words, but an exact design of what should be placed in which position, as with AREXX school lab: radio wave scanner v2, where the circuit board contains drawings and symbols indicating which components should be soldered where and in which position. Nothing is left to think about.

The assembly process is usually constructing the object piece by piece and can go fairly swiftly thanks to the instructions. It can make the user feel like they manage to build an interesting project on their own.

Tinkerability usually is low, since exactly the components necessary to build the project are delivered, and the instructions are so precise the user can finish building without thinking at all.

2.2.3 Category 3: Challenges to discover

Sets in this category are similar to kits with precise instructions, but they invite the user to do or discover something on their own. Sciencebuddies’ Archimedes Screw[4] and Fire Snake[5] videos, for instance, give the user explanation on which materials they need and how they should perform the experiments. Then, it asks questions leading to trial and error-wise discovery.

Instructions are usually very specific, until the point where the user has to do or discover on their own, they leave some space open there for the user to find their own results, instead.

Not counting gathering materials, the assembly process is usually quite short, since that is not the focus of the challenge. Instructions help building the object fast.

Tinkerability is usually low, but the gained insight can potentially be used in making processes. The trial, error, reflect mentality these kinds of challenges teach is useful in tinkering as well.

2.2.4 Category 4: Products affording to use other things creatively

These types of products are designed in such a way that they create situations in which other objects can suddenly be used in a new way. As an example: makedo plugs and saws transform scrap cardboard into building materials.

4 https://www.youtube.com/watch?v=PszGCm1PqSo
5 https://www.youtube.com/watch?v=7xkbXPzBTHE

Instructions are usually minimal and consist mostly of examples of what can be done with the product, because the product already shows what it can be used for.

These items are highly tinkerable, as they are designed to make other materials more tinkerable.

2.2.5 Category 5: Challenges to creative use

An example of challenges to creative use is the MacGyver Challenge6. Every week, it tells contestants to hack something with a specific product. At the end of the week the most useful hack is chosen. Getting the assignment to do something extraordinary with an ordinary product forces the contestants to think out of the box and see new possible uses for objects around them.

No instructions are delivered, just the challenge and a few examples of what is possible with the chosen product.

The challenge itself is not tinkerable, but it does put contestants in the mindset to look at the world as a playground and see possible new uses in all objects.

2.2.6: Examples of creative use

By being shown what kinds of things are possible when getting rid of regular conceptions on how objects are supposed to be used, and how that can be done, people can get inspired to first try those things themselves and later find their own creative uses of items. The book Rolfs Maakbare Wereld7 is a prime example of this type of product.

The instructions in these types of products range from very precise, as in 5-minute crafts videos8, to basic explanation of components and function of the result, as in Rolfs Maakbare Wereld.

Similar to challenges to creative use, the examples themselves are not tinkerable, but it can help get people to become makers by showing what results they could produce and how that is possible.

2.2.7 Important information

This information paints a background picture of what types of kits there are and in what ways zeros are invited to become makers. By far most STEM kits fall under category 2, so that will be the one focused on. It is expected that the techniques used in categories 3 and 5 will be most effective to improve the chances of STEM kit users becoming makers.

2.3. Literature Review9

As part of answering the second subquestion, a literature review towards curiosity and its application in instructions has been conducted. This gave insight in common definitions of curiosity, current knowledge about curiosity, and ways curiosity is used in learning and experimentation at this moment.

2.3.1 Introduction

In this world where nearly anything can be created with electronics, a rising trend is the educational STEM kit (Science, Technology, Engineering, and Mathematics). These kits deliver the user parts and instructions to build a water heater, a backflipping robot, a coffee pourer, and more. But, to science's great dismay, the kits do not inspire the user to keep on

6 https://lifehacker.com/macgyver-challenge-hack-something-using-zip-ties-733655549
7 http://rolfhut.nl/rolfsmaakbarewereld/
8 https://www.youtube.com/watch?v=jySrwZc4sZo
9 This literature review was also the end project of a different course, which means the way it was written differs from the rest of the thesis.

building after their object has been assembled, or to investigate why the technology does what it does; making the kit miss its point: teaching the user how the technology works. This research is conducted as part of a graduation project for the Bachelor of Science Creative Technology. The graduation project aims to design a STEM kit which affords the user to tinker with its materials. Tinkering is a researching method in which a person has a certain object or goal and finds out how the object can be used or how to reach that goal by trial, error, and reflection. Curiosity is a very effective method to get someone to try new things (Kang et al., 2009). Instructions of STEM kits could potentially be designed in such a way that they spark the readers' curiosity and get them tinkering. Therefore, the information gathered from literature will be used to gain insight in how curiosity can be applied in instructions.

In order to do so, curiosity should first be defined. Many definitions exist at this time, making it hard to draw definitive conclusions without picking a side (Kidd and Hayden, 2015). The next step is to find out how curiosity can be sparked. To use curiosity in instructions, it is necessary to know how curiosity comes to be. And lastly, it is important to see if other factors influence a person's level of curiosity, that knowledge may prove an advantage by knowing what to do and what to avoid.

2.3.2 Defining curiosity

Over time, there have been a multitude of definitions of curiosity. There appear to be two main viewpoints. Starting with the 20th century's pioneer in the field of curiosity research, Berlyne (as cited by Kidd & Hayden, 2015), who argues curiosity to be defined exploratory behavior along two dimensions, these being perceptual against epistemic exploration and specific against diversive exploration. Followed up by his colleague, Day (as cited by Arnone, 2003), who explains curiosity as a curvilinear relationship between the level of arousal and efficiency. At the optimal level, a person enters a zone of curiosity where they are excited and interested and will explore. If the arousal is too high in relation with the efficiency, the person becomes anxious; on the other side of the zone, they become bored and unmotivated. Elaborating Berlyne's description of epistemic curiosity, Subasi (2018) presents the Dynamic Systems Theory which, as the author phrased well: "offers a new language to describe the motivational dynamics of epistemic curiosity in its multi-dimensional complexity and variability" (p. 14). However, Subasi also admits his research shows the complexity and elusiveness of human curiosity makes it impossible to clearly describe or measure epistemic curiosity.

On the other side of the discussion we find Loewenstein (as cited by Chater & Loewenstein, 2016)., with the second definition. He refutes these explanations by defining curiosity as a drive similar to hunger or sexual desire. It is a hunger for information, an unconditionally rewarding stimulus to find that bit of knowledge necessary to tie two pieces of information together. Loewenstein calls this phenomenon an information gap. He continues this definition by listing four terms in which curiosity should be addressed:

1. Intensity
2. Transcience and dependence on immediate stimulus
3. Association with impulsivity
4. Tendency to disappoint when satisfied

Other research has been built upon this information gap theory and added to its definition. Jirout and Klahr (2012) argue uncertainty is an important factor for the drive to fill an information gap. This is not meant as uncertainty in a person but uncertainty about a situation and its outcome. Without uncertainty, there would be no gap to fill; while a high level of uncertainty would make the gap too big to fill with a little extra knowledge. And finally, Kashdan et al. (2017) research the parts of which curiosity consists and concludes with a list of five factors: Joyous exploration, Deprivation sensitivity, Stress tolerance, Social curiosity, and Thrill seeking.

Each has substantive relations with personality, emotion, and well-being measures. Based on these factors, they identified four distinct types of curious people: The Fascinated, Problem Solvers, Empathizers, and Avoiders.
Due to the different definitions of curiosity, it becomes difficult to build a clear view on what is currently understood as curiosity. Multiple terms exist for the same things, while multiple things are named by the same term in different circumstances (Kidd & Hayden, 2015). This makes it difficult to get a full view of what is currently understood as curiosity and as such, an overall agreed upon definition does not yet exist. However, Kidd also argues the absence of a single definition of curiosity does not necessarily have to be a bad thing. In her words: “We consider this diversity of definitions to be both characteristic of a nascent field and healthy.” (p. 449) For the graduation project, one view of curiosity should be chosen to follow; as multiple will give too many viewpoints to work from. For that reason, during the rest of this research, curiosity will be regarded from Loewenstein’s information gap theory instead of Berlyne’s exploratory behavior theory, since a drive can be awakened and induced while a behavior needs to be changed and trained. To be clear, the information gap theory explains curiosity as a hunger-like drive for information necessary to close the gap between two pieces of information already known.

2.3.3 Sparking curiosity

Now that a definition of curiosity has been selected, it is time to set out the facts others have found on how curiosity can be sparked and sustained. According to the literature, there are two prominent methods to spark curiosity. The first method is to provide an information gap. Following from Loewenstein’s information-gap theory (as cited by Jirout & Klahr, 2012; Chater & Loewenstein, 2015) curiosity can be sparked by receiving information that does not yet quite make sense (Chater & Loewenstein, 2015). For instance, a video with the title “These ten ways to use a sidewalk tile in your daily life will blow your mind!” will make the recipient confused about the use of a sidewalk tile and how that will blow their mind; and therefore curious to what the video will tell them to make sense of the title they just read. On the other hand, Kidd and Hayden (2015) explain the method to spark curiosity is to place a person in a situation with uncertainty. If a person has no knowledge of a subject at all, they are certain their expectations of a situation are wrong or will not have expectations at all; if a person has a very high amount of knowledge on that subject, they are certain their expectation of a situation are correct. Neither of these people will be interested in the outcome of that situation; while someone who thinks they might have a correct expectation but is not sure will want to find out whether they were right and why.

Research following other definitions of curiosity also prove curiosity is triggered by uncertain situations. In his research towards the importance of curiosity in learning, Kang et al. (2009) mention the type of curiosity Berlyne called specific epistemic curiosity is triggered by trivia questions, especially if the test subject is about 50% certain of their answer. For the graduation project these ways of sparking curiosity should be explored and tested, together with potential ways to sustain that curiosity.

2.3.4 Other factors influencing curiosity

Since curiosity is a state of mind, many seemingly unrelated things may affect a person’s curiosity. There are two factors usually influencing curiosity. One is the way the information is perceived and the other is the personality of the recipient. Chater (2015) advocates sense-making – which is based on the information gap theory (Loewenstein, as cited by Chater & Loewenstein, 2015) – is, in Loewenstein’s words “a drive similar to hunger”. An impulsive drive to acquire and consume information, explaining a person’s curiosity is closely related to their impulsivity. Adding to that, Kashdan et al. (2017) noticed each of their five factors of curiosity had substantive relations with the personality, emotion, and well-being of a subject, coming to the conclusion these three factors also influence how curious a person is at the moment of measurement. On a sideroad of this research, Aschieri, Durosini, and Smith (2018) introduce the effects of intelligence, culture, and stage of life development on someone's self-curiosity. Although self-curiosity is focused inward, while the curiosity this paper looks for focuses outward, it can be expected they are influenced in the same way. As previously mentioned, the second factor influencing curiosity is the way information is received. Earlier in this literature review, uncertainty of a situation was discussed to induce curiosity. The level of uncertainty influences the amount of curiosity a subject experiences (Kidd & Hayden, 2015). Kang et al. (2009) support this by explaining the same in different terms. They say the level of confidence a person has in their knowledge of a subject influences their curiosity towards situations and questions pertaining that subject. Malone (1981) preceded them with the suggestion that the challenge of an assignment can influence the level of curiosity the subject experiences and how long they will stay curious. Perceived challenge can also be viewed as a person's confidence in their ability to handle the assignment. During experiments for the graduation project these other factors cannot be influenced, a persons personality cannot be changed for an experiment. However, it is important to keep these factors in mind when reviewing gathered data, they could be clear explanations of otherwise strange data.

2.3.5 Conclusion

What sparks curiosity and how can that be applied in instructions? To summarize the research above: there are multiple definitions of curiosity, which is healthy and logical for a rising field of research, but for this graduation project curiosity will be viewed as a means to fill information gaps in order to reduce uncertainty. Curiosity can be sparked in two ways: by providing information which does not immediately make sense (or which might make sense of previous information) or by providing a situation with uncertainty. Curiosity is further affected by the personality of the recipient of the information and the way they perceive the information they received: high uncertainty will not make them curious and neither will low uncertainty, the level of uncertainty should lie in a medium range.

Based on the literature it seems the best way to apply curiosity in instructions of, for instance, STEM kits is to provide the user with projects to make with the instructions that have an outcome which might be guessed but is not certain, applying to the correlation between uncertainty and curiosity. In order to do so, crucial information has to be provided but possibly details that tie them together can be left out, making use of the information gap theory.

There are few articles about curiosity and most discuss it as a tool instead of a phenomenon which can be investigated itself. Not all papers cited in this review had curiosity as their primary research goal. This makes some statements little underlaid. The discussion of the definition does return to older articles by Berlyne and Loewenstein. The other factors influencing curiosity have not been a primary research target at all, these conclusions were drawn from parts of cited articles. Chances are conclusions to subquestions could have been different or more elaborate if there were more sources to use, this means experiments and research will have to be conducted during the graduation project in order to find out whether conclusions drawn from literature were correct and sufficient.
In the future, it is necessary to conduct research toward the circumstances under which people are most and least curious, this data could be invaluable to designs of interventions, tinkering sessions, and even classrooms. For a highly evolved information gathering method, we know far too little about how this survival method can be induced.

2.4 Conrad's vision

This project is closely related to Conrad and should therefore aim in the direction of their vision. Conrad's vision about what STEM kits should achieve comes close to the vision of 'lekker samen klooien'10. Lekker samen klooien concisely explains its vision and where it came from in the manifest on their about page. The group believes the world is an amazing place we make together, everybody in their own way, and that it is important to understand

10 https://lekkersamenklooien.nl/about/

that we have that power. They see that making is sometimes stopped by fears or practical problems, but if people start after all, they find their own way of making and become happy and proud. They wish to help being curious together, to help be brave and work full of confidence, with the ideology that everything is a resource, every idea is a plan, and the world is owned by everyone.

3 Method and Techniques

In this chapter, the method by which the research question will be answered is set out, as well as the techniques that will be used in that method. The method begins with finding out the differences between makers and zeros by interviewing them about the factors that aid and obstruct them in the process of making. Those factors and differences will be used to ideate ways to overcome obstructions zeros experience by using aids makers experience. The next step is to define specifications for those ways to be applied by STEM kits, and to specify those into clear requirements any final solutions to the problem should adhere to. In order to test the solutions, an application of those requirements is implemented and discussed with experts in the field of making and the psychology of instructions. And finally, the opinions and expectations of the experts will be used to form a conclusion and give an advice to Conrad.

3.1 Method

Most users of STEM kits do not use their gained knowledge and skills to play with or improve the world around them, or objects in it. In order to truly find out how to help these zeros become makers, it is necessary to ask people from two groups. The groups that will be interviewed are those who are makers, and zeros, those who want to become makers; with the goal to gather information about why the first group is able to make what they want and why the second group is not, what obstacles they encounter. Combining this information will provide methods to help aspiring makers to take the necessary steps.

3.1.1 Ideation

The first interview's structure will be designed as such, that most information is gained from the makers. Examples of information interesting for this research could be: their reason to make, which special circumstances allow them to make, and what previously gained knowledge and skills they apply. This information can then be distilled into common patterns in order to find possible answers to subquestion 1: What allows makers to build the things they want to?

The answers found in the previous question will be used to improve the interview format in order to find out which drives zeros have and what stops those drives. The found patterns are used as a checklist to see if they are present and possibly obstructed, and to see if there are more causes for zeros to let themselves be stopped. This new information can possibly prove or disprove answers to subquestion 1 and provide answers to subquestion 2: What stops zeros from building the things they want to? Since the interview subjects might have built one or two projects, they can potentially deliver information for the first interview as well.

After information has been gathered on what drives, aids, and obstructs the type of people who will be the main users and the type of people who the main users should become, the logical next step is to see where there is overlap, which positives can cancel out which negatives. The murder board technique will be used to find the most possible connections. These connections will be taken as basis for possible methods of exploiting them in order to increase the size of the maker community. Those methods are answers to subquestion 3: What is necessary to help zeros become makers?

The methods found during this ideation phase need to be applied to STEM kits. They are still broad ideas and, in order to apply them in specific ways, they need to be sorted and tweaked. To find ways in which to apply the found methods in STEM kits, another brainstorm is in order. The results of this brainstorm can answer subquestion 4: How can findings from subquestion three be applied in STEM kits?

3.1.2 Specification

After the ideation phase, all four sub questions have an answer, but the solution should be tested in order to be able to conclude if it will work. In the specification phase, the requirements for improvement of STEM kits found in the ideation phase will be set out into clear requirements for the implementation and sorted in level of importance using the MoSCoW method described later in this chapter.

3.1.3 Realization

One of the ideas will be implemented and discussed with experts to gather their opinions and thoughts about the solutions. Their opinions, arguments, and expectations will be thoroughly explored and compared with each other in order to find out if the ideas created in the ideation phase are satisfying answers to the research question.

3.1.4 Conclusion

After answering all subquestions and testing the ideas by discussing them with experts, the gathered information will be reviewed to see if an answer has been found to the research question: What is necessary to help a zero become a maker and how can that be supplied by STEM kits? Regardless of whether an answer has been found, an advice on STEM kit design will be given to Conrad based on the thoughts of the experts, as well as recommendations on how to continue refining the requirements and design in the future.

3.2 Techniques

3.2.1 Questioning Techniques[11]

In order to receive the necessary information from interviews, it is crucial to ask the right questions. The interviews have been designed as open as possible, so the person interviewed is invited to give elaborate answers from which the interviewer can use parts to ask more specific questions to why and how they created or did not create what they talked about. In order to go into these points deeply, the interviewer needs to ask probing questions, and potentially use the 5 why's technique.[12] Instructions on what type of probing questions can be asked are included in the interview structure.

3.2.2 Semi-structured interview

In a semi-structured interview, there are two participants. One is the interviewer who has prepared a structure or a list of questions for the interview, the other is the respondent who will attempt to answer the questions posed by the interviewer to their best ability. The goal of an interview is for the interviewer to gather useful information or insight from the respondent. What makes a semi-structured interview special is that they take the form of a conversation which is only started and sometimes lead by the prepared questions and structure, allowing both participants the chance to go deeper into subjects they find important.

3.2.3 Murder board technique

This technique has roots in the blue hat of De Bono's Thinking Hats (1992) In essention, this technique is similar to the brainstorming technique bisociation; however, instead of generating ideas, it is used to find out how several parts of knowledge work together. In order to make connections between multiple points and pieces of information one would not always put together, expositioning them on a board and drawing lines between them is a useful technique. This technique allows for drawing parallels, seeing repetition and connections, noticing patterns, and pointing out differences. In order not to lose overview, it is advised to use more ways to show connections than lines; only using lines can create a web which in which it is hard to see which points are connected. This technique will be used to find patterns for subquestion 1 and 2, and connections for subquestion 3.

3.2.4 MoSCoW method[13]

The MoSCoW method is used to make explicit which requirements are essential, which are optional, and which are optimistic dreams of the future. This is done by separating them in four categories: Must have, Should have, Could have, and Won't have.

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11 https://www.mindtools.com/pages/article/newTMC_88.htm

12 https://www.mindtools.com/pages/article/newTMC_5W.htm

13 Mulder, P. (2017). *MoSCoW Method*. Retrieved 07/07/2019 from ToolsHero: https://www.toolshero.com/project-management/moscow-method/

Must have requirements are the bare necessities of a system. The minimal requirements that are determined in advance for the end result to meet.
Should have requirements are additional and highly desired. They have a high priority, but are not essential in order for the end result to be usable.
Could have requirements are those that can be considered if there is time left, they will make the end result better but will not have a negative impact if they are vacant.
Won't have requirements are usually impossible to realize or cost a lot of time and money; they are often regarded as wishes for the future

4 Ideation

Now that the work method has been set out, the first part will be executed. The ideation begins with two sets of interviews – one with makers and one with zeros. The next section explains combining outcomes of those interviews into methods to make it easier for zeros to become makers. The fourth section sets out the requirements for these methods to be applied in STEM kits. The interviews with makers showed that resource availability, possessed knowledge, personality, a helpful network, seeds, and causes to make for are helpful factors in the process of making. The interviews with zeros showed that costs exceeding benefits, distractions, outside constraints, a lack of (self-)belief, and missing knowledge are obstructing factors, which stop zeros from becoming makers. Solutions found from making combinations pertain providing inspiration to give seeds, helping to build a network in order to ask for help when necessary, and changing the design of kits, mainly their instructions in order to let the user experience making while they work with the kit. These solutions, together with physical specifications and Conrad's vision provide requirements which will be taken into the next chapter.

4.1 Makers

In order to find out why makers can build their projects and which factors help them do that, a number of interviews will be conducted with makers. The goal of these interviews is to find out for each participant how their making process works, what skills and knowledge they use during that process, and which other factors help them to make. For their making process to be placed in context and to help the subject remember their process as clear as possible, the conversation will be focused around projects the makers undertook. Because of that, the conversation will be different with every participant, forcing the interview to have only limited structure, based on open questions and a small conversation tree.

For ethical reasons (and common courtesy), all participants will be asked if they have objections to notes being taken of the conversation and their input being used in scientific research. Furthermore, no one of an age below 18 will be interviewed, and all respondents will remain anonymous.

4.1.1 Interview design

The interview structure in table 1 has been designed to help get a conversation started about the process of making. After greetings and small talk to ease the subject, the conversation starts with the question at the top, the split questions receive an answer that can be indicated as yes or no, which decides in which direction the rest of the interview will go. The interviewer needs to practice interviewing beforehand, specifically in the field of asking probing questions, and the subjects' names will not be displayed because of privacy.

The Maker Festival Twente is a wonderful opportunity to talk to makers, as many of them will be gathered in a relatively small area.

Interview Guideline: The expectation is that making is a very different process with vastly different results per person. Therefore, these questions are very open. It is important to listen carefully to the interview subject and ask probing questions based on what they made and how they did so to find out why they make and what helps them do that. If the interviewer deems it necessary, deviation from the structure is possible; however, for full results, all split questions that are applicable need to be asked.

<table>
<tr><td colspan="3">SPLIT QUESTION
Were there moments you had inspiration to build or improve something technological?</td></tr>
<tr><td colspan="2">1: Yes</td><td>2: No</td></tr>
<tr><td colspan="2">What was it?</td><td rowspan="2">If they have had inspiration to build or improve something non-technological, some data can be gathered by following path 1.
If not, little data useful to this specific project can be gathered from this person.</td></tr>
<tr><td colspan="2">Why did you want to make it?</td></tr>
<tr><td colspan="2">SPLIT QUESTION
Did you create it?</td><td></td></tr>
<tr><td>1.1: Yes</td><td>1.2: No</td><td></td></tr>
<tr><td>What knowledge or tools did you use?</td><td>What stopped you?</td><td></td></tr>
<tr><td>Where did you obtain these?</td><td>Why did that stop you?</td><td></td></tr>
<tr><td>Were there other factors which helped you?</td><td>Were there other reasons?</td><td></td></tr>
</table>

Table 1: interview structure for the first interview. More explanation can be found in the paragraph above.

4.1.2 Execution

On Saturday May 25th, a total of nine interviews have taken place at the Maker Festival in Enschede. The environment was full of interesting projects, and most people are eager to impress. The interviewer walked around the festival area in order to speak with both visitors and makers who are showing what they made. The visitors and participants are predominantly male. The participants age between 21 and around 60. All interviews have been conducted in Dutch. The translation of the notes taken during the interviews can be found in Appendix C.

The findings from these interviews have been written out in lists on a whiteboard, after which the Murder Board Technique has been used to look for common factors, connections, and to identify categories of factors by using those connections. For overview, the six categories found were set out on a different whiteboard as word webs with the category in the middle and all factors belonging to the category attached to them.

4.1.3 Results

The important notes taken during the interviews can be found in Appendix C. Nine people in total were interviewed, four subjects of the second interview added information to the set later. Images 2-3 describe the processing of the information. The found connections can be seen in image 3. The categories and the aids that belong to them are also listed underneath image 3. These connections have been made by looking for similar factors, removing person-specific factors, and keeping an eye out for factors with the same cause. Then, they all have been sorted in categories based on the type of benefit they provide.

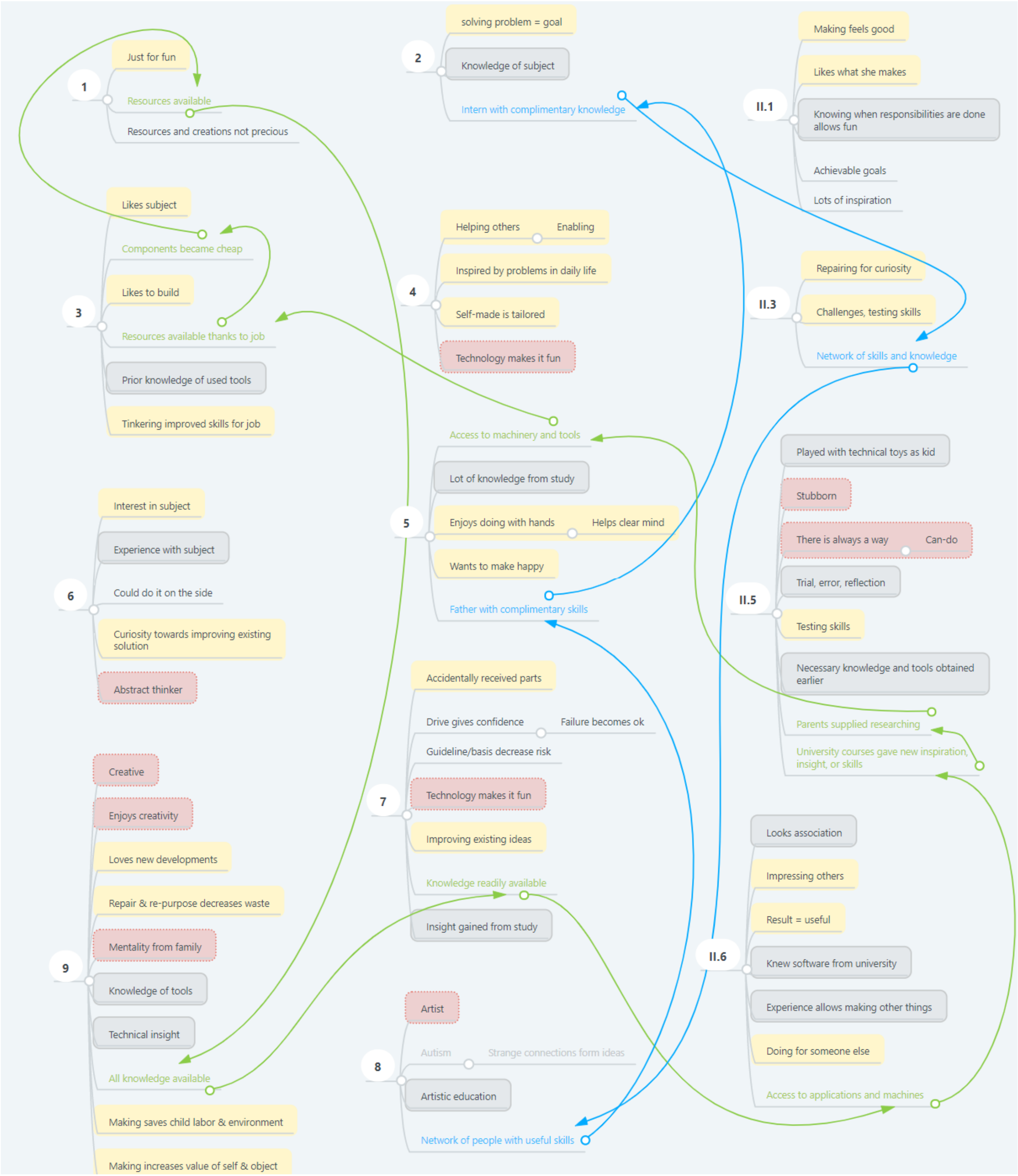


Image 2: Lists of aids for making and reasons to make. Green arrows show a connection because the factor is related to availability of resources. Blue arrows indicate a relation based in help from others. Personality traits have been noted in red, reasons and seeds have been noted in yellow, and prior knowledge factors have been noted in grey. One factor, autism, has been greyed out, indicating it is not likely a factor which would be an aid to others.

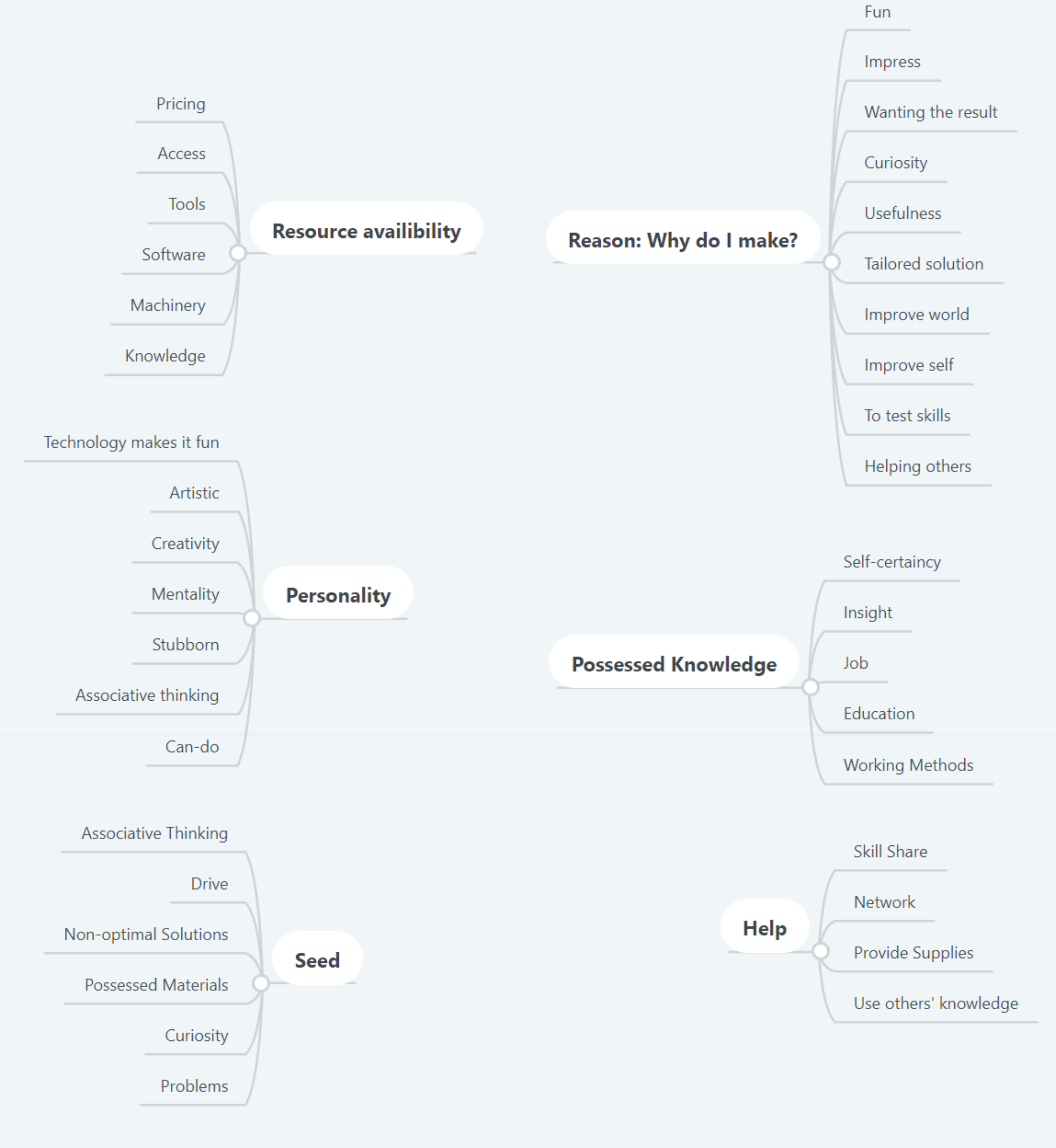


Image 3: the six categories found from the connections drawn in image 2 and what they contain.

Resource availability

54% of the interviewed explained their ability to make was increased because they had access to the right knowledge, materials, machinery, software, and tools. 31% would not be able to make without access to these resources. Ways in which resources become more available are:

- Pricing
- Access because of job/education
- Knowing owners of resources

Possessed Knowledge

Knowledge about subjects which are useful to your project provides benefits in the way the project is tackled. 77% of the interview subjects had significant prior knowledge about one or more aspects of their projects. The following lists show where they gained their knowledge and the benefits of prior knowledge, respectively:

Obtaining knowledge

- Raised with technical toys
- Education
- Job

Benefit of knowledge

- Self-certainty
- Insight
- Working methods

Personality

Even though there will be little chance of changing a person's personality, enough of the interviewed people (46%) talked about one or more of their personality traits as being helpful for making. Therefore, the important personality traits are listed here:

- Creativity
- Mentality
- Stubbornness
- Associative thinking
- Can-do attitude

Help

If there are parts of a project the maker does not understand, have access to, or simply is unable to do, others might be able to help out. 38% of the interviewed mentioned having a network of people they can ask for help with projects. Ways in which other people can be helpful are the following:

- Applying their skills
- Providing supplies
- Sharing or supplying their knowledge and insights
- Expanding the network

Seed

In order to start making, inspiration is necessary. A seed can come from anywhere but must be seen as such. Seeds can come from the following:

- Drive to make
- Suboptimal solutions
- Associative thinking
- Problems
- Curiosity
- Possessed materials

Reason

Every maker has a reason to start making. Without a reason, a person would not put effort in a project. The following categorized lists provide reasons given by interviewed, in order of how often they appear, they are accompanied by the percentage of the total amount of interviewed people who stated the reason or one very similar:

Out of interest 62%

- Interest in the subject 38%
- For fun 31%
- Curiosity 23%

Circumstance 54%

- Desiring the result 15%
- Wanting to work with hands 15%
- Available resources 15%
- Tailored to the maker 8%

For the world 38%

- Solving a problem 15%

- Improving existing ideas/solutions 15%
- Decreasing waste 8%
- Improving value of object 8%

Improving self 38%

- Testing skills 15%
- Improving value of self 15%
- Independency 8%

For others 23%

- Helping others 15%
- Impressing others 8%
- Making others happy 8%

6.1.4 Theories

After having identified the factors that aid makers in their process based on the categories and most common reasons for making, the following five theories can be crafted out of those categories of factors:

- Makers can make because they feel confident in their ability to make what they want.
- Makers feel they have the necessary prior knowledge to build their project.
- Makers can make because they have access to resources or a helpful network.
- Makers make out of interest, fun, or curiosity.
- Makers have personality traits that help them make.

The hypothesis is that zeros are kept from making because, for them, one or more of these reasons is obstructed. The next section will test that hypothesis by comparing them with the results of interviews with zeros about their making process and what obstacles they encounter. If the obstructing factors interfere with these reasons, the hypothesis has been verified, showing that the aids found in this section can help overcome the obstacles found in the next.

4.2 Zeros

In the previous section, factors which aid makers in the process of making have been gathered and categorized. In order to find ways to help zeros become makers, it is necessary to find out which factors obstruct them in the making process. Possibly, those factors can be counteracted by the aids found previously. In order to see if that is possible, the theories crafted about why makers can make will be inverted into hypotheses why zeros cannot make and compared with findings from another set of interviews; this time with people who want to become makers or already are makers to some extent but leave many projects uncompleted. The goal of these interviews is to gather information from each respondent about what factors stop them from making or finishing their projects. If these factors are the same as the five reasons hypothesized by inverting the theories in the previous section, the hypothesis that makers' aids can help zeros overcome their obstacles has been verified; otherwise, new reasons can be added to the list, one or more reasons can possibly be removed, and then those can be used as targets to solve. To help the subjects get into the mindset they have when playing with an idea for a project, the conversation will revolve around one or two projects they have had in mind or started but never finished. Because of that, the conversation will be different with every participant, forcing the interview to have only limited structure, based on open questions and a small conversation tree.

4.2.1 Inverted theories

By turning the reasons from 6.1.4 around, these five hypothetical reasons for why zeros are stopped from making are created:

- Zeros feel less confident in their ability to make what they want to.
- Zeros (think they do) not have the necessary prior knowledge to build their project.
- Zeros do not have access to resources or a helpful network.
- Zeros have yet to find the subjects they in which they have enough interest to make.
- Zeros have personality traits that stop them from making.

The obstacles found in the following interviews will be compared with these reasons, if they do indeed match, the hypothesis that one or more of the reasons why makers can make are obstructed for zeros has been verified. This would mean that the aids found in the previous section can be used to counteract the obstacles found in this section. If that is not the case, new reasons will be constructed from the obstacles found and other ways to find solutions to those reasons will be ideated.

4.2.2 Interview design

The interview structure is similar to that of the previous interview, but enriched with a reason checklist. Furthermore, the interviewer will probably need to use more probing questions than in the previous interview, enforced with the five why's method in order to get to the root of why people are being stopped from making. This is because people generally prefer to talk about what they did over talking about what they did not do. The structure can be seen in table 2. And again, or ethical reasons (and common courtesy), all participants will be asked if they have objections to notes being taken of the conversation and their input being used in scientific research. Furthermore, no one of an age below 18 will be interviewed, and all respondents will remain anonymous.

Interview Guideline: The expectation is that, similar as with making, reasons and obstructions differ per person. Therefore, these questions are very open. Most subjects would rather talk about what they did than what they did not do. Ask probing questions about every aspect of failed or never-started projects to find out whether that aspect had a part in the reason why the subject stopped. Again, if the interviewer deems it necessary, deviation from the structure is possible; however, for full results, all split questions that are applicable need to be asked.

SPLIT QUESTION Were there moments you had inspiration to build or improve something technological?		
1: Yes		**2: No**
What was it?		*Little information useful to this specific project can be gathered from this person.*
Why did you want to make it?		
SPLIT QUESTION Did you create it?		
1.1: Yes	**1.2: No**	
Although this is not the purpose of this interview, ask for data which can be used to improve the value of the previous interview. Then, ask if there are projects which they did not finish.	What stopped you?	
	Why did that stop you?	
	First let them talk and go into that, try to find out what the answers are to the following questions; then, if there is no clear answer, ask the following questions.	
What knowledge or tools did you use?	Did you possess the knowledge necessary to create your idea?	
Where did you obtain these?	Did you think you would be able to finish the project?	
Were there other things that helped?	Did you have the drive to work on the project?	
	Were there other reasons?	

Table 2: interview structure for the second interview. More explanation is available in the paragraph above.

4.2.3 Execution

On Thursday June 14th, a total of seven interviews have taken place on the campus of the University of Twente. The environment was different in several interviews, they are described together with the notes in Appendix D. The participants age between 21 and 26 and are all students of the University. Most of the interviews have been conducted in Dutch. The findings from these interviews have been written out in lists on a whiteboard, then the Murder Board Technique was applied to find correlations and inequalities among them; and to identify categories of factors.

The seventh respondent is the person who performed all other interviews and this project. Because of the self-insight direction of the interview, the chance of this negatively affecting the data is small. This risk has been taken because this person knows exactly which kind of information is being sought after and falls in the category of zeros who want to become makers.

When the data was being reviewed, it appeared two important questions had not been asked. They have been asked to all respondents via WhatsApp, the conversations have been documented in Appendix E.

4.2.4 Results

The notes taken during the interviews can be found in the appendix. Seven people in total were interviewed, four of which also gave information useful for the previous interview. Images 4-5 describe the processing of the information. The found connections can be seen in image 5. The points shown are also listed underneath the images. These connections have been made by looking for similar factors, removing person-specific factors, and keeping an eye out for factors with the same cause. Then, they all have been sorted in categories based on the type of benefit they provide.

Image 4: Lists of reasons to stop making and connections between those. The lists have been sorted per respondent and connections have been drawn with arrows, categories were indicated by coloring the factors. Green arrows indicate self-doubt, orange arrows indicate perfectionism, grey arrows indicate missing knowledge. Yellow shows a distracting factor, red shows an accessibility problem, blue indicates missing belief, green shows a lack of self-belief, light grey accentuates missing knowledge, and solid grey underlines costs which exceed benefits.

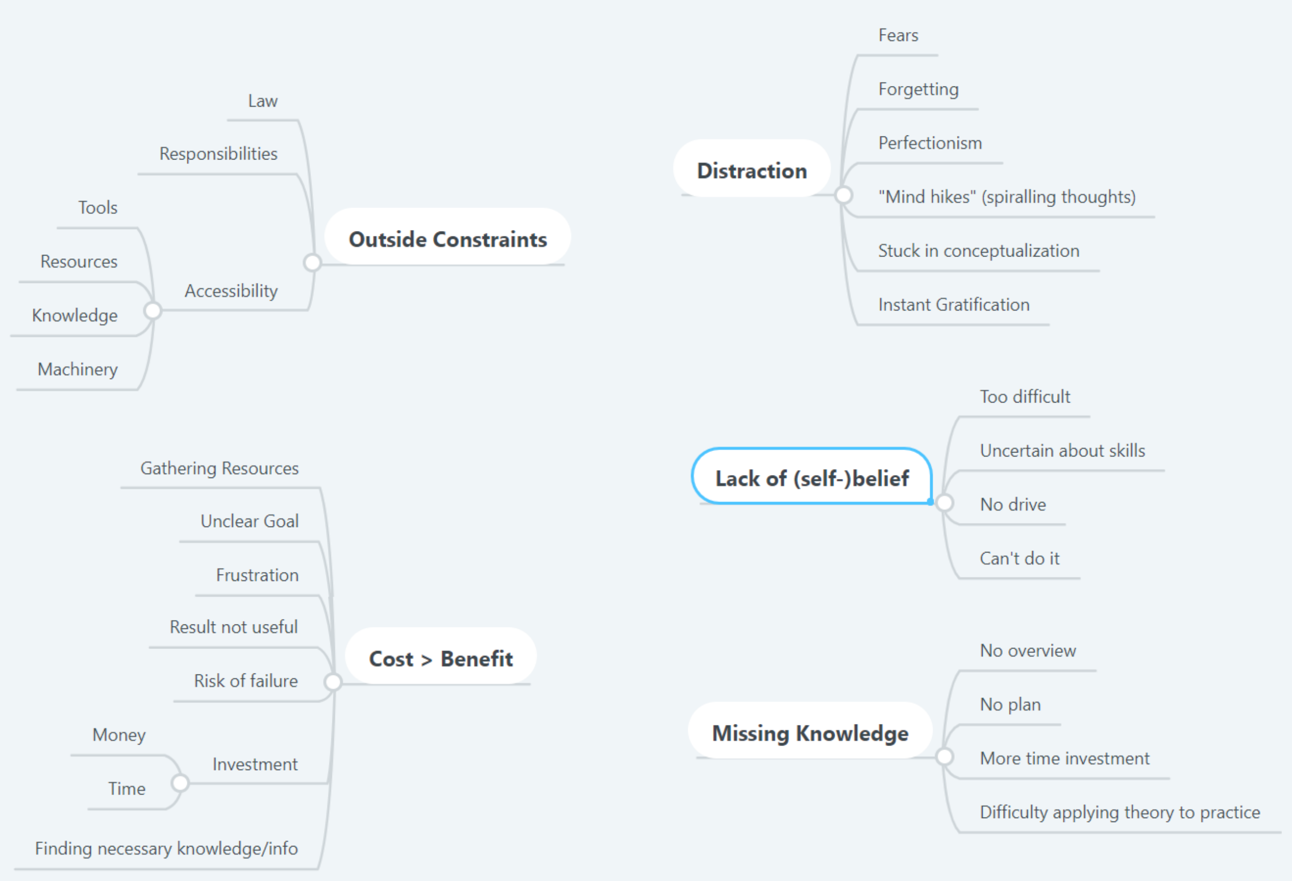


Image 5: the five categories found from the connections drawn in image 4 and what they contain.

Costs over benefits

57% of interviewed let projects go if the perceived costs outweigh the perceived benefits. The interviewed mentioned the following circumstances that can cause an increase in perceived cost or a decrease in perceived benefit:

- An unclear goal
- Resources that need to be gathered
- Investment of time and/or money
- Having to search or outsource for necessary knowledge and/or information
- Frustration
- Low usefulness of the object which is the goal
- Risk of failure during the process

Distraction

71% of interviewed tend to get distracted before or while working on a project. Potential distracting factors the interviewed mentioned are:

- Fears and anxieties
- Forgetting about the project
- Perfectionism
- Instant gratification
- “Mind hikes” or spiralling thoughts
- Staying stuck in conceptualization
- Losing Focus

Outside constraints

43% of interviewed mentioned one or more constraints they could not easily influence were keeping them from their projects. The constraints they talked about are:

- Responsibilities
- Laws
- Accessibility of Knowledge
- Accessibility of Tools
- Accessibility of Machinery
- Accessibility of Resources

Lack of (self-)belief

71% of the interviewed gave reasons for letting go of a project that can be attributed to a lack of belief in themselves or the project.

- Feeling the project will be too difficult for them
- Uncertainty about their skills
- No drive to work on the project

Missing knowledge

Even though most knowledge is available within a few clicks, it is a constraint 71% of the interviewed explained for not starting on a project. Below, there is a list of problems that are being caused by a lack of knowledge:

- No clear plan on how to take on the project
- No overview over the project and its process/progress
- Difficulty translating theory to practice
- Needing to invest extra time in finding missing knowledge

6.2.4 Theories

At the beginning of this section, the hypothesis has been stated that zeros are kept from making for the following reasons (one or more reasons per person):

- Zeros feel less confident in them their ability to make what they want to.
- Zeros (think they do) not have the necessary prior knowledge to build their project.
- Zeros do not have access to resources or a helpful network.
- Zeros have yet to find the subjects in which they have enough interest to make.
- Zeros have personality traits that stop from making.

Of these reasons, factors falling under lack of knowledge and little confidence in abilities have been named multiple times and remained dominant categories of obstacles. Access to resources has been named as well, but a lack of network was not; it is possible the respondents were not aware of the possibility the problem might lie in their network, or lack thereof. In either case, accessibility remained an important factor in the category of outside constraints. Multiple respondents talked about fears and anxieties, sometimes implicitly; one person specifically stated a personality trait (perfectionism) to be hindering him, others talked about desires for instant gratification. This reason is therefore also part of the problem and is accounted for in the category of Distractions. Low interest has been mentioned by only one respondent; possibly meaning this reason is not a main concern. It has therefore been incorporated in the category Lack of (self-)belief as a single factor. And finally, the category of costs over benefits has not been foreseen in the previous set of reasons, but based on these interviews, it should be added to the list. Four of the five reasons have been addressed frequently, and the fifth was shown to be a part of the problem, albeit a minor one. This verifies the hypothesis that zeros are stopped from making because one or more of the reasons to make have been obstructed, with the addition that costs exceeding benefits can stop from making as well. This shows that the aids found in section 4.1 can be used to fight the obstacles found in section 4.2, methods to do so will be ideation in the next section.

4.3 zero to maker

After gathering the information in the previous sections, the next step is to find solutions to the problems zeros explained in the second interview. The reasons why zeros are being stopped from making that were constructed from negatives of reasons why makers can make correlate with the reasons for being stopped found in the second interview. Therefore, the beneficial factors makers explained in the first interview are expected to be able to provide solutions. In order to find these solutions, the categories of factors found in the interviews will be set out on a whiteboard and connected using the Murder Board Technique again, see image 6. The results are shown below, in tables 3 and 4.

6.3.1 results

Idea	Removed obstacle	Used aid
Lists of examples and problems	Distractions	Seed & Reason to build
Project consultants	Fears & Anxieties	Help
Knowledge sharing platform	Missing Knowledge & No Plan & Lack of Self-belief	Network & Sharing Knowledge (& others' work methods/insight)
Fab Labs	Gathering resources & Inaccessibility	Network
Reduce prices	Money investment constraints	Pricing
Gradually invite to try new things or improve skills by designing the instructions for that purpose	Uncertainty about skills & lack of (self-)belief	Improving Self & uncertain outcome
Turn "Not sure if I can" into "Try if I can" by motivation and making failure okay	Risks & Fears & Uncertainty about skills & Difficulty translating theory to practice	Testing skills & information gap

Table 3: results of the Murder Board Technique

Part 1	Part 2	Result
Possessed Materials	Curiosity	Designing kit so that user becomes more curious towards potential of owned materials
Possessed Materials	Tool accessibility	Provide useful tools like screwdrivers with kits, so they can also be used for other purposes.
Working on it on the side (From interview 1, subject 6)	Time investment	Time investment can be spread out into overseeable moments
Materials not precious (From interview 1, subject 6)	Fear of breaking materials (From interview 2, subject 7)	Breaking materials is okay
Guideline/Basis (From interview 1, subject 7)	Stuck in conceptualization & fear of doing things wrong (From interview 2, subject 4)	Decreases chances of failure and bypasses conceptualization.
Achievable goals (From interview 2, subject 1)	Lack of self-belief & No overview	Increase self-belief & Gives overview

Table 4: other ideas, gained by connecting small, single points.

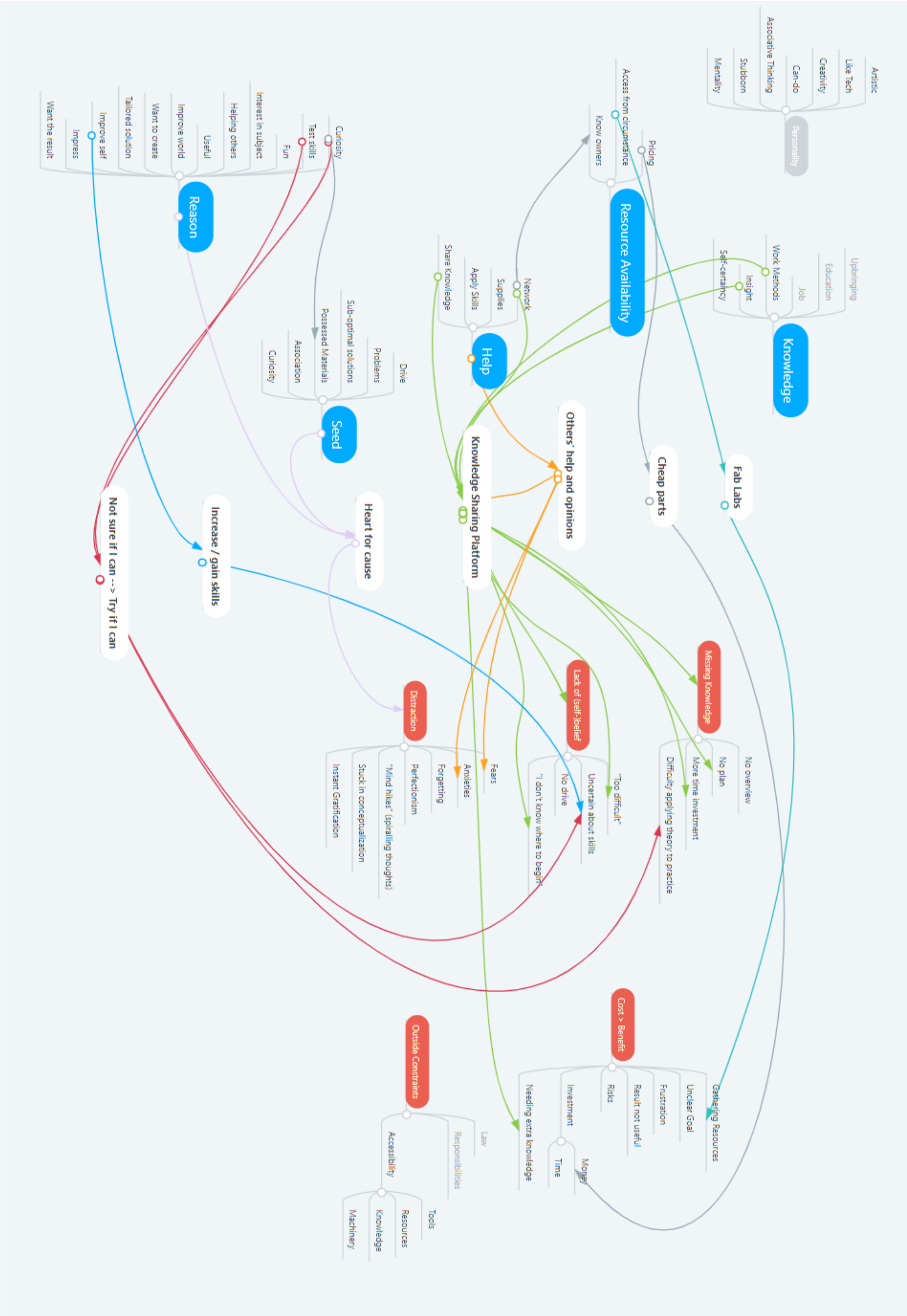


Image 6: the categories and their subparts of both lists have been added together. Obstacles in red and aids in blue. Connections have been drawn with arrows, gathering at the ideas of their implementation.

Ideating using the aids and obstacles to find ways in which zeros can be helped to become makers has brought forth the list of ideas shown in table 3, these ideas should all be useful for helping zeros become makers. However, at this point they are still broad, the ideas need to be refined in order to be applied in, with, or by STEM kits. That is what will be done in the next section.

4.4 Applying to STEM kits

The ideas gathered in the previous section can all be used to help people who want to make to actually start making. However, not all of them can be applied in, or combined with STEM kits. In order to answer the last sub question: How can the findings from sub question 3 be applied in Conrad's STEM kits, both the requirements for applicability in STEM kits and Conrad's requirements and wishes need to be heard. After that, the ideas will be checked if they fulfil those requirements, or if they could after applying small changes.

4.4.1 Requirements

The rough requirements have been set out in chapter 2, the analysis. These are the ones set out there:

Features commonly returning in STEM kits:

- Total contents small and light enough to be carried by hand.
- Teaching scientific or technological phenomena.
- Interesting results after completing the kit.

Wishes from Conrad:

- Allowing anyone to become a maker.
- Open ended results from the kit.
- Low costs.
- If possible, improve sales.

Factors gathered from 'lekker samen klooien':

- Teach the user to use new techniques or tools.
- Let the user gain experience with techniques and tools.
- Help the user see the tools and ideas in what they already have.
- Help the user understand what the kit teaches them by trying it out.
- Get the user to work with their hands.
- Remove fears and practical constraints.
- Make users curious.
- Help users to be brave.

4.4.2 Results

Taking another look at tables 3 and 4 while comparing the contents with findings in this chapter can provide a list of what is and is not possible with STEM kits. This list is shown in table 5. From this list, more requirements can be gathered based on the obstacles and aids picked.

From generated ideas list:

- Remove fears & anxieties
- Give users a reason to build
- Help users see seeds
- Provide knowledge or experience users feel they lack
- Make resources and tools available
- Help users believe in their own capabilities
- Help users see that mistakes are allowed
- Let users improve their skills

That makes for a list of requirements to work with. The only thing left to do is test if these requirements would work in practice. In order to do so, the requirements need to first be organized into which are most important, which will be done in chapter 7; after that, a test will be designed to verify these requirements and their practical effects in chapter 8.

Category	Idea	Removes Obstacle	Using Aid	STEM kit
Inspiration	Lists of examples to try and problems to solve	Distractions	Seed & Reason to build	A list which fits the components or learning goal of the kit can be delivered.
Networ-king	Project consultants	Fears & Anxieties	Help	Helpful people could be on the knowledge sharing platform to provide help, but it would first need to be established or the consultants need to be hired.
	Knowledge sharing platform	Missing Knowledge & No Plan & Lack of Self-belief	Network & Sharing Knowledge (& others' work methods/insight)	Include access code to (parts of) online knowledge sharing platform
	Fab Labs	Gathering resources & Inaccessibility	Network	Provide promotion for established 3D print hubs and PCB service
Access	Reduce prices	Money investment constraints	Pricing	Not desirable
Changing kit designs	Gradually invite to try new things or improve skills	Uncertainty about skills & lack of (self-)belief	Improving Self & uncertain outcome (from literature review)	Show which level of experience a kit requires. The higher the level, the less specific the instructions and more materials and tools are not delivered, requiring more thinking and creativity from the user.
	"Not sure if I can" into "Try if I can" by motivation and making failure okay	Risks & Fears & Uncertainty about skills & Difficulty translating theory to practice	Testing skills & information gap (from literature review)	Instructions can be designed as such that users are gradually testing their skills and knowledge by providing information gaps (see literature review). This can open their eyes to trying before giving up.

Table 5: solutions and their compatibility with STEM kits.

4.5 Next steps

Factors aiding makers in their process of making and factors obstructing zeros in making processes have been combined into multiple ideas to help zeros overcome their obstacles and become makers, these ideas have then been refined and changed in order to be applicable with, in, or by STEM kits. This means that all four sub questions have been answered. However, the results and their practical application still need to be tested in order to fully answer sub question four and the research question. In order to do so, a list of requirements for methods to help zeros become makers with the use of STEM kits has been formed from these ideas, features common or important in STEM kits, and Conrad's vision. In the next chapter, these requirements will be organized on importance, in order to allow testing them in the chapter after that.

5 Specification

In order to move from an idea to a concept, it is important to specify which requirements are vital, which are optional, and which are optimistic future plans. The MoSCoW method will be used to do so. Furthermore, the ideas will be separated into functional and non-functional requirements. The deciding factor is simple: if a requirement can be measured, it is functional; if it is necessary to do user tests in order to see if a requirement has been met, it is non-functional.

5.1 MoSCoW organizing

Must Have	
Functional	**Non-functional**
Help the user understand what the kit teaches them by trying it out.	Teaching scientific or technological phenomena.
	Teach the user to use new techniques or tools.
	Get the user to work with their hands.
	Remove fears and practical constraints.
	Help users believe in their own capabilities
	Help users see that mistakes are allowed

Should have	
Functional	**Non-functional**
Open ended results from the kit.	Interesting results after completing the kit.
Total contents small and light enough to be carried by hand.	Let the user gain experience with techniques and tools.
Low costs.	Make users curious.
	Help users to be brave.
	Provide knowledge or experience users feel they lack.

Could Have	
Functional	**Non-functional**
	Allowing anyone to become a maker
	Give the users a reason to build.
	Help the users see the tools and ideas in what they already have.
	Let users improve their skills

Would Have	
Functional	**Non-functional**
Improve sales	Make resources and tools available

5.2 next steps

Of the Must Haves, Removing fears and practical constraints, helping users believe in their own capabilities, and helping users see that mistakes are allowed are not yet thoroughly incorporated in all STEM kits. The other Must Have requirements are already inherently part of STEM kits. In the next chapter, Whether the implementation has succeeded can be tested by checking if the functional requirements have been met and evaluating the non-functional requirements with users. That is what will be done in the next chapter by realizing the changes to instructions and testing them out.

6 Realization

After organizing the requirements in their level of importance to the essence of the end result, all is ready to start testing. In this chapter, multiple methods of implementation and testing will be discussed. The instructions of a STEM kit have been altered to leave room for the user to experiment, reflect, and learn by implementing uncertain situations and an information gap; this in line with the ideas in Changing Kit Designs of table 5. And to close off, the structure for a semi-structured expert interview is set out to find out if the expert thinks the presented instructions invite the user to change their behaviour towards instructions, and whether the expert believes the ideas in table 5 will work.

6.1 Ideating test method

Mind map of testing and implementation

6.1.1 Testing methods

Expert interviews: requires a very small amount of people, respondents can give insight on how to improve the discussed materials from an experienced point of view, and results can be further explored with the respondents because there is a conversation.

Focus group: requires a large amount of time and a product nearly ready for use.

User tests: requires permission of the ethical committee, a large amount of willing users, and a thoroughly designed set of instructions. On top of that, the product should be nearly ready for use, while these designs are still in early stages. Performing the user tests takes a large amount of time as well.

Survey: takes time to reach enough people and gather enough responses and processing it requires a high amount of time and effort. That while the results gained cannot be further explored with the respondents since there is no conversation, which means the value of each response is low. Furthermore, the types of designs that can be tested via surveys is limited; physical products will be difficult to test.

To conclude, since it fits best in the time left and the stage of development, the design will be tested via expert interviews. In expert interviews, more than applied solutions can be discussed; the experts could also give their opinions about theoretical solutions.

6.1.2 Implementation methods

Lobbying: Testing this will be difficult. It will hardly be possible to see which people have been reached and what the effects on them were. Furthermore, this has little to do with STEM kits.

Seeing seeds: Testing this can be rather easy via user tests or expert interviews. However, this requires more research into what can be seeds and how to present them, since little of that knowledge has not gathered in this research.

Set up a platform: Setting up a platform can potentially reach a large amount of test users, which will make sending out a survey to enough people relatively easy. The users can then find the platform via invitations included in STEM kits. Doing so will require a high amount of effort, and might provide harmful experiences during testing to potential users of an actual platform Conrad might set up in the future. It will also require time for the platform to take off.

Sell things for cheap and see what people might do with them: Useful insight can be gained from applying this. Sadly, this would oppose Conrad in the market, which would not be good for relations and Conrad's sales. Furthermore, to test this it will be necessary to follow customers in order to see what they do with the products they could more easily afford, which is highly intrusive.

Hire project consultant: To test this, a consultant needs to be hired for multiple people who each work on their projects. This requires large amounts of money and time, which are both unavailable at this point. Also, people helping users out can help them reach the desired results, but has little to do with STEM kits.

Go to Fab Labs and talk with people: A cheaper and more network-oriented version of hiring a project consultant. Similar to the consultant, this requires multiple people who each work on their projects, whose progress will be followed in order to see the results of the help of Fab Lab communities. Tracking the processes requires a large amount of time, which is not available. And, in this case as well, the implementation has little to do with STEM kits.

Design ultimate flexible kit: This is more of a dream scenario than an actual option. Knowledge of how to do this is missing at this stage, more needs to be tested in order to know what an ultimate flexible kit should have and should not have.

Make a part: Requires time and understanding of the kits. Required time is little and understanding of a part like instructions is there. Providing problems to work with can be done but knowledge on how to design problems which really motivate is missing.

The implementation which consumes least time and money, and still stays close to STEM kits is to implement changes to instructions of STEM kits. The instructions can be changed according to the Changing Kits' Designs category of table 5, and problems to work with or examples of what can be done with the contents of the kit by adding own parts and knowledge can be included in the form of challenges at the end of the instructions, after the user has learnt to understand the scientific phenomenon the kit teaches.

6.1.3 How to test

Concluding both these sections: the ideas in table 5 will be tested by implementing suggested changes to instructions of a STEM kit, and discussing those with experts in expert interviews. The experts can also take a look at the whole list of ideas in table 5 – which are not all implemented – to give their opinion on the other ideas as well.

6.2 Instruction construction

As such, the Must Have requirements have been implemented by redesigning instructions of a STEM kit. To be precise, they were the instructions of the Arexx School Lab magic Light Kit, redesigned according to the implementation ideas of the 'changing kits design' category in table 5, the result of which can be found in Appendix F. In the new instructions, the order of the steps has not been changed, but the new instructions contain only the most vital information of each step in the original instructions, leaving out most tips and warnings. Information on which materials should be used to put two parts together has been deliberately left out, so users get the chance to either use screws delivered or grab their duct-tape, tie-rips, or any other material they can find. These two design choices will likely cause the users to make mistakes in the assembly process, which they will have to solve using their own insight. Doing so will improve their self-belief. Furthermore, the information about how LED lighting works is placed at the beginning, so users for whom the LEDs do not immediately work are confronted with an information gap they can fill by remembering what they learned at the beginning of the assembly process, possibly looking back in the instructions, or maybe even searching online. Solving that problem on their own will increase self-belief even further.

6.3 Testing the ideas

In order to best test if the Must Have and Should Have requirements have been met, user tests are in order. Sadly, a lack of time disallows user testing; therefore, the implementation will instead be discussed with two experts. The first is Dave Borghuis, professional maker and founder of TwenSpace and other maker spaces. His experience with making, the maker movement, and knowledge of many makers can provide meaningiful insight and opinions. The other is dr. Joyce Karreman, researcher at the University of Twente Faculty of Behavioral, Management and Social Sciences; specialized in instructions for specific target groups. Her knowledge and experience of instructions and their psychological effects can provide insight on the behavior that is likely to be the result of the newly designed instructions. The benefit of discussing the instructions with experts is that they can also give insight on their view of the problem, bring new ideas to the table, and share their opinion on the other ideas in table 5.

6.3.1 Interview Structure

The goal of the interview is to find out:

1. If the expert thinks the presented instructions invite the user to change their behavior towards instructions.
2. Whether the expert believes the found solutions will work.
3. If so, what the expert believes is necessary to make the found solutions work.
4. And finally, what the expert thinks will be necessary to help STEM kit users become makers.

The interviews will be semi-structured, because input from the experts can lead to new information which should be explored, preferably during the interview. There is more structure than with the previous two interviews, as the questions to answer with these interviews are more specific. The respondents will not immediately be told what the goal is behind the design choices of the new instructions, since that might lead to a confirmation bias; they will initially be told they were designed as a method to improve engagement. And finally, the interviews will be conducted in Dutch, as that is the native language of both respondents. The full structure, in Dutch, can be found in Appendix G.

6.4 Next steps

In this chapter, the method has been set out for testing the ideas and requirements resulting from previous chapters. Instructions of the Magic Light Kit have been altered to leave room for the user to think for themselves and experiment by using uncertain situations and an information gap. These instructions, together with table 5 will be discussed in two expert interviews, one with a professional maker, one with a doctor of psychology, specialized in instructions. From these interviews, expectations and opinions of the experts will be gathered and those will be set out and discussed in the following two chapters, in order to use them to draw a meaningful conclusion.

7 Results

In the previous chapter, all has been prepared to perform a test of the viability of the ideas set out in this research. New instructions for a STEM kit have been designed and the structure for expert interviews about these instructions and table 5 has been set up. The goal of the interviews was to find out:

1. If the expert thinks the presented instructions invite the user to change their behavior towards instructions.
2. Whether the expert believes the found solutions will work.
3. If so, what the expert believes is necessary to make the found solutions work.
4. And finally, what the expert thinks will be necessary to help STEM kit users become makers.

In this chapter, the results from both expert interviews will be discussed. The interviews can be read in full in Appendixes H and I, but the most important take-aways have been noted down in this chapter.

7.1 Dave's opinions

Dave expects a more vague instruction method would indeed push the user in a more experimental mindset and get them to work differently, so it would work. However, it needs intensive beta testing to find the sweet spot between scaring users into giving up and guiding them by hand without letting them think. As it is now, it does not invite to work with the materials, possibly because there are no visual links between the instructions and the materials. Images can help bridge the gap. Furthermore, should a user who is not used to technology try to use it, they might end up having to give up because they run into a problem they cannot solve alone. Maybe showing the level of experience a user is expected to need to successfully work with a kit can minimize the amount of people that have to give up. Another option is to provide instructions on multiple levels and tell the user to first try difficult, and if they run into problems they cannot solve, they can take the full instructions. The new way of instructing would help people recognize to trust in their own abilities and try before giving up, but only if they manage to complete the kit. If they give up they will have had a bad experience and will be less likely to try building anything electronical again.

Dave suspects many people who buy a kit like this just want the result, and as quickly as possible. They will not be happy with vague instructions that require them to think. For these people, complete, IKEA-style instructions should be included. What is also important is to make sure the users know that making mistakes is perfectly fine, and an important part of making and learning. People tend to fear making mistakes because they have the feeling that they cannot do something because they have not done it before. A message at the start of the instructions could help the user loosen up. It could tell the user that they will become a maker, which includes making mistakes and that that is fine, as long as they learn from them.

For the rest, Dave believes the combinations make sense, and will work. He suggests to add the concept of mistakes being okay to 'turning "Not sure if I can" into "Try if I can"'. Maybe the project consultants will be pricey, that might prove problematic for individual makers and schools. To omit that problem, try to find able people without certification for that.

Dave mentions communities at Fab Labs and Maker Spaces can be very useful and helpful, but people who have not been there generally expect they do not belong there, they have a mental barrier because they think people will not want them there, much will be expected from them, or other similar expectations, which usually are not true at all. Furthermore, they do not know how to approach people there and might ask them for help in a way that will make them unlikely to agree. An option is to add text and images of Fab Labs, Hackerspaces, and maker spaces close to the retail point where the kit is sold, including explanation of what is possible there and general advice on asking help from technology hobbyists at fab labs and other such spaces.

Judging Dave's behavior while building the Magic Light, it might be beneficial to remove tedious parts of kits, such as the last step in the Magic Light Kit with the screws and plates. It takes time and patience and adds little to the essence of the kit. Either the user will not perform the step and stop using the kit, like Dave did, or the user will be bored afterwards. In both situations, challenges added at the end will not be tried out.

7.2 Joyce's opinions

Joyce expects vague instructions and challenges alone will not get users to experiment, what she suggests is improving morale to keep trying by showing examples of what others in the same target group did with the kit and explanation of how they were able to do that. Informal messages in instructions can motivate to keep going and give the users confirmation they are on the right track. Images can add to that by giving users information about whether what they did was right or not. The way these instructions have been designed, they look somewhat daunting and might scare inexperienced users away. If that happens, those users are unlikely to try anything with electronics again. If the user manages to build the lamp with these instructions, the goals should have been reached. They should be more aware of their own problem-solving capabilities and possibly more curious towards possibilities not specified. However, in order for a user to actually finish the building process with these instructions, they need to already be motivated, interested, and somewhat persistent. Motivating elements, like personas explaining what they managed to do and what helped them might help in the motivation and persistence parts.

It might be necessary to explicitly state these instructions are different from what users might be used to in order to get them to change how they look at the instructions. Adding a message about how these instructions do not have to be followed to the letter, how making mistakes is probable and fine, and examples of what others did with the kit will invite users to keep trying.

Joyce believes the ideas in table 5 will prove valuable in increasing the chance of a STEM kit user to become a maker because many of the ideas have also been shown in results of research. She expects the knowledge sharing platform, removing fear, and improving self-belief are the best methods to go by. In all these cases, being careful is very important: a platform can easily go off rails or contain wrong information if not well moderated; and being wrong in showing which level of experience is required for kits will have an adverse effect on fear and self-belief.

7.3 Missed information

Dave overlooked warnings about LEDs in original instructions, possibly because of an information overload. Joyce either missed the information about how LEDs work or did not see its connection with step 8 in the new instructions.

7.4 Next Steps

In this chapter, the opinions, ideas, and expectations shared by Dave Borghuis and dr. Joyce Karreman in interviews have been set out. They both believe that improving instructions will have a positive impact on the chance of the user taking steps to become a maker, they also believe the instructions designed in the previous chapter need work. Both of them think the ideas in table 5 will be successful; however, they have different expectations on which ideas will work best and how. In the next chapter, their thoughts will be discussed and compared to draw conclusions out of them about the implementation of the new instruction design and the ideas presented.

8 Evaluation

After setting out the opinions, ideas, and expectations of the experts, what is left is to evaluate what they mean. In this chapter, the thoughts of mr. Borghuis and dr. Karreman will be discussed and compared to draw conclusions out of them about the expected results on users of the discussed implementation of the new design of instructions compared with the original instructions, and the expected effectiveness of the ideas in table 5.

8.1 Dave Borghuis

- The ideas in table 5 seem logical
- This method of instruction improvement will expectedly work, but beta testing is necessary.
- Users might give up if the instructions are too difficult for them, if that happens they will feel electronics is not up their alley and are less likely to try anything similar again.
- Occurrence of this problem can be minimized by thoroughly testing instructions, showing a difficulty level on the cover of kits, and
- The project consultants idea might prove costly
- Information can be added to STEM kits on where to find fab labs, what to expect there, and how to approach the community

8.1.1 ideas

Put multiple levels of instructions in one kit and invite the user to take the difficult instructions first and if they cannot find out how to build the object, take a more detailed version. Possibly add answer envelopes as some sort of hint system.

8.2 dr. Joyce Karreman

- The solutions in table 5 are good ideas, many are similar to what prior research has shown as possible solutions.
- Instruction improvement will work, but vagueness alone will not be enough. Personas of the target group showing examples of what they managed to do will motivate.
- Nice, motivational messages help with a sense of achievement and persistence.
- Images can give users information about whether what they did was right or not.
- Very vague instructions without images can look daunting to people inexperienced with the subject of the kit.
- These instructions will bring forth the intended behavior and mindset, but only if they successfully put the kit together.
- It is likely they do not since it requires motivation, persistence, and interest in the subject.
- Showing required level of experience is one of the best solutions, but has to be done carefully.
- Setting up a knowledge sharing platform and promoting it in kits is one of the best solutions, but has to be performed carefully.

8.2.1 ideas

Adding a message about how these instructions do not have to be followed to the letter, how making mistakes is probable and fine, and examples of what others did with the kit will invite users to keep trying.

8.3 comparison

Points both experts agree upon

- The ideas make sense and should work.

- Instructions with room for uncertainty and information gaps will not work as they are now and might scare people away.
- Showing which level of experience users are expected to need to bring the kit to successful results will be beneficial, since that will lower the chance a user is scared away from electronics or bored with a kit.
- Images are good for instructions. Whether it is because they make them more inviting or because people can check if what they are doing is correct.
- Original instructions contain too much information.
- Explicitly tell the users they will make mistakes and that that is fine, as long as they learn from them.

Point the experts disagree upon
The experts disagree upon how to increase the effectiveness of the instructions. Dave believes they might be too difficult to understand for inexperienced users and suggests adding multiple levels of instruction, maybe even tips and answers in envelopes. On the other hand, based on research, Joyce believes information gaps and uncertainty will not invite to be persistent but require persistence instead. She believes using personas in examples and explanations will improve motivation and persistence. Luckily, these additions are not excluding one another, so both can be applied.

What can be concluded from their statements?

- Images should be used in instructions.
- The new method of designing instructions needs beta testing in order to be refined.
- Adding motivational elements and multiple levels of instructions is advised.
- It is fruitful to look into the possibilities of setting up a knowledge sharing platform.
- Determining and showing which level of experience with the subject of a kit will minimize negative results, but only if that is done carefully.
- In order for users to learn how LEDs work, the instructions about them should grab their attention. That is not the case in either instruction design.
- The other ideas in table 5 can prove useful as well and are worth further investigation.

The ideas suggested by the experts have been incorporated in the table of ideas. The new table can be viewed in table 6.

The thoughts of the experts brought forth interesting additions to what needs to be done in order for the ideas in table 5 to work. In the next chapter, these conclusions will be used to attempt answering the research question and give an advice to Conrad about how to proceed when using STEM kits to help zeros become makers.

Category	Idea	Removes obstacle	Using aid	STEM kit
Inspiration	Lists of examples to try and problems to solve	Distractions	Seed & Reason to build	A list which fits the components or learning goal of the kit can be delivered.
Networ-king	Project consultants	Fears & Anxieties	Help	Helpful people could be on the knowledge sharing platform to provide help, but it would first need to be established or the consultants need to be hired.
	Knowledge sharing platform	Missing Knowledge & No Plan & Lack of Self-belief	Network & Sharing Knowledge (& others' insight)	Include access code to (parts of) online knowledge sharing platform
	Promotion	Gathering resources & Inaccessibility	Network	Provide promotion for established 3D print hubs and PCB service
	Hobbyist approach advice	Missing Knowledge & Gathering Resources & Inaccessibility	Network & Sharing Knowledge & Others' work methods/in sight	Include pictures and info about Fab Labs and Maker Spaces close to retail point of kit, including what is possible there and how to ask technology hobbyists for help.
Access	Reduce prices	Monetary constraints	Pricing	Not desirable
Changing kit designs	Gradually invite to try new things or improve skills	Uncertainty about skills & lack of (self-)belief	Improving Self	Show which level of experience a kit requires. The higher the level, the less specific the instructions and more materials and tools are not delivered, requiring more thinking and creativity from the user.
	"Not sure if I can" into "Try if I can" by motivation and making failure okay	Risks & Fears & Uncertainty about skills & Difficulty translating theory to practice	Testing skills	Instructions can be designed as such that users are gradually testing their skills and knowledge by providing information gaps (see literature review). This can open their eyes to trying before giving up.
	Ease user up for making mistakes	Fears & Uncertainty about skills	Directly targeting fears, no specific aid	Message at the start of instructions telling the user they will become makers by using this kit and that making mistakes is okay, as long as they learn from them.
	Examples from user group	Uncertainty about skills	Compariso n with others, no specific aid	Images and explanations of creations by people or personas which fit intended user group as challenges.

Table 6: how to apply solutions to STEM kits, including ideas of the experts.

9 Conclusion

This chapter starts off with a summary of the research process, after which an answer is provided to the research question, and finally, an advice will be given to Conrad on how to use STEM kits to help zeros become makers.

9.1 Summary

First, makers have been interviewed to find out what aids them in their making process, the findings have been noted and theoretical reasons for making have been formed. The hypothesis has been stated that zeros are stopped from making because, for them, one or more of those reasons are being obstructed. Inverted versions of these reasons have been formed to compare with explanations of zeros. Then, zeros have been interviewed to find what obstacles they encounter in the making process. The obstacles explained were very similar to the inverted reasons, which meant that the aids could provide solutions to the obstacles; the list of reasons has been updated with one new reason: costs exceeding benefits. As a next step, the factors which aid makers and the factors which obstruct zeros have been combined to find ways for the obstacles to be nullified or turned into positive factors. These combinations provided possible ways to help people who want to evolve into makers take that step. Finally, the invented solutions have been compared with lists of requirements for application in a STEM kit and Conrad's desires and goals. Most ideas could be adapted in ways to be applicable in or with STEM kits. These ways of removing obstacles provided more requirements, which have been added to the list.

In order to test the findings, one of the methods has been chosen to implement based on the requirements. This implementation, together with the table showing the other methods have been discussed with two experts in expert interviews. They have given their opinions, arguments, expectations, and even new ideas. Their thoughts have been analyzed and compared with each other in order to improve the list of ideas, and now they can be used to provide expectations and advice for Conrad in how to work with STEM kits in the future.

According to the experts, the found solutions are promising. Dave Borghuis believes providing information gaps and uncertainty in instructions – as implemented for the expert interviews – can bring users to enter an experimental mindset, which is necessary to see possibilities for making. Joyce Karreman believes a knowledge-sharing platform on which user-generated content and ideas can be viewed and other users can be asked for help will motivate, inspire, and allow users to try and make their own ideas. Both of them also believe that the shown implementation of changes in kit design will be unsuccessful due to different reasons. Mr. Borghuis suggests including instructions in multiple difficulty levels, so users can still complete the kit if the more vague instructions are too difficult for them. Dr. Karreman advices to add images and explanations of creations by people who fit within the intended user group of the kit in order to inspire and motivate the users. Several informal motivational messages will also help in that respect. Both will urge the users to be more persistent. And finally, they both advise to print an indication on the cover of STEM kits, which shows the level of experience needed to successfully complete the kit, and to include a message that the it is highly probable the user will make mistakes; this message should emphasize that making mistakes is not at all a bad thing, and will allow the user to learn.

9.2 conclusion

All these actions have been undertaken in order to find an answer to the research question: What is necessary to help a zero become a maker and how can that be supplied by STEM kits? Has this question been answered? According to the experts, the list of solutions provides an answer to the research question. They expect these ideas will bring forth the desired results, especially improving instructions, a knowledge sharing platform, and showing which level of experience with the relevant subject is needed to use a kit. They also explain that the first method, which was implemented for the expert interviews, would need to be expanded, as discussed in the previous paragraph; it would also require thorough beta testing in order to make sure the instructions have the desired results. The other two methods must be done extremely carefully. A correct indication of necessary experience reduces the amount of people being either bored by the kit or feeling like they are unable to work with the technological domain the kit belongs to; while a wrong indication of the necessary experience increases the chances of that happening. And a well moderated platform can give its users a helpful network of people with the same interests, who might have faced the same problems and can show and explain what interesting things they did with materials they had; where a platform which is not well moderated can grow to contain incorrect information and toxic users, or not grow at all and remain unused.

On a side note: the list of combinations can prove useful for more than just these ideas. Experienced designers might be able to design kits in such a way to specifically target the zero obstacles with the maker aids paired with them. This list can prove extremely helpful in future design sessions.

To conclude: both experts believe the ideas will be fruitful, especially the knowledge sharing platform, indicating required experience for a kit, and instructions with room for experimentation. The latter will need several additions and multiple rounds of beta testing, the other two need to be implemented carefully in order to function properly. The advice is to try to implement all three methods, while taking the advice of the experts into account.

10 Discussion, Recommendations, and Future Work

No piece of information is perfectly pure. In this chapter, all facts are displayed that should be taken into consideration when thinking about this research and looking at its conclusion. Then, this chapter sets out what can be done better in a next research and what should be done next.

10.1 Discussion

In interviews, subjects are known to not always tell the truth. This can happen because they give socially desirable answers instead of honest answers, it can be that they remember situations differently than they actually were, maybe they project a version of themselves they want to be, or they would rather not talk about the truth. (Van Tulder, 2012, section D) Furthermore, because of the fact that people do not generally talk about projects they did not start or those they stopped half-way, all participants of the second interview were students who the interviewer knew personally, and are also all students at the University of Twente. Lastly, the seventh participant of the second interview is the person who conducted the other interviews and this research. Since this interview regards self-insight, the potential for harmful effects on the data caused by bias because of inside knowledge of the project is small, but it is still important to be aware of this fact. In case of that data proving to tell a strange story, it can be disregarded.

10.2 Recommendations

In future research, it is important to try to interview people of a wider variety than those interviewed for this project. The respondents were accessible on short notice, but do not represent the entire user basis of STEM kits and Conrad as a whole. Furthermore, it is probable there are more ways to apply the ideas in table 6, there is possibly more to be gained from this insight than relatively simple ideas of practice.

10.3 Future work

B before widely applying the three ideas which were advised to be used in the conclusion, it is necessary to test them to see if they have the intended result. For new instructions and showing the experience level, that can be done by letting groups of test users play around with preliminary versions of the products. For the platform, a beta version can be released on which a close eye should be kept in order to make sure it and the users on it behave properly.

Appendix A

A.1 Kits providing materials

- Protobox
- LittleBits 
- Several Klooikoffers 

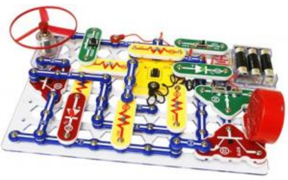
- AREXX Engineering: Marvin 

A.2 Kits with precise instructions

- AREXX School Lab: Magic Light Kit 
- Arduino Starter Kit 

- Wooden assembly kits 
- Makeblock mBot 

- Bionicle 

- LEGO 
- K'nex 
- Snap Circuits 

A.3 Kits providing challenges

- Several Klooikoffers 
- Sciencebuddies 

- Groovy Lab in a box

- Creation Crate

A.4 Products affording to use other things creatively

- Makedo

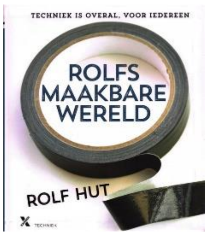
A.5 Challenges to creative use

- McGyver challenge (internet competition)
- Build a bridge

- Drop an egg

A.6 Examples of creative use

- Rolf's Maakbare wereld (book)



- 5 minute crafts (YouTube videos)

Detailed ratings of kits that could be tested

AREXX School Lab: Magic Light Kit

Instruction Languages: English, German, Dutch
Instruction level: IKEA with explanation of every part of every step. Inconsistencies make it hard to follow
Mistakes: They speak of a spring ring which is not part of the kit. The wire is referred to as insulated and there are various instructions telling me to make sure the uninsulated part is on a specific place. BUT THE WHOLE WIRE IS UNINSULATED.
Enjoyability: low
Assembly process: step by step
Assembly time: 30min-1h
Mood: okay
Final product: looks nice but that is it
Spare parts/extra materials: 1 5mm wood screw | 1 ring | missing 1 m3x12 bolt
Affordance of tinkering: none
Tools delivered: None, no special tools were necessary, but still, a kid would love their own screwdriver. Screwing apart the coffee machine and stuff

AREXX Engineering: Marvin

Developed by JM3 Engineering

Instruction Languages: English and German on the box
Instruction level: Explanation on the box of what the board already contains and the programming environment but that is it.
Mistakes: Already adding wheels with catterpillars, this nudges strongly towards the robot driving in single directions. Not including batteries, reduces ease-of-use.
Enjoyability: Kinda fun
Assembly process: Already assembled
Assembly time: depends on internet connection.
Mood: Kind of excited, also a little stressed
Final product: Looks very bare-bones.
Spare parts/extra materials: None
Affordance of tinkering: Compatible with C/C++, pins on microcontroller allow to add shields, sensors, and output. The bare-bones look makes it less precious so you could take it apart and try/add some stuff.
Tools delivered: Blockly-like programming environment
Other notes: No explanation on how to connect. Invitation to try or to give up?

Hong Ri: Grey Wolf

wooden assembly set

Instruction Languages: English and Chinese
Instruction level: Basic explanation of how an assembly process should go in 5 steps. Where pieces are supposed to be assembled, they have the same number.
Mistakes: Speaks of included sandpaper, while none included. Pieces do not look the way they look in the instructions, or at least are not organized in the same way.
Enjoyability: gets frustrating after a while
Assembly process: devious, the wood and cuts are of low quality, which means intended assembly is sometimes difficult to achieve
Assembly time: 1h
Mood: Kind of excited, a little hungry
Final product: Looks pretty good, but wouldn't do more than stand on my cupboard and fall over at some point
Spare parts/extra materials: Wooden frame

Affordance of tinkering: little, if you would give it wings or something it would be hard to make them look in the same style.
Tools delivered: None

AREXX school lab radio wave scanner v2 (ARX-RWS)

Instruction Languages: N/A
Instruction level: medium, requires knowledge of electric components in order to know which component is which letter and how the capacitors should be attached.
Mistakes:
Enjoyability: fun to solder stuff together on a board, feels like you're actually doing something
Assembly process: figure out what goes where and solder together
Assembly time: 1hr
Mood: excited, happy environment
Final product: doesn't seem to work
Spare parts/extra materials: earplugs can be used elsewhere
Affordance of tinkering: for people with little experience in electric systems: low, they don't know what else they could do. Plus its very clear what needs to go where and nothing else would fit.
Tools delivered: none, requires own soldering iron

Appendix B

Appendix B is attached as the Excel file “Appendix B – evaluating materials”.
It is a worksheet in which the author and two other researchers worked.

Appendix C – Interview series 1

Setting: Maker Festival Enschede. Environment bristling with creativity and people eager to impress. All interviews are conducted in Dutch.

1

Female. Est. age: 22. Daughter of owner of LED bureau. Helping out her father with his workshop and stand.

No real inspiration to make, used to craft as a child for saint nick's surprises and such. A lot of scrap wood available from father's workshop, most crafts had to be disassembled so the wood could be reused. No real goal in crafting, just playing.

Creatively drawing or painting, using felt as well. Sometimes proud of those results.

2

Male. Est. age: 48. Owner of LED bureau (father of respondent 1). Has stand at festival and short time to talk. Had negative interaction with Conrad in the past, specifically with contact person. Explicitly stated he was okay by being interviewed for a Conrad-affiliated project. Seemed somewhat annoyed during interview, possibly scared of giving away information he wanted to keep to himself.

Designed toolboxes to teach people how to use LEDs.

Was able to do so because owns an LED lighting company and had an intern who was able to design with user in mind.

Tested at every step.

3

Male. Est. age: 54. Employee of the University of Twente in the field of biomedical engineering. Eager to talk about his creations. Has stand at festival but does not mind taking the time to talk.

Designed and built his own synthesizers.

Enjoys playing with sound, processors became cheap, just wanted to try.

Already works with microprocessors in his job.

Enjoys building, was able to apply knowledge from work. Tinkering also positively influenced work.

Sound samples available thanks to job.

4

Male. Est. age: 42. Founder of makerspaces. Eager to talk about possibilities in his makerspaces. Has a stand at the festival

Has founded multiple makerspaces. Wanted to enable people to work with technology.

Wants to turn consuming into producing. Running into problems in daily life gives inspiration to make in order to fix those problems.

Assumes people find it too hard or complex to build their own things; a little help can go a long way.

Wants to be independent and benefit that self-made things are tailored to the maker.

5

Female. Est. age: 26. Has a stand at the festival.

Designed puzzles together with her father.

The principle already existed, her father found the code ugly and improved it, she wants to try and make it commercial. Prefers making things by hand and making people happy over having factories do it and make them just for profit.

Was able to do this because father could write the program, she had access to a laser cutter and knowledge of materials from her studies. Knowledge allows certainty in own doing.

Making is a sort of therapy to empty head.

Doing something for the first time is a confirmation of capabilities and gives self-confidence.

6

Male. Est. age: somewhere in his 50s. Helping customers sometimes broke up interview.

Father of respondent 5. Helping his daughter at the stand.

Improved a program for generating puzzles (Father of subject 5)

Had prior experience with and interests in combinatorial problems.

Worked on the program as a side thing, only toyed with it every once in a while.
Started working on it because of curiosity (more info on www.iwriteiam.nl)
Useful skills: abstract thinker
why not physical? Abstract thinker. Feels no need to make it physical.
7
Male. Age: 21. Visitor of festival. Acquainted with interviewer.
Builds quite a lot. e.g. lasercutting tiny things. Made a universal ambient light.
Was inspired for that project by YouTuber Great Scott, who made one. However, there were many necessary parts and some were quite expensive. At some point ordered the wrong cable for a different project which actually was necessary for the Ambient Light. Started collecting other parts and ordered the last few from Alyexpress. When he built it, he made the Ambient Light more universal and user friendly.
He could do this because the knowledge was readily available and his Pre-master Industrial Design Engineering helped with insight in production processes.
The drive to build gives self-confidence and makes it okay to make mistakes. Prefers to make for himself, making things for others triggers stress and perfectionism.
What stops from building: costs. Workaround is looking for cheaper options, if that is not possible, he lets the project be.
Technology makes projects interesting.
A project he wants to do but doesn't: build a car. Why? He suspects it will require a large amount of time and money. A project needs to have a use, especially if it requires an investment like this one. Since a self-built car will never be allowed on the road, it is not worth it.
If possible, he likes to have a guideline or basis to work from, provides less risks. He prefers to have as little risks as possible.
8
Male. Age: Lower 60s. Visitor of festival.
Is an artist. Made singing sunflowers and a project to cycle around in Second Life.
He can set up these projects because he has access to a network of people with different skills. His autism helps him connect dots others would not, which greatly helps making.
Had an arts education.
Is professional artist
His website is an archive.
Has a network of people to work with.
TNO: company
9
Male. Est. Age: 37. Looking out for his son at some moments in interview. Visitor of festival.
Is creative and enjoys creativity, also enjoys fun discoveries. Loves new developments.
Builds or fixes things at home. Does not want to throw things away, because that is a shame. They should be used until they are worn out.
Has technical insight, knowledge of tools. A lot of knowledge is available on YouTube. There are a lot of fixers and builders in his family, so he was raised with that mentality.
Work method: First try new things with something and/or at a location where it is okay if it goes wrong.
All necessary knowledge is principally available. The value of an object and oneself increases by making it yourself.
Making causes less littering in environment and human rights

Appendix D – Interview Series 2

Respondent 1
Dutch, Female, Age: 22. Location: the SmartXP lab at the University of Twente. Sitting next to each other at a table without others present at that table. Background is lively, but not distracting. Notes being taken on laptop.
Maakt lijstjes om te doen voor vakantie. Knutselshit. Kettingen en oorbellen maken bijvoorbeeld, maar iets gedetailleerder. Moeite met dingen afmaken, halve kettingen, halve afwas. Focus kwijtraken. Grotere projecten in vakantie, willen leren borduren ofzo. Dan toch maar niet doen, te veel denkwerk. Te veel investering voor veel dingen. Echt nodig om knop om te zetten om aan het werk te gaan met eigen projecten. Geeft vaak goed gevoel.
Als ergens aan begonnen dan komt het uiteindelijk wel een keer af.
Heel veel lijstjes met dingen om eens te doen. HEEL VEEL. Zo veel dat pinterest geen goed idee zou zijn.
Laatst ketting gemaakt met 3d-printer.
Niet zoveel technische projecten.
Moet praktisch toepasbaar zijn
Lampen repareren

Dingen laten liggen meestal omdat er geen tijd voor is. Soms als ergens op gewacht moet worden word het vergeten.
Gevoel dat er een gebrek is aan kennis om met technologische projecten aan de gang te gaan. Daardoor is ermee beginnen een grote investering, ook al is de kennis beschikbaar.
Lasersnijden zou ook leuk zijn maar dat doet ze niet omdat ze het niet kan omdat ze het niet doet omdat ze het niet kan omdat ze het niet doet.
Maakt na en verzint zelf
Gewoon hobby, houdt van kleurtjes, vind sieraden leuk, ook leuk om zelf te maken.
Gaat ook wel eens wibra-schoenen verven.

Als je van tevoren voelt dat het lang duurt begin je er minder graag aan. Altijd een druk bureau, zoals het hoort. Soms zo'n gevoel van 'nou nu ga ik die afmaken en dan die en dan die'
Plaatsing in ruimte van voorwerpen kan invloed hebben op activiteit.
Wanneer eenmaal op gang gekomen met een haalbaar doel dan gaat het lukken
Lijstjes maken helpt ook. Week indelen zodat duidelijk is wanneer er genoeg gedaan is voor de dag.

respondent 2
Dutch, Male. Age: 25. Location: the SmartXP lab at the University of Twente. Sitting next to each other at a table with respondent 1 present at that table. Background is lively, but not distracting. Notes being taken on laptop.
Ja heeft wel drang/neiging maar doet het niet
Niet de focus, vaak afgeleid door spelletjes oid. Onderdelen niet beschikbaar of niet zeker hoe aan te pakken. Dan afvragen of
Sommige onderdelen zijn duur.
Stoplicht jatten en dan gebruiken om aan te geven of de wc bezet is of niet.
Begint met stoplicht jatten en dat was eigenlijk al een probleem. Vervangen met iets anders is niet zo leuk.
Heeft het gevoel niet voldoende met wifimodules overweg te kunnen. Vind dat het eigenlijk geen probleem zou hoeven zijn want kennis is te vinden.

Onvoldoende vertrouwen in eigen kunde. Komt door het gevoel dat hij eigenlijk net niet goed genoeg weet hoe 'die shit' in elkaar zit en wanneer je het wel of niet opblaast om het aan te durven.
In Smart Tech wel geprobeerd hoe een andere opstelling zou werken. Of anders aangesloten. Met als doel om er zelf achter te komen wat het nou allemaal doet en wanneer het wel of niet te ver gaat. (Papert constructivisme ofzo) Hands-on experience geeft extra inzicht. Kent de theorie wel maar weet niet hoe te vertalen naar praktijk. Die praktijk krijg je juist door te experimenteren.
Misschien kan ik het wel, moet ik t gewoon doen.
Ideeen ontstaan : woonkamer en toilet was best een stukje uit elkaar, steeds kijken was veel moeite. Heeft stoplichtinstallatie bij anderen thuis gezien. Zou natuurlijk klein kunnen maar groot is leuker. Idee van ineens een stoplicht in huis is absurd en grappig.
Respondent 3
Dutch, Male. Age: 21. Location: outside the Starbucks at O&O square. Weather is warm and sunny. Facing each other across a table, respondent is wearing sunglasses, facial expressions harder to read. Notes being taken on laptop.
Ideeen: Roomba gekregen van vader (robot-stofzuiger) die was kapot. Meteen vol energie aan gaan sleutelen, snel op fouten gestuit die hij niet zelf kon fixen. Heel erg elektro, kan niet bij de software en heeft niet voldoende kennis van analoge systemen, zegt hij.. Lijkt hem erg handig om werkend te hebben. Er komen mensen met nuttige kennis helpen.
Website die nog net niet af is, content mist.
Tijd houdt tegen. Activiteit voelt als werk houdt ook tegen. Zit tussen werk en vrije tijd in. Voor hard werk is schoolwerk, voor relaxen is meer praten of spelletjes.
Begonnen aan een personal assistant zonder naam. Die werkt ongeveer maar nog niet helemaal naar behoren, achtergrondgeluid overstemd geluidsinput. Toen hij begon wist hij nog niet hoe het werkte om handig te doen, nu zonder inspiratie voor wat er aan toegevoegd kan worden. Kan youtubevideos op commando afspelen bijvoorbeeld. Zichzelf gaan uitdagen met functionaliteit die lastig te implementeren was.

Voorbeeld: Wil graag een keer een spel maken in Unity. Ideeen uitgeschreven, concept is goed. Maar nog niet aan begonnen. 1 keer unity geinstalleerd, 5 min gekut en unity verwijderd. Gestopt omdat hij al programmeerkennis heeft, maar in Unity niet meer op dezelfde manier aan de gang kon gaan. Er moest veel tijd in gaan zitten om uit te zoeken hoe binnen Unity geprogrammeerd kon worden. Geen nieuwe skill leren maar een bezeten skill niet kunnen beoefenen. Heel demotiverend.
Heeft het idee dat hij veel tijd nodig zou hebben om goed te kunnen werken in Unity. Makkelijker wanneer je weet waar je je ideeen kwijt kunt en hoe je dat kunt gaan doen. Begint eigenlijk altijd wel maar wanneer er te lang geen vooruitgang is stopt hij. Dat kan een mix van factoren zijn. Soms word een project uiteindelijk vergeten, andere gevallen komen weer terug wanneer nieuwe kennis beschikbaar is. Projecten die hij begint vind hij leuk en staat hij achter, anders begint hij niet.
Information gap niet van toepassing.
Denkt dat het de resources zijn. Makkelijker om te beginnen als je weet dat je alles hebt wat je nodig hebt.
Respondent 4
Dutch, Male. Age: 26. Location. the SmartXP lab at the University of Twente. Sitting at a table with respondent 1 and 2 present at that table. Background is lively, but not distracting.
Ideeen die wel bedacht zijn maar niet uitgevoerd:
Desklight maken. Eerder al eens een gemaakt, nu anders proberen. Tweede nooit verder gekomen dan de tekening
wat heeft je tegengehouden?
Ontwerp kwam niet echt rond → gevoel dat het nog niet klaar is?
Wist al dat het veel werk zou worden → investering
Misschien een beetje dat andere projecten leuker waren → focus lag op andere projecten.

Zat nog vast in ideation → ontevreden met model en gevoel dat hij het niet goed zou kunnen maken. Te negatieve gedachtegang, had het waarschijnlijk eigenlijk wel gekund. Wou er teveel toeters en bellen aan hangen. Zichzelf te veel uitgedaagd wat tijd betreft.

Ook vaak drang om iets te doen maar geen inspiratie voor wat.
Vind dat hij veel te lang over dingen doet. Raakt steeds afgeleid tijdens het proces.
Als mensen op de hoogte zijn van het project of er een deadline is werkt hij veel sneller. Meer gefocust, harder werken, stukje laten zien want cool.
Extra drive als mensen er vanaf weten. Slap excuus voor zichzelf “iemand weet ervan dus ik moet wel.”

Ideeen komen langs op basis van dingen die hij ziet en dan combineert of aanpast.
Misschien dat ervaring met solidworks zou hebben geholpen.

Nog een lampidee. houten blok-achtig-ding met plexiglas waaruit licht kwam. Waarom eigenlijk? Had niet echt nut zoals het design was.
Te veel onzekerheid over hoe het zou uitpakken. Was ook een groot project geweest.
Respondent 5
Dutch, Male. Age: 23. Location: in a booth in a quiet hallway. Facing each other across a table. Notes being taken on laptop.
Als kind vaak systemen gezien en gedacht: kan ik dat ook maken of op een andere manier gebruiken? Met K’nex gebouwd als kind. Later met NXT ook electronische dingen geprogrammeerd (geen controle over circuits). Tegenwoordig bouwt hij van alles in Maya of als web developer. Resizing system voor de afbeeldingen gemaakt voor op zijn eigen website, om werk te besparen. GIFs vervangen door video’s. Zelf moeten schrijven hoe de video’s ondersteund konden worden en ook thumbnails konden worden.
Wanneer er een idee is gaat hij door, hoe lastig het ook word.
Kan er op elk moment mee beginnen, geen drempel want hij kan het programma openen met een enkele klik. De ervaring in kennis heeft hij. Wanneer hij een idee heeft en denkt dat het wel kan maar vervolgens lukt het niet kan hij heel koppig zijn en doorgaan.
Trial and error werker. Ook voor het downloaden van films.
3D-modellen waar wel aan begonnen word maar niet word afgemaakt. Leert hij wel veel van maar kan het niet laten zien. Heeft op een gegeven moment door hoe het werkt en heeft het gevoel dat hij niet veel meer zal leren als hij ermee doorgaat. Alleen om te oefenen en laten zien dat hij het kan.
Voor afstudeeropdracht leren werken met een nieuw programma, omdat die langer mee kan dan programma waarmee hij bekend is.
Komt niet snel uit comfort zone. Zoekt wel nieuwe functionaliteit op in dingen die hij al kent.
Balancerend karretje gebouwd met NXT 1.0. Vroeger geprobeerd om op die manier een gyrosensor te gebruiken, nooit echt gelukt. Nu weer proberen. Had geen schematic van Rubix’ robot, toen met die robot beziggegaan, gyrosensor weer opnieuw geprobeerd om te kijken of knowledge gap gevuld is. Een hoop papers gelezen over hoe dat zou moeten.
Layman’s approach gebruikt om er te komen.
Gebruikt de NXT tegenwoordig zo weinig dat het niet als mogelijk hobbyproject of bouwsteen word gezien. Maya en WebDev wel.
LEGO MINDSTORMS NXT → nieuwe sensorpakketten.
NXT: mechanische kennis had hij al van de K’nex. Programmeren: geleerd programmeren op een TI 84, had daar ook optimalisatiekennis geleerd. Minecraft mod computercraft (zelf programmeren). Vanuit daar met NXT gaan programmeren op drag&drop methode.
WebDev-ervaring opgedaan
Als klein kind veel speelgoed gesloopt om te kijken hoe het intern werkt, zo ook veel kennis opgedaan. Heeft daarmee connecties kunnen leggen.
Uiteindelijk ook dingen in elkaar gaan zetten om te kijken of kennis klopt.
Speelgoed gehad waarmee je zelf bv een radio kon bouwen.
Ouders hebben gezorgd dat onderzoeken veilig was ipv onderzoeken afgeleerd.

Beginnen en mogelijkheid Maya en WebDev:
Voor Rubix' robot overgestapt naar een echte programmeertaal. Zo ook geleerd over pre-compiled constanten.
Vak Web Development gaf een nieuwe kans om een nieuw project op te pakken. Had al php gezien maar niet echt gebruikt op middelbare school. Geleerd van code van vrienden. Over tijd steeds verder aan gaan werken.
Kennis opgedaan bij de HYTTIOAOA committee door problemen te zoeken in andermans code. Heeft daar leren omgaan scss, geeft veel meer mogelijkheden.
Maya was beetje random. Altijd naar de technische kant gekeken, niet de visuele kant. In een studievak met Maya leren omgaan, vond hij heel interessant omdat het een technische kant van visueel werken. Dan was het iets hebben gemaakt, renderen, dit is mislukt, maar wel blij mee, hoe kan ik dit verbeteren? Trial and error. Renderen vind hij interessanter dan het modelleren. Materialen, belichten, hoe render je dit nou goed. Hoe kun je echte natuurkundige principes namaken?
Veel trial, error, and reflection.
Respondent 6
Indonesian, Male. Age: 22. Location: quiet wing of university cafetaria. Facing each other across a table. Background is lively, but not distracting. Notes being taken on a laptop. Respondent is a little bit in a hurry.
He saw a trash can that looked like R2D2, now is making it a singing R2D2. Piano teaching piano-playing. Dabbled in Unity.
R2D2 trash can: knowledge of Arduino, experience with coreldraw
other projects: solidworks
using software he was exposed to by the university.
Without this knowledge he wouldn't do the projects or make them way too complicated.
Biggest issue he had was not taking initiative to make things based on what he doesn't know
He does this because he does not know how feasible things are without full knowledge
Having experience allows making other things.
Piano: lasercutting might be too pricy
Games: time constraints
Having someone else makes him more motivated to do stuff.
Not going past concept phase: possible reasons:

- money constraints
- time constraints
- other unfinished projects
- feels he misses knowledge

Wants to make an iron man suit but feels he will not be able to build it. For cosplays. It should be able to play the theme song and spray flames.
Has found a way to create the flamethrowers, but it's stuck in concept hell. Because it can be dangerous and it is illegal in the Netherlands.
Access of applications/machines he uses to create things can be a constraint.
Hates doing maintenance, one of the reasons not to own the machines. Not sure where to store them. Waste of money if he doesn't know if he will use it.
Him and 5 built a PC because he felt it was worthwhile since he would use it a lot. Cost and profit kind of deal.
Kind of unlucky with stuff, things always break and he doesn't know why.
Motivations: trying to impress friends and women.
Railgun: doesn't know how to do it. saw a video of someone explaining but didn't understand what the guy was explaining. Seemed to complicated and it didn't have a use because what are you gonna do with a railgun?!? Did look up and see how to build it. Realized a lot of investment is required, will not be practical, he doesn't need it.
Usually lets himself be stopped because of multiple problems. One problem: depends on level of frustration. Frustration counts as some sort of the cost (bigger than money, even)

towards the profit. That is why he prefers simple projects, they do not cause much frustration.
Enjoys projects that can separate thinking and doing. Think and design beforehand and just do while building.
Also sometimes has inspiration for stories, but does not enjoy writing the story, does not like the amount of fleshing out necessary for writing. The drive is not high to write. Prefers turning them into games.
Whenever has time, has no motivation. Whenever has motivation, has no time. The more he has to do something, the more he wants to do something else.
When working on those, looks at game review videos to find out what he has to incorporate in his design, but doesn't actually start working.
Easily distracted.
Respondent 7
Respondent is interviewer of other and this project's researcher. Dutch, male. Age: 21.
Location: project room in the University Library. Very quiet background. Whiteboards filled with notes present.
Has ideas for funny things like curtain climbers, robots that search light switches and turn them off, and automatic dice rollers. Never actually worked out the ideas, let alone build them.
Gets a lot farther with ideas when working with others.
It's not as interesting to work on a project without a real goal for yourself.
He usually just does not have the drive to work out the idea further than just an idea.
What also does not help is that he is wary of breaking things or changing them into a state where they can no longer be used as what they were. Everything could be useful at some point. Well, maybe the way they could be useful is by using them this way..
Not sure if he does not have the necessary knowledge. Probably does, even, but never got to test it out because he didn't start on any ideas. He would definitely be able to do it, one way or another. Knowledge not possessed can be gained or outsourced. Every hurdle can be jumped if you want to.
Starting to work on an idea gives vision of a feeling of accomplishment in the future. But, in the present, instant gratification is more interesting. This person lives in the present, very much so.

Appendix E – Extra questions after interview series 2

After asking more questions to increase the value of interview 2 via WhatsApp. Respondents are numbered the same as in Appendix D

respondent 2

Denk je dat je eigenschappen hebt die het moeilijk maken om te bouwen wat je wilt bouwen? En zo ja, welke en waarom houden die je tegen?
Ben soms erg snel afgeleid, heb dan ook weinig zin om verder te gaan met een of ander project en dan ga ik gewoon spelletjes spelen.
Weet je hoe het komt dat je snel afgeleid raakt?
Motivatie issues denkik, weet ook niet waar dit vandaan komt enzo
Denk je dat er iets persoonlijks achter ligt?
Ja denk het wel
Okee, dan is de kans groot dat de oorzaak van motivatieproblemen bij jou anders is dan bij anderen. Maar motivatieproblemen op zich zijn wel een vaker voorkomend thema
Zou je er alsnog iets over willen vertellen of liever niet?
Ik merk het verder ook bij de studie, zowel bij bmt als nu bij create. Dit is ongv alles wat ik er over weet te zeggen
Zou het kunnen dat de projecten die je wilt doen maar niet uitvoeren geen onderwerpen bevatten die je echt interesseren?
Zou misschien kunnen, maar durf het niet zeker te zeggen. Over het algemeen lijkt het me wel leuk, maar dan nog valt het soms vies tegen.
Extra: ik merk dat als het om "analoge" projecten gaat, dat het me weer wel lukt. Denk aan; een fiets repareren of upgraden, kastjes maken of plaatsen, en sloten vervangen
Denk je dat de kans groter is dat het klopt of juist dat het niet klopt?
Kans groter dat het niet klopt.
Ah, dank je wel voor het inzicht!
Interessant, die extra! Hoe komt dat, denk je?
Omdat ik met ons pap heel veel in en rond het huis deed en nog steeds veel doe. Met arduino werk ik pas sinds de uni en ik heb het gevoel dat ik er niet echt veel van weet.
Ah, je hebt dus meer ervaring met analoge projecten?
Klopt ja
Dank je wel voor de inzichten, vind je het goed als ik de inhoud van dit gesprek in mijn appendixen zet?
Jazekers
Bedankt!

respondent 3

Denk je dat je eigenschappen hebt die het moeilijk maken om te bouwen wat je wilt bouwen? En zo ja, welke en waarom houden die je tegen?
drukheid 😇 Als ik druk ben denk ik niet meer aan hobbyprojecten
Wat voor drukheid bedoel je? Drukke planning, druk hoofd, adhd, rondkutten, of nog iets anders?
Nee druk met school, als ik veel verplichte dingen heb dan doe ik daarnaast liever niks dan dat ik bezig ga met projecten
Ah, bedankt voor de opheldering. Dat snap ik ook wel. Je bent soms wel wat hyperactief, heb je daar last van als je projecten onderneemt?
Nee dat is net als met school als ik mn focus ergens op krijg dan houdt ik die ook
Het motiveert me meer 😋
Dat klinkt goed! Ik zou willen dat ik dat ook had.
Zou het kunnen dat de projecten die je wilt doen maar niet uitvoeren geen onderwerpen bevatten die je echt interesseren?
Nee, als ik een project verzin om te doen vindt ik het ook altijd interessant

fijn dat je daar geen last van hebt!
Bedankt voor je antwoorden! Vind je het goed als ik dit gesprek in een appendix zet?
Ja hoor geen enkel probleem
Bedankt!

respondent 5

Denk je dat je eigenschappen hebt die het moeilijk maken om te bouwen wat je wilt bouwen? En zo ja, welke en waarom houden die je tegen?
Dat komt omdat ik van die vlagen/perioden heb waar ik dus veel van 1 ding doe. dus paar weken lang alleen maar web dev geen maya, en dan weer een paar weken lang andersom, etc. er zijn zat projecten blijven hangen op het einde van een periode: als je interesse weer terug is is het lastig om een oud project op te pakken. vaak is iets nieuws maken aantrekkelijker
en dus het interesse in het leren > het eindproduct. zoals ik al zei heb ik 20x meer maya bestanden dan dat ik werk heb dat ik wil laten zien, en wss in 100x meer scenes gewerkt dan dat ik daadwerkelijk heb opgeslagen
Ah, right, bedankt dat je die nog even weer aanwijst
Weet je hoe komt het dat je die vlagen hebt? En dat nieuwe projecten aantrekkelijker zijn dan oude weer oppakken?
oude projecten oppakken kan lastig zijn omdat ik weet dat ik de vorige keren er aan werken weinig vooruitgang heb gemaakt, als de scene te zwaar is geworden in maya bijv. maar ook als ik niet zo goed weet hoe ik verder moet, of als het alleen nog om goed uitwerken gaat, als ik alle interessante dingen al geleerd heb
die vlagen komen wss omdat ik vaak extreem veel tijd in iets steek, en dus op een gegeven moment een beetje uitgeblust ben
dus dan focus ik op iets anders, en ga daar weer compleet mee in het extreme
Ahh, op die manier, helder
Zou het kunnen dat de projecten die je wilt doen maar niet uitvoeren geen onderwerpen bevatten die je echt interesseren?
Die vraag snap ik niet helemaal.
Wat ik met de vraag bedoelde: als je een project laat liggen, kan dat komen omdat het onderwerp van het project je niet (meer) interesseert?
dat klinkt een beetje als het lastig oppakken van oude projecten
Zou kunnen, als je nieuwe projecten begint in plaats van met oude verdergaat, ben je dan nieuwe technieken of principes aan het proberen?
Ik denk dat ik hierop al antwoord heb gegeven toen ik vertelde over waarom ik oude projecten niet zo snel weer oppak.
Nog niet helemaal, ik probeer uit te zoeken of projecten links worden laten gelegen als ze geen onderdelen of factoren (meer) bevatten die de maker interessant vind. Bijvoorbeeld als je bezig bent met het bouwen van een robot maar je interesses niet echt liggen bij programmeren, gadgets, mechanica, of elektrotechniek.
joah to a certain extent
bij die balans robot heb ik voor de 'makkelijke' route gekozen, ookal werkt die slechter. voor de beste oplossing zou ik wiskunde moeten doen waar een wiskunde PhD huisgenoot moeite mee had. ik ben zo'n persoon die geloofd dat iedereen alles wel kan leren met genoeg tijd en inzet, maar die inzet had ik dus niet, en ik vond het de tijd investering ook niet waard
ah, interessant! Heb je zoiets ook vaker gehad?
Of was dit een enkel geval omdat het bijzonder moeilijke wiskunde was?
nou vaak zet ik dus wel door, en pak ik de moeilijke weg. (denk aan mijn "het zou ook eens makkelijk zijn bij jou" anekdotes)
wiskunde houd ik niet van, maar ben ik vaak wel bereid uit te zoeken
maar dit ging me echt aan alle kanten de pet te boven
hahaha goed punt. Okee, dat is dus voor jou niet zo’n probleem behalve in dit ene geval

vaak snap ik kleine stukjes, waardoor ik het hele ding wel kan ontcijferen
maar hierbij herkende ik letterlijk geen enkele term
dat maakt het wel lastig inderdaad
Bedankt voor je hulp!
Vind je het goed als ik dit gesprek in een appendix zet?
sure
maar ik weet niet of het iets waard is
met de referenties naar het eerder gesprek
Zeker wel!
De notities van het eerdere gesprek zijn ook nuttig geweest en nu zie ik een deel ervan nog helderder
oh en natuurlijk geen nummer er bij ;)
natuurlijk, was ik niet van plan want privacy maar goed dat je het zegt

respondent 6

Do you think you have personality traits that hinder you in building what you want to build? And if so, which and why?
Personality trait issue: short attention span and short interest duration. I got excited for a new project before finish the previous one and during production I also lose focus from time to time either because of academia, games, videos or other interest
Both work in conjuction with one another and alsi creates a loop
Short attention span leads to doing other stuff
Doing other gives new ideas. Start new project
Now 2 projects are made each distracting one another
Sacrificed one of them
And the cycle repeats
Could it be that the things you want to make do not contain any subjects which really interest you?
Programming
Like in game design, programming is such a turn off
Also some tasks that are laborious I often prospone to whenI feel like doing it
Thanks for your answers! Could you enlighten me on which subjects do interest you?
Depends on what I feel like
Its completely random

respondent 7

Do you think you have personality traits that hinder you in building what you want to build? And if so, which and why?
Yes, my tendency for hoarding and preserving makes it difficult to use materials I own or buy.
Why do you do that?
I think that is because I expect everything still holds value, everything can potentially still be used.
What if its use is to be used in a project?
Maybe it is that I try to avoid changing things beyond a point where they cannot be reverted back to what they were. Things seem precious really quickly to me.
Could it be that the things you want to make do not contain any subjects which really interest you?
That could very well be. However, I believe that projects which would really interest me would contain levels of physics or electrical engineering much higher than my own.
Why do those high-level things intrigue you?
Because they seem awesome!
And why do you think their level is too high for you?
I have not actually tried. Maybe I could do it. Starting on something like that just seems daunting, so I don’t.

What makes them seem daunting?
That they look so awesome, I do believe I can make things, but not that they will be worth much, look good, or be awesome.
Why is that?
I think it is because what I build usually looks very bad and is just made for being functional, and is nothing more than barely functional. Maybe, after all, I do not trust my ability to create the ideas I have in the same awesome way I have them in my head, that I turn fun ideas into daunting, awesome projects that I will never dare to start as well.

Appendix F – New instructions for Arexx Magic Light Kit

Present together with the first two pages of the original, English MLK manual

An LED is a Light Emitting Diode. A diode is an electronic component through which electric current can only flow one way. Think of it as the valve in a bicycle tire: the air can only flow in and not out. This means that for an LED to shine, the + and - sides cannot be reversed.

Step 1: Attach the screw terminal to the top plate, try not to obstruct sides or large holes.
Step 2: Attach the switch on the other side of the top plate.
Step 3: Put the threaded sleeve in the lamp socket and make sure it does not fall out. Then put the LED string through the sleeve in such a way that both wire ends will be outside the lamp when it is attached.
Step 4: Attach the lamp socket to the top plate and make sure it cannot move.
Step 5: Put the string in the light bulb and screw the bulb into the socket.
Step 6: Attach the battery holder, keep some distance between it and the top plate.
Step 7: Connect the wires as shown in the circuit.
Step 8: Insert a battery, are the LEDs working? If not, try to find out why and find a solution.
Step 9: Attach the side plates using the left over materials.

Challenges
If you managed to get the light functional, maybe you could try out some of these ideas, or anything you think of yourself of course! Necessary information can all be found on Wikipedia.

- Connect multiple LED strings to the same battery.
- Replace one of the lights in your home with LEDs. (WARNING: make sure there is no current flowing when you tinker with lights in your home, that is dangerous!)
- Replace the on/off switch with something else.

Appendix G – Structure expert interview new instructions

This structure is in Dutch, since both interviews have been held in Dutch
Doelen:
Denkt deze professional dat deze oplossingen gaan werken?
Denkt deze professional dat de instructies nog dezelfde inhoud bevatten?
Denkt deze professional dat deze specifieke methode goed is uitgevoerd?
Wat denkt deze professional dat er nodig is om deze methodes werkend te krijgen?
Wat denkt deze professional dat er nodig is om dit probleem te verhelpen?

Vertellen dat dit interview voor een thesis is en geef aan dat respondant niet zal worden gequoted, vraag of het goed is als het volledig uitgeschreven interview in een appendix wordt geplaatst.
Eerst kort uitleggen wat er in het interview gaat gebeuren. Presenteer de aanpassing als een instructiemethode die bedoeld is om meer engagement te veroorzaken.
Wat is je naam en een goede omschrijving van je functie?
Nieuwe instructies laten lezen en onderdelen van Magic Light laten zien.
Hoe verwacht je dat een gebruiker die bekend is met elektronica reageert op deze instructies?
Hoe verwacht je dat een gebruiker die onbekend is met elektronica reageert op deze instructies?
Denk je dat iemand die onbekend is met elektronica direct begrijpt wat hij/zij moet doen aan de hand van deze instructies?
Denk je dat deze persoon dit zou kunnen uitvinden?
Denk je dat deze instructies duidelijk genoeg zijn om iemand die onbekend is met elektronica dit object zo in elkaar te zetten dat het werkt?
Hoe groot acht je de kans dat het bouwproces de eerste keer mislukt?
Verwacht je dat de gebruiker ontstane fouten of problemen kan oplossen?
Oude instructies laten lezen
Zijn er verschillen in inhoud van beide versies?
Welke versie lijkt je leerzamer? Waarom?
Uitleg over reden voor verandering
Denk je dat dit goed is uitgevoerd?
Verwacht je dat deze nieuwe methode gaat uitnodigen tot gedragsverandering?
Gaat het ogen openen tot proberen voor opgeven?
Waar voorzie je problemen?
Hoe zou het beter kunnen?
Laat Table 5 zien
Kloppen de oplossingen voor de defactors?
Zijn de benefactors logische keuzes om de defactors te verhelpen?
Met welke oplossingen voorzie je problemen?
Denk je dat dit de juiste manier is geweest om dit probleem aan te pakken? Waarom?
Zo nee, wat lijkt jou een goed idee?
Heb je nog andere opmerkingen of vragen?

Appendix H – Expert Interview with Dave Borghuis

Notities Interview Dave Borghuis

29 Juni 2019 | Omgeving: TwenSpace, in Daves werkplaats. Veel apparatuur in de omgeving, waaronder een luide lasersnijder. Het is erg warm. Notities worden gemaakt in een noteblock.

Eerst wat small talk om op ons gemak te komen. Na een minuut of tien beginnen we

Bedankt dat je me wilt helpen met dit interview! Om ethische redenen zul je niet worden geciteerd in de thesis, maar is het goed als notities en wellicht het volledig uitgeschreven interview in een appendix worden geplaatst?

Dat is prima

Om het niveau van engagement van STEM kits te verbeteren heb ik nieuwe instructies ontworpen voor een bestaande kit, die zul je straks te zien krijgen. Eerst voor de duidelijkheid: wat is je naam en hoe zou je omschrijven wat je doet?

Mijn naam is Dave Borghuis en ik zou mezelf omschrijven vooral als maker. Ik heb altijd tegen de Hackercultuur aangezeten en heb Tkkrlab en TwenSpace opgericht.

Hier zijn de instructies die ik ontworpen heb, zou je die door willen lezen? *Instructies geopend op een laptop. Onderdelen van de Magic Light Kit worden op tafel gelegd.*

Een eerste reactie op deze instructies is dat ik het meer grafisch zou doen, vooral kinderen hebben vaak moeite om tekst te vertalen naar actie.

Hoe verwacht je dat een gebruiker die bekend is met elektronica reageert op deze instructies?

Die kijkt er niet naar, want het is een erg eenvoudige kit. Misschien dat die eerst de LEDjes zou willen testen.

Hoe verwacht je dat een gebruiker die onbekend is met elektronica reageert op deze instructies?

Dat zal wel even puzzelen worden. Die komt er waarschijnlijk wel uit maar maakt waarschijnlijk een paar fouten.

Denk je dat iemand die onbekend is met elektronica direct begrijpt wat hij/zij moet doen aan de hand van deze instructies?

Je moet wel af en toe terugkijken naar de onderdelenlijst om te begrijpen welk onderdeel met welk woord word aangeduid. Alleen tekst geeft ruimte voor aannames en daarmee fouten.

Verwacht je dat de gebruiker ontstane fouten of problemen kan oplossen?

Ik denk het wel, de bedrading zou het grootste probleem kunnen worden maar die heeft een duidelijk schema.

Okee, dank je wel. Hier zijn de originele instructies, zou je die ook willen lezen?

Originele instructies worden in het Nederlands en Engels op tafel gelegd.

Ah, dit is al veel visueler, dat is eigenlijk wel wat ik verwacht van instructies.

Om het echt te ervaren moet ik hem eigenlijk in elkaar zetten met de instructies.

Ga vooral je gang! Laat me weten wat je denkt tussendoor.

Ik ga de Nederlandse versie van de originele instructies gebruiken, omdat ik Nederlands het gemakkelijkste lees en de visuele hulp erbij wel fijn is.

Gebruikt eigen schroevendraaier

Staat dat eigenlijk ergens genoemd? Dat er een schroevendraaier nodig is?

Na even zoeken pas gevonden dat het wel is aangegeven op de tweede pagina.

Belangrijkste gebeurtenissen van bouwproces:

Waarschuwing over hoe LEDs werken viel niet op.

Hm. Het is me niet helemaal duidelijk hoe ik de LEDs moet aansluiten. Ik kan het wel even testen. *Na eenmaal aan het testen begonnen gaat hij door tot hij tot de conclusie komt dat de LEDs niet meer werken. Misschien komt dat doordat de draad niet geïsoleerd is.*

Er staat te veel informatie in, dan mis je de belangrijke dingen.

Dat gepiel met de schroefjes aan het einde is me te veel gefröbel, ik vind het wel goed zo.

Zijn je gedachten bij iets anders dan de instructies geweest op enig moment?

Het is makers eigen om eerst te proberen voordat je naar de handleiding kijkt. Toen ik eenmaal keek probeerde ik om kritisch te zijn of wat er staat wel klopt.
Voor verderop in interview, zijn gedachten zijn niet buiten de instructies geweest, niet gedacht aan wat hij verder nog met de lamp zou kunnen doen.
Zijn er verschillen in inhoud van beide versies?
De inhoud is wel hetzelfde volgens mij. De plaatjes van het origineel maken die wel prettiger maar daar staat wel te veel informatie bij.
Welke versie lijkt je leerzamer?
Het origineel, omdat die visueel is. Ik ben een visuele denker.
Dank je wel voor je input. De verandering die ik heb aangebracht is voortgekomen uit een vraag van Conrad om te zorgen dat STEM kits mensen meer uitnodigen tot spelen met de objecten om hun heen. Die te verbeteren, repareren, of zelf dingen te maken. Een manier die ik daarvoor gevonden heb is door instructies vaag te houden zodat de gebruiker zelf moet gaan nadenken en fouten kan maken die hij of zij dan zelf moet oplossen.
Ah, ja. Dat is ook een manier om ernaar te kijken.
Denk je dat deze oplossing goed is toegepast?
Dat is moeilijk in te schatten. Te vage instructies kunnen namelijk gaan frustreren.
Hoe zou dat beter kunnen?
Je zou een niveau van benodigde ervaring kunnen aangeven, zodat mensen weten waar ze aan beginnen. Sowieso zul je veel moeten testen om de sweet spot te vinden van de hoeveelheid instructie.
Goede punten, die ga ik meenemen. Verwacht je dat gebruikers eerst zullen proberen om de lamp in elkaar te zetten voordat ze het opgeven?
Ik denk het wel maar de vraag is of dat tot een goed resultaat komt. Als mensen afhaken levert dat hen een slechte ervaring op en zijn ze minder geneigd om nog eens met elektronica te proberen te spelen omdat ze denken dat ze het niet kunnen.
Ik verwacht dat veel mensen die zo’n kit kopen gewoon snel resultaat willen zien en dus niet blij worden van vage instructies waarbij ze moeten gaan nadenken.
Misschien is het mogelijk om meerdere niveau’s van instructie te leveren? “Probeer eerst dit en als het niet lukt pak dan de echte handleiding.”
Interessant idee, dat zou nog wel eens goed kunnen werken als een soort uitdaging van jezelf. De vage instructies was één oplossing die ik vond. Hier is de tabel met alle mogelijkheden (Table 5). Zou je daarnaar kunnen kijken?
Ik denk al meteen dat ik het meer generiek zou aanpakken: Zorg ervoor dat mensen weten dat fouten maken een optie is. Dat deel wordt vaak niet gepresenteerd door makers, terwijl het een essentieel onderdeel is van het proces. Learning by doing.
Veel mensen hebben een instelling van: “Dat heb ik nog nooit gedaan, dus ik kan het vast niet.” Terwijl we het meest leren van een Pippi Langkous-aanpak: “Dat heb ik nog nooit gedaan, dus ik kan het vast wel.”
Goede toevoeging. Hoe zou dat voortgebracht kunnen worden, denk je?
Nou, dat is een cultureel dingetje, dat krijg je niet zomaar aangepast. Terwijl het er bij kinderen nog wel in zit, mensen gaan zichzelf vaak remmen naarmate ze ouder worden.
Waar komt dat vandaan, denk je?
Een soort angst om fouten te maken die groeit met iedere fout, denk ik.
Interessant, wat veroorzaakt dat?
Ja, dan kom je toch weer uit bij de maatschappij. Fouten maken wordt er niet echt in geaccepteerd, terwijl fouten maken en ervan leren eigenlijk de meeste vooruitgang boekt.
Zoals Adam Savage van de Mythbusters mooi zegt: “Failure is always an option.” Dat laten ze ook echt zien in het programma, als een eerste methode niet werkt gaan ze uitzoeken waarom en die kennis gebruiken voor een nieuwe methode.
Wat ik me ook afvraag, trouwens, STEM is bijna alleen gericht op kinderen. Zijn volwassenen geen doelgroep meer?
Ik moet zeggen dat dat me nog niet zo zeer is opgevallen. Volwassenen krijgen naar mijn idee ook wel kits, al zijn die vaak duurder. Misschien dat een disclaimer aan het

begin kan helpen? “Hee, je gaat waarschijnlijk wat fouten maken, maar als je nagaat wat er gebeurt en het oplost is dat helemaal prima.”
Ja, iets als: “Je word nu maker, daarbij hoort het om fouten te maken want daar kun je het meeste van leren en niets gaat meteen goed.” Zoiets kan wel wat losser maken maar ik denk dat het nog niet voldoende is.
Goed, die kan worden toegevoegd! Maar goed, even terug naar de tabel. Denk je dat deze positieve factoren en ideeën goede manieren zijn om de negatieve factoren tegen te gaan?
Ik denk dat de combinaties wel aardig kloppen, al zou ik het concept dat fouten okee zijn nog toevoegen aan het aanpassen van “Not sure if I can” naar “Try if I can”.
Ik zie hier ook netwerk als oplossing tussen staan, wat ik weet van Tkkrlab is dat iedereen eigen kennis en ervaring met zich meebrengt. Die kan gebruikt worden door anderen om problemen op te lossen als ze weten hoe ze het moeten vragen. Dat soort hulp is ook wel te vinden in communities van andere fab labs, hackerspaces en makerspaces. Daar zit vaak alleen een hoge drempel aan om naartoe te gaan, dat komt waarschijnlijk omdat mensen er opvattingen van hebben die niet kloppen, zoals dat het duur is of moeilijk om binnen te komen, of dat er van alles van je verwacht word.
Zou het kunnen helpen om een stukje tekst en afbeeldingen mee te leveren van fab labs en dergelijke in de buurt van waar de STEM kit is gekocht, inclusief uitleg hoe de mensen in een fab lab vaak het best te benaderen zijn?
Oh, dat zou wel wat kunnen opleveren inderdaad. Zelf geef ik workshops over bijvoorbeeld lasersnijden in de hoop die drempel te verlagen.
Met welke oplossingen voorzie je problemen?
Ik denk dat projectconsultants een flink prijskaartje zullen hebben, dat is vooral voor individuele makers en scholen een probleem. Begeleiding is wel handig maar misschien is het niet nodig om gecertificeerde consultants aan te nemen, iemand die in de praktijk goed werkt is beter. Eigenlijk is dat voor makers ook belangrijk om te leren, dat vaardigheden belangrijker zijn dan een papiertje.
Denk je dat dit de juiste manier is geweest om dit probleem aan te pakken?
Op zich wel, ik zou alleen misschien een voorbeeld of zo mogelijk een demonstratie bij de vage instructies geven, anders gaan de gebruikers met te weinig kennis beginnen en word het overweldigend, waardoor ze gaan stoppen.
Okee, dat waren mijn vragen als het goed is. Ik loop ze nog even hardop langs, dan kun je nog één en ander toevoegen als dat nodig is of een vraag beantwoorden die ik onverhoopt gemist heb.
Denk je dat deze instructies duidelijk genoeg zijn om iemand die onbekend is met elektronica dit object zo in elkaar te zetten dat het werkt?
Daar twijfel ik over. Ik denk dat iets te veel mensen gaan afhaken. Ontstane problemen zouden voor zo’n 10% ook onoplosbaar kunnen zijn.
Misschien zouden we die extra hulp kunnen leveren?
Misschien met een antwoordenvelop voor als je er niet uitkomt. Een uitdaging voor jezelf.
Verwacht je dat deze nieuwe methode gaat uitnodigen tot gedragsverandering?
Het gaat meer experimenteel worden. Het vereist meer nadenken en levert een andere aanpak. De originele instructies moet je gewoon volgen.
Zou deze kit met de nieuwe instructies ogen openen tot proberen wat je kunt voordat je het opgeeft?
Als het de gebruiker lukt om de lamp in elkaar te zetten wel. Het heeft wel eerst meer doorzettingsvermogen en analytisch denken nodig. Misschien moet je dit testen met groepen gebruikers. De ene groep krijgt de oude instructies en de andere groep de jouwe. Dan kun je gaan vergelijken wat het percentage is van mensen die de lamp werkende krijgen en wie er nog meer mee gaan doen.
Heb je nog andere opmerkingen of vragen?
Zou ik het uiteindelijke verslag kunnen krijgen?
Natuurlijk. Dank je wel voor je hulp!
Hoe groot acht je de kans dat het bouwproces de eerste keer mislukt?

Losse opmerkingen:
In sommige bouwpakketten zijn de onderdelen in de lijst op ware grootte getekend zodat je ze er alleen maar op hoeft te leggen om ze te herkennen.
Op houten onderdelen zou je kunnen graveren welke gaten waarvoor zijn bedoeld.
Misschien een vervanging voor instructies of delen ervan maar waarschijnlijk niet.

Appendix I – Expert Interview with Joyce Karreman

04-07-2019 Thursday: Joyce reached a deadline yesterday, possible she feels relieved, tired, or stressed. Contact semi-warm: I received her name from a professor I wanted to interview but who had no time and we made the appointment in person. Environment is calm and well-known to her, since it is her office. Sitting across from each other at a table, I am taking notes on a notebook. The interview is in Dutch, the native language to us both. She only has one hour of time, which should fit but could cause stress near the end.

Een klein beetje small talk vooraf om op ons gemak te komen.

Dit interview is voor mijn Bachelorthesis, ik heb geen toestemming gevraagd aan de ethische commissie, daarom zal ik je niet direct mogen citeren. Zou je het goed vinden als ik de uitwerking van dit interview in mijn Appendixes zet?

Ja, prima. Ik zal het wel zeggen als ik het achteraf toch liever niet heb.

Lijkt me goed inderdaad. Mijn onderzoek is geweest naar de instructies van STEM kits, die zouden in het Nederlands betakits genoemd worden. De bedoeling ervan is om de gebruiker bepaalde technologische of wetenschappelijke principes te leren. Ik keek voornamelijk hoe de instructies meer engaging kunnen worden gemaakt.

Voor welke doelgroep zijn die?

Eigenlijk voor alle leeftijden, al worden veruit de meesten voor kinderen ontworpen.

Om te gebruiken op de basisschool?

Dat wordt wel gedaan, maar de meesten worden thuis gebruikt.

Ah okee.

Maar eerst: kun je vertellen wat je zoal doet aan de universiteit?

Ik ben begonnen met veel onderzoek naar geschreven handleidingen en later ook instructies. Vooral voor specifieke doelgroepen, zoals laaggeletterden en ouderen. Gisteren heb ik een dissertatie afgerond over instructies in verschillende culturen.

En hoe ben je in dit veld gekomen?

Dat was toevallig eigenlijk. Ik heb Nederlands gestudeerd, psycholinguistiek. Toen ik echt wat wilde gaan doen was hier een opening en ben ik begonnen met een onderzoek naar functionele instructies, zoals alle instructies toen waren. Ik keek of dat eigenlijk wel de beste manier was om instructies te maken. Ongeveer tien jaar later zijn we pas gaan kijken hoe belangrijk motivating elements en engagement zijn.

Een bijzondere route inderdaad. Goed, ik heb aan de hand van mijn onderzoek deze instructies ontworpen voor deze kit. Zou je die willen bekijken?

Nieuwe instructies van Magic Light Kit (EN) en onderdelen van Magic Light Kit worden op tafel gelegd.

Oh ja, nu heb ik al een beter beeld wat voor kit je bedoelt.

Laat het me vooral weten wanneer iets opvalt of je een opmerking hebt.

Heb je dit helemaal ontworpen?

Nee, de eerste twee pagina's komen uit de originele kit, omdat daar de nodige waarschuwingen en voorschriften staan met nog een nuttig overzicht van de onderdelen. Ik heb alleen de derde pagina ontworpen.

Wauw, er staan wel veel spelfouten in. Zo moeilijk is het toch niet om "five" te spellen?

Ja, dat was me ook al opgevallen. Ik geloof dat het in het Duits is ontworpen.

Het zijn er veel ook.

Instructies zijn doorgelezen

Hoe verwacht je dat een gebruiker die bekend is met elektronica reageert op deze instructies?

De stappen zijn nog best wel duidelijk. Het is wel alleen maar tekst, ik zou er plaatjes bij verwachten, dat zou helpen. Maar het zou te doen moeten zijn. De instructies zouden wel beter en duidelijker kunnen.

Waarom zou je er plaatjes bij verwachten?

Uit meerdere onderzoeken blijkt dat plaatjes helpen met visualiseren. Zoals in LEGO- en IKEA- instructies bijvoorbeeld. Er staat hier bij geen van de stappen een verwachte uitkomst,

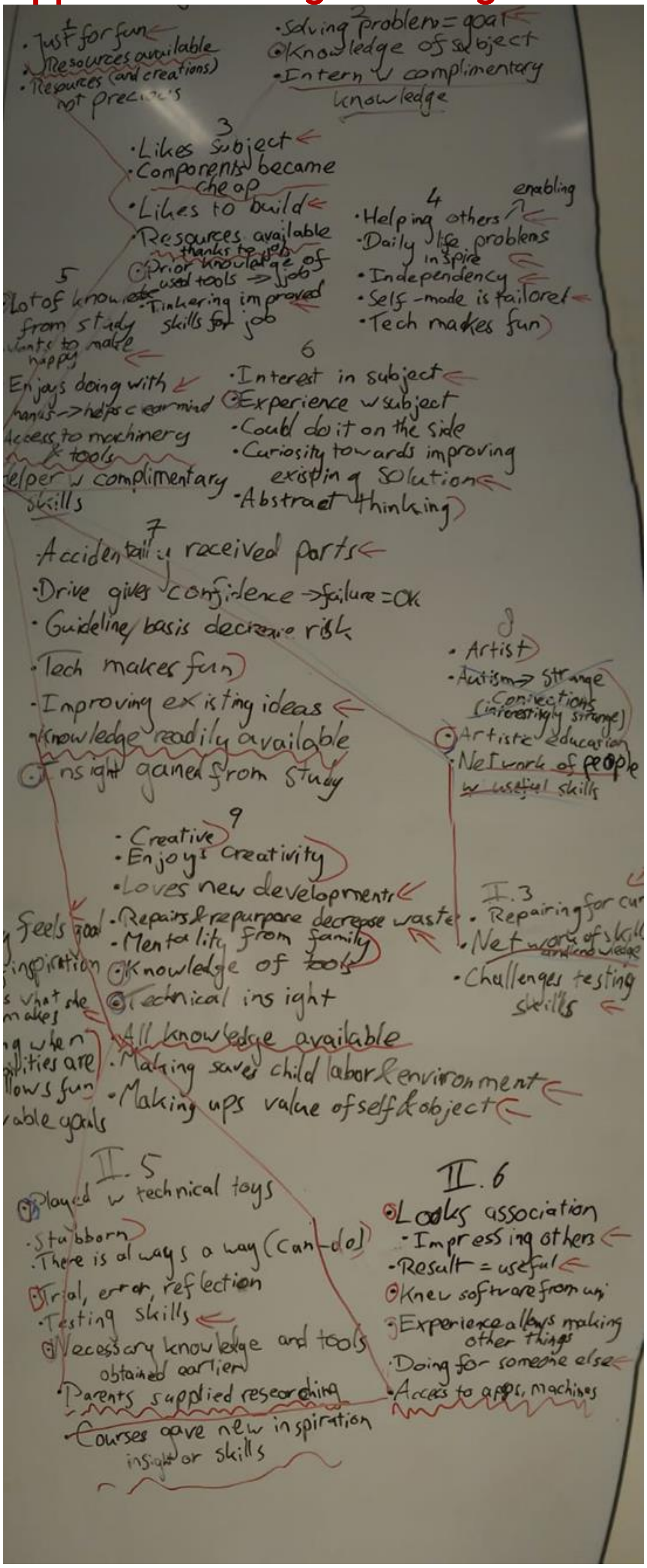
dus je weet niet wat het doel is of wat eruit moet komen. Je kunt niet controleren of je goed bezig bent. Voor een simpele kit als deze zou het wel moeten kunnen maar als het een ingewikkelder proces is word het lastig.
Ja, dat snap ik. En hoe verwacht je dat een gebruiker die onbekend is met elektronica reageert op deze instructies?
Die zou het wel erg ingewikkeld vinden, denk ik.
Denk je dat die direct begrijpt wat hij/zij moet doen aan de hand van deze instructies?
Nee, niet direct en die zal ook wel een paar fouten maken.
Zou deze persoon wel kunnen uitvinden wat die moet doen?
Uiteindelijk zou dat wel moeten kunnen, denk ik. Voor goede instructies zou het uitgebreider moeten zijn. Het scheelt wel dat de gebruikte woorden overeenkomen met die in de onderdelenlijst, dan raakt daar geen verwarring over.
Denk je dat deze instructies duidelijk genoeg zijn om iemand die onbekend is met elektronica dit object zo in elkaar te zetten dat het werkt?
Ja, ik denk dat het wel werkende te krijgen zou zijn, maar dat weet ik niet zeker.
Hoe groot acht je de kans dat het bouwproces de eerste keer mislukt?
De eerste keer? Dan gaat er sowieso iets mis, dat heb je met LEGO-autootjes ook, maar dat is niet per se iets ergs. Dat is meestal snel opgelost.
Verwacht je dat de gebruiker ontstane fouten of problemen kan oplossen?
Hier zouden sommige fouten lastig op te lossen kunnen zijn. In stap acht, bijvoorbeeld, staat “Are the LEDs working, if not, try to find out why and find a solution.” Ik zou niet weten waar ik de nodige informatie zou kunnen vinden. Dat zou het wel lastig maken voor gebruikers.
<u>*Mogelijk valt de uitleg over hoe LEDs werken niet voldoende op of wordt de informatie heel snel vergeten.*</u>
Hoe zou een gebruiker dat aanpakken, denk je?
Tja, trial and error misschien. Of ze gaan zoeken.
Zou het kunnen dat een aantal het opgeven?
Misschien geven ze het wel op inderdaad, dat hangt af van hoe gemotiveerd ze zijn.
Dank je wel. Dit zijn de originele instructies, zou je die ook willen bekijken?
Originele instructies van Magic Light Kit (EN) op tafel gelegd.
Ook nu weer, als er iets opvalt of je een opmerking hebt, laat dat dan vooral weten.
Ah, met een plaatje.
Instructies uitgelezen.
Dit is meer wat ik zou verwachten. Die plaatjes zijn handig. Het is wel een beetje schreeuwerig met al die ‘important’ en ‘advice’, vooral die ‘advice’. De plaatjes zijn goed; tenminste, ik weet niet of de inhoud goed is maar het idee is mooi in ieder geval. Het is ook fijn dat stap drie in vieren is verdeeld. In jouw versie is dat één hele lange instructie. De handleiding ziet er niet zo aantrekkelijk uit, maar ik denk wel dat die aardig duidelijk is.
Ik vind het niet echt mooi, maar het is wel aardig duidelijk, denk ik. Het is wel hoe een standaard handleiding er uitziet, wat wel voldoende is. Het kan een stuk beter en die pagina’s zien er niet uit zo. Maar je kunt de stappen vinden en het bouwen is er wel mee te doen.
Zijn er verschillen in inhoud van beide versies?
Er zijn vooral verschillen in vorm. Het origineel is veel uitgebreider en je hebt daarin ook al die ‘important’ en ‘advice’, dat is op zich mooi maar nu wel heel veel. Misschien is dat ook wel goed. Je vroeg of er inhoudelijk verschil is, dat denk ik niet.
Okee, en welke versie lijkt je leerzamer?
Dat is moeilijk te zeggen. Het origineel geeft inzicht in wat je doet, terwijl je in de nieuwe zelf dingen moet uitzoeken. Beide kan leerzaam zijn. Voor mensen bekend met elektronica is de nieuwe versie waarschijnlijk beter, want die is gewoon korter; maar ook dan zouden plaatjes fijn zijn. Voor onbekenden is het origineel sowieso beter.
Dank je wel voor je inzicht. Gezien de tijd ga ik door. Mijn onderzoek was niet alleen gericht op instructies. Het ging erom dat STEM kits bedoeld zijn om de gebruiker een technologisch of wetenschappelijk principe bij te brengen zodat ze die kennis kunnen gebruiken in het dagelijks leven om apparaten te repareren of bouwen. In de praktijk

doen ze dat bijna niet. Ik heb onderzocht waarom en hoe dat verholpen zou kunnen worden. Een methode die ik vond is delen van instructies onduidelijk laten zodat gebruikers zelf moeten gaan nadenken.
Denk je dat dat hier goed is uitgevoerd?
Ja, dat is wel goed uitgevoerd nu, maar ik heb een onderzoek gelezen waar mensen instructies kregen voor een spreadsheetprogramma, gewoon Excel, geloof ik. Die instructies zijn ook op deze manier gegeven, inclusief uitdagingen of oefeningen die ze aan het eind van ieder hoofdstuk zouden kunnen proberen.14 De mensen deden dat helemaal niet. Er kan natuurlijk een verschil zijn omdat dat onderzoek gericht was op software en dit juist werkt met fysieke materialen.
Ik ben bang dat de nieuwe instructies gebruikers kunnen afschrikken, terwijl de oude instructies juist mensen helpen met bouwen. Bij die zou je misschien achteraf kunnen aansporen om verder te onderzoeken. Een ander onderzoek heeft aangewezen dat leuke dingen en informele boodschappen in de instructies motiverend kunnen werken. Iets als: “Het is moeilijk, maar probeer het, je kunt het!” of “Goed gedaan!”
Hoe bedoel je niet zo sterk?
Er is gewoon nog niet veel onderzoek gedaan naar motiverende elementen in instructies. Deze dissertatie gaat vooral over ouderen maar geeft wel aan dat iemand
Verwacht je dat deze nieuwe methode gaat uitnodigen tot gedragsverandering?
Dit gaat niet uitnodigen tot gedragsverandering, omdat het nergens staat dat de gebruiker anders om moet gaan met deze instructies. Misschien dat ze het zelf verzinnen maar dat denk ik niet. Voor heel gemotiveerde mensen zal het wel gedragsverandering teweeg brengen want je moet wel zelf gaan nadenken met deze instructies. Onbekenden in de elektronica zouden bang worden en het laten liggen. Als dat gebeurt zouden ze niet snel weer elektronica aanraken.
Hoe zou het beter kunnen?
Ik denk dat het wel goed is maar er moet nog iets omheen. Plaatjes en een doel, wat je gaat doen. De challenges moeten sowieso uitgebreider, leken zullen geen idee hebben wat ze daarmee kunnen. Voorbeelden van wat anderen met de challenges gedaan hebben zouden ook erg uitnodigend kunnen werken. Toch even de ouderen er weer bij halen: als in een handleiding van een mobiele telefoon stukjes tekst en afbeeldingen staan van Ans die haar telefoon heeft leren gebruiken en ook een oudere is, zijn de lezers meer gemotiveerd om het ook te proberen dan zonder die stukjes. “Als Ans het kan dan moet ik het ook wel kunnen.” Een persona van de doelgroep die uitlegt wat die doet, gedaan heeft of kan blijkt erg engaging. Dit zie je online ook veel op fora en dergelijke. Een gebruiker die laat zien wat hij of zij gedaan heeft met een product, de instructies zijn vaak helemaal niet zo goed maar omdat iemand van dezelfde groep laat zien wat die kan nodigt het uit om ook dingen te proberen.
Gaat deze instructiemethode ogen openen bij de gebruikers dat ze kunnen proberen voordat ze opgeven?
Ik weet niet of dit helpt, deze instructies kunnen werken maar er is al interesse of motivatie nodig om ermee te werken. Motiverende elementen, zoals de persona’s die ik net noemde waarschijnlijk wel. Die zorgen er niet voor dat de resultaten beter worden maar wel dat mensen langer blijven proberen.
En hoe zou dat beter kunnen?
Ik denk dat als je een boodschap erbij zet in de richting van: “Hier staat hoe je dit zou kunnen doen maar het hoeft niet perfect. Probeer maar gewoon om het te doen. Dit is een voorbeeld van iemand die er iets leuks mee heeft gemaakt en zo heeft die dat ongeveer gedaan.” Dat nodigt uit tot blijven proberen.
Tabel 5 word op tafel gelegd.
Tot slot heb ik nog deze tabel, waarin de belangrijkste andere methoden staan die ik gevonden heb. Zou je daar naar kunnen kijken en een oordeel geven of je verwacht dat ze zouden werken?

14 Referring to Glasbeek (2004)

Dat is wel van alles en nog wat, he? Ik denk wel dat het allemaal zou kunnen helpen. Veel van deze dingen zijn ook aangewezen met onderzoeken. Het is wel overdreven om dat allemaal voor zo'n lampje te doen.
Klopt, dit is bedoeld voor STEM kits in het algemeen.
Zo'n platform kan heel goed zijn.
Je zegt 'kan'?
Ja, over het algemeen gaat het goed maar soms komt het niet van de grond of word het niet goed gemodereerd, waardoor er foutieve informatie op komt te staan of het onderwerp ontspoort. Of soms komen er gewoon te weinig mensen. Maar op zich is user-generated content wel heel goed voor motivatie of hulp.
Zou een forum behulpzamer zijn dan bijvoorbeeld Wikipedia?
Het zou vooral motiverender zijn omdat je kunt zien wat anderen hebben gedaan en hoe ze dat hebben gedaan. Plus je kunt daadwerkelijk aan andere mensen vragen hoe je problemen op kunt lossen.
Als je er zo naar kijkt, denk je dat de gekozen aids om de obstacles tegen te gaan logische combinaties maken?
Ja, dat klopt wel zo'n beetje.
Van welke ideeën verwacht je dat ze het beste zullen werken?
Dat hangt natuurlijk af van welke obstacles het meest voorkomen.
Ik denk dat iedere mogelijkheid om het met andere mensen over je projecten en problemen daarmee te hebben goed zal werken. Onzekerheid en gebrek aan zelfvertrouwen bevechten is ook heel effectief, bijvoorbeeld door de vereiste ervaringsniveau's aan te geven maar daarmee moet je wel oppassen hoe je het doet.
Waarom moet je daarmee oppassen?
Omdat dat snel averechts kan werken als het aangegeven ervaringsniveau niet klopt. Als bij een kit staat dat het een laag niveau van ervaring vereist maar het is toch eigenlijk best wel ingewikkeld, dan geeft het de gebruiker het gevoel dat hij/zij blijkbaar dom is.
En als een makkelijke kit word aangeduid als lastig, wat zou daar het effect van zijn?
Dan zou de eigenlijk bedoelde gebruiker waarschijnlijk worden afgeschrikt en de gebruiker van het aangeduide niveau de kit saai vinden. Mocht iemand van het eigenlijke niveau van de kit die toch proberen, zal die zich wel goed voelen dat hij/zij een kit van zo'n hoog niveau heeft kunnen gebruiken.
Helder, dat komt dus heel nauw.
Denk je dat deze methode van obstakels van de ene groep met helpende factoren van de andere groep bestrijden de juiste is geweest om dit probleem aan te pakken?
Hoe heb je de data verzameld?
Ik heb veel mensen van de betreffende groepen geïnterviewd.
Dan was het de juiste manier, inderdaad.
In dat geval zijn we erdoor. Heb je nog andere opmerkingen of vragen?
Nee, niet dat ik nu kan bedenken.
Dan loop ik nog even snel met je door wat we besproken hebben om te kijken of we alles gehad hebben en of je het nog eens bent met je antwoorden.
Voor deze vraag: Denk je dat iemand die onbekend is met elektronica direct begrijpt wat hij/zij moet doen aan de hand van deze instructies?
Ik kan dat erg lastig inschatten.
Heb ik je gevraagd met welke oplossingen in de tabel je problemen voorziet?
Nee, maar de problemen die ik voorzie heb ik al wel genoemd. Zelfvertrouwen bevorderen kan verkeerd gaan als het niet goed word uitgevoerd en het opbouwen van een knowledge sharing platform ook.
Dan zijn we nu helemaal klaar. Vind je het nog steeds goed als ik dit in mijn appendixen zet?
Ja, dat is geen probleem.
Okee, dank je wel voor je tijd en tot ziens!

Appendix J – Original images



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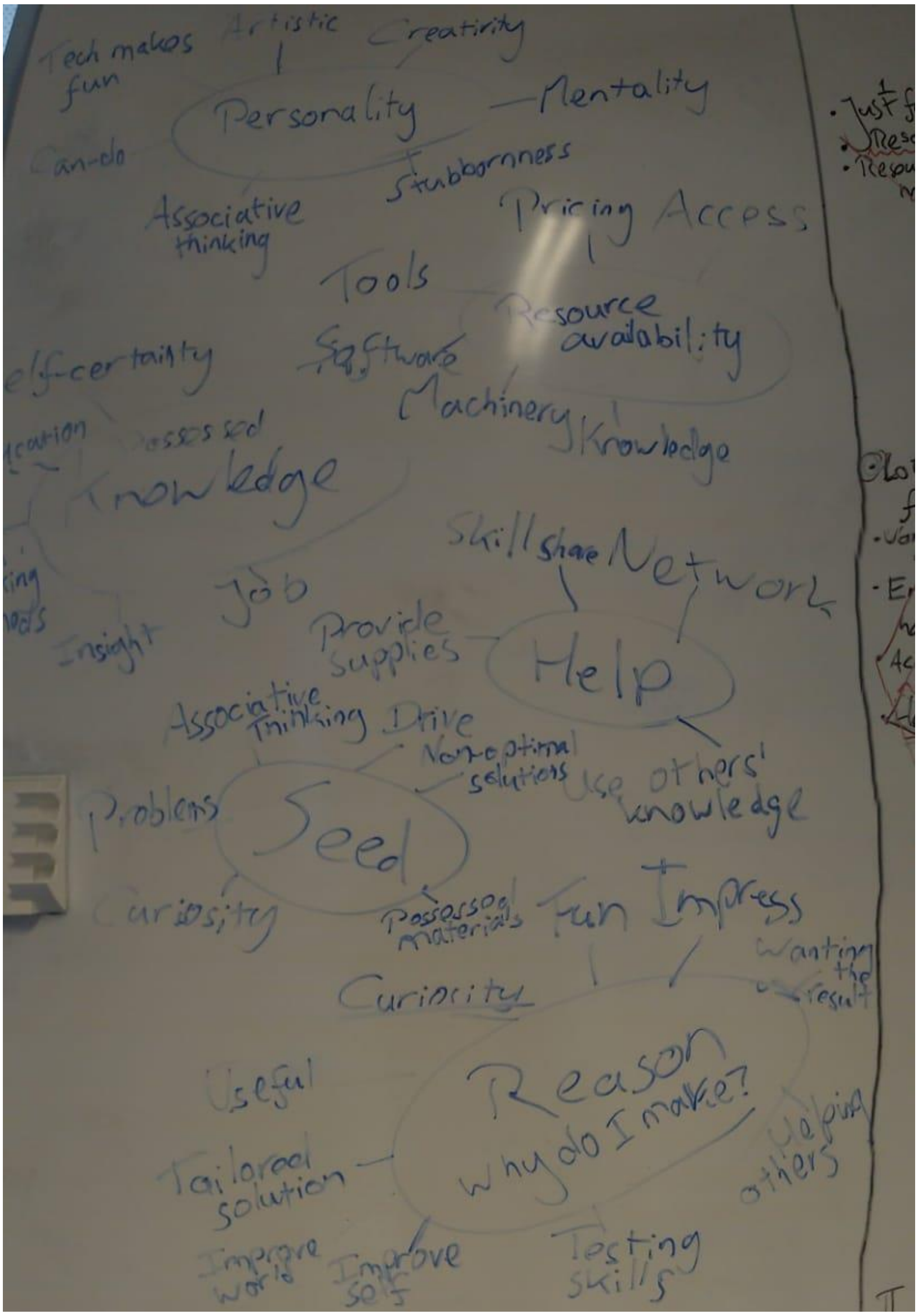

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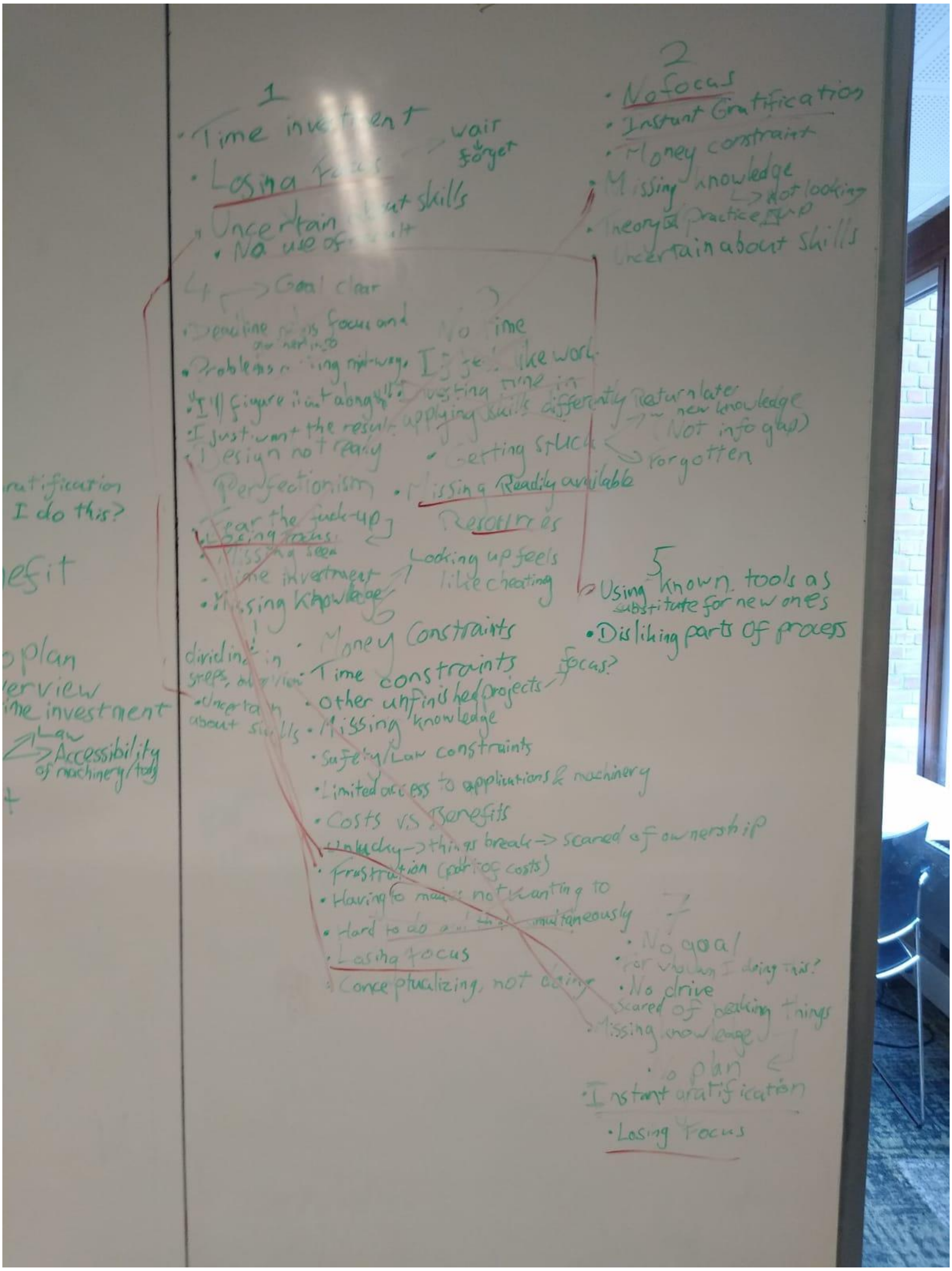

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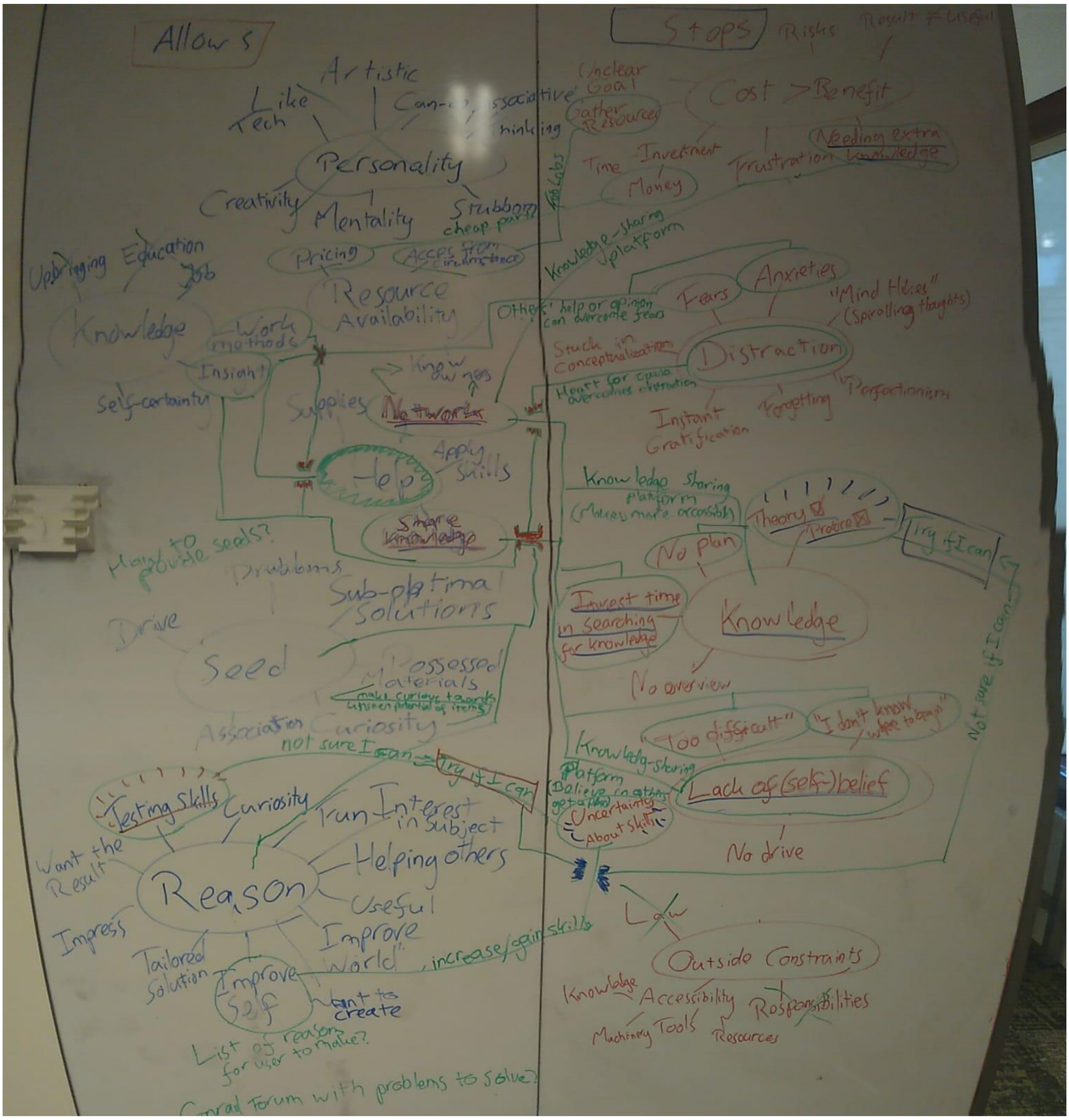

The original of image 6

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These two still need correct referencing style
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Thinking hats (mostly blue) (cf. De Bono, 1992)

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