A Toolkit To Spark Interest In Engineering Among Young Adults

Master's thesis
January 2024

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In collaboration with Cities of Things Lab 010

cities of things

TU Delft

Preface

Dear reader,

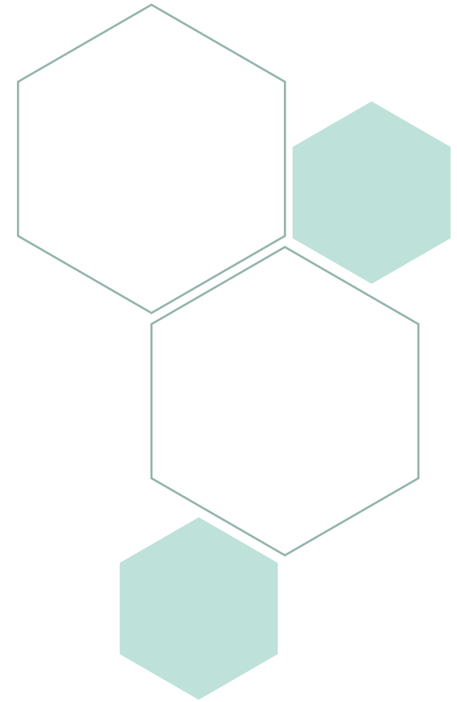
In the following pages, you'll join me as I explore the current situation in the engineering field. During my Aerospace Engineering bachelor's study, I always wondered why my classmates were so few girls. My mindset at the beginning of the project was to empower females so badly and bring as many girls into Engineering! However, I should not just force them to like it. Also after reading more literature and interacting with people, I realised that we should not transfer the message to blame one gender only and try to flip it. I don't think creating an inverse is helpful for the situation. The whole process of this "revolution" should be neutral even though it is slow, and we should work on this together. Through this thesis, I want to say that performance is not determined by gender, everyone gets an opportunity to try and figure out what they like and want to do.

This project would not have been possible without my supervisor team, Tomasz and Adrie, whom I thank for sharing their expertise and enthusiasm during the project. Teaching me how to conduct research through design. Remind me to think big but finish the small thing first. I would also like to thank Wiebe at PMB for providing feedback on 3D printing errors and giving me tips while I was prototyping. And thank you 3D printers :)

Last but not least, thanks to my family, friends, girlfriend, and boyfriend for supporting me throughout this project, even though some of you are in a different time zone from me. What a wild ride this has been, full of ups and downs. Thank you all for being a part of this crazy journey. Snacks, coffee, calls, texting, beer, wine, hugs, advice, jokes, talking, laughing :) My master's thesis wouldn't be what it is without your support, and I'm beyond grateful.

And thank you, Yin, you did a great job :D

Cheers!



Executive Summary

Project Intentions

This project aims to introduce engineering in a way that captures students' interest. Therefore, expanding the original knowledge of engineering during the design ideation process becomes crucial. Beginning with the identification of factors contributing to the underrepresentation of female students in the field. Additionally, this study collaborates with Cities of Things Lab 010, which strives to incorporate citizens' opinions into the neighbourhood robot design process. Hosting the workshop and making robot development accessible to all citizens. For me, I narrowed down the scope to focus on students. Thus, the initial questions are:

1. Why does the educational robotics toolkit and engineering field currently lack attractiveness for female students?

2. What are the barriers or challenges that hinder female students' participation in the engineering environment?

Research Gap

After conducting literature research, I identified two research gaps. First, the majority of gender learning research in STEM education focuses on ages before 15, with only a few extending into high school. Due to the lack of research regarding ages above 18, it is challenging to maintain consistent tracking and make improvements in education. Second, there is limited research on the male perspective on this topic. However, it's essential to recognize that the educational and working environments involve both genders. Therefore, we should not isolate consideration to only one gender.

Therefore, I formulate the research question and define the problem: How can a toolkit make students feel involved and broaden people's image of robotics? According to the findings of literature research, I then conducted the interviews with STEM education organisations, the surveys for both female students and males.

The Design Goal and The Final Concept

The design goal of the toolkit is to make everyone feel involved and comfortable to share their opinion in the group discussion. Encouraging the incorporation of different viewpoints and getting inspired by other people's ideas. Ultimately, broadens the existing original impression of robotics. To visualise the design goal and validate the final concept, I developed a prototype of an inspirational toolkit with fellow students mainly from the DP3 course in the IDE bachelor program. Since the group assignment of the DP3 course is to design a cleaning robot for the campus. Utilising this toolkit to inspire students in the early stages of robot design can have a positive impact on the design process. I conducted multiple user testings to improve the prototype, considering the interplay of aesthetics, form, user experience and assembly.

Validation and Recommendation

Final design HiveMind, I conducted user testing with a group of students to validate whether the after-use effect of the prototype aligns with the design goal. All participants agreed that they feel encouraged and comfortable expressing their ideas, and the toolkit helps them get on the same page. Furthermore, the toolkit improves group discussions in the early stages of the design process, especially when everyone in the group is not familiar with each other. The validation result shows that each participant has a more diverse impression of robots after using the toolkit. However, I observed that the shape of the robot they drew for the assignment still adheres to a traditional representation of how a robot should be. This suggests that future design recommendations could focus on the relationship between picture cognitive association, the impact of different game rules, and using the toolkit before or after hands-on activities.

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Chapter 1. Engineering is Male-Dominated

Project Background

This chapter provides a global perspective on the enrollment of female students in STEM education, with a specific focus on engineering. Also, utilizing the Delft University of Technology (Netherlands) as a case study. Furthermore, the chapter explores the impact of the absence of female role models in the field of engineering. And revealed two initial research questions.

STEM
(noun)

Science, Technology, Engineering, and Mathematics, encompass a multidisciplinary approach to education and careers in these fields.

Engineering
(noun)

The application of scientific, mathematical, and technical knowledge to design and build solutions to improve the world around us.

1.1 Female students are less likely to enrol in STEM fields

Historically, engineering has been a male-dominated field. Despite recent higher global enrollment and graduation as well as great performances in mathematics and science test scores, women are less inclined to choose Science, Technology, Engineering and Mathematics majors. Globally (2015-2019), only 7 percent of women opt for engineering, manufacturing, or construction, in contrast to 22 percent of men (Beegle et al., 2020).

As national income rises, so does the gender gap in enrollment in STEM fields. In low-income countries, women are 7 percentage less likely than men to attend higher education courses in engineering, manufacturing and construction. In upper-middle-income and high-income countries, these gaps widen to 15 percentage and 17 percentage respectively (Beegle et al., 2020).

Figure 1. Global percent of students enrolled by career program

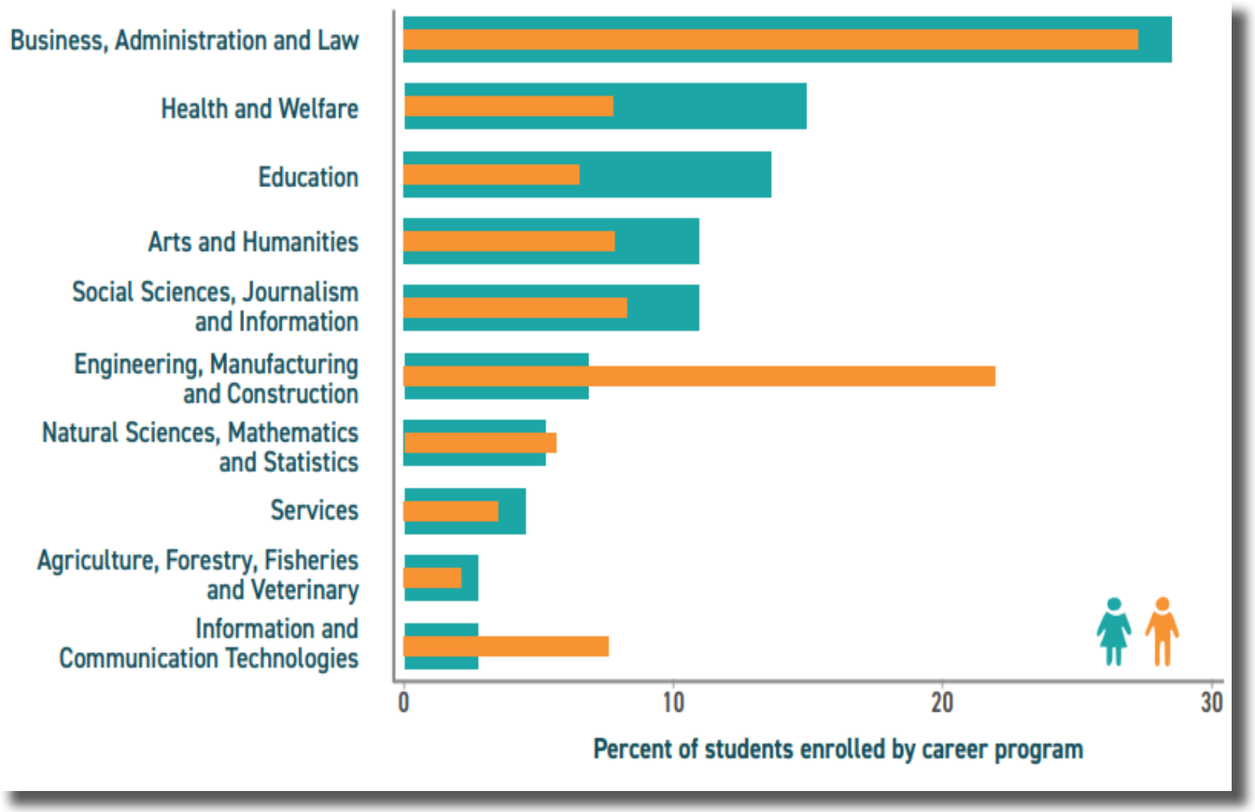
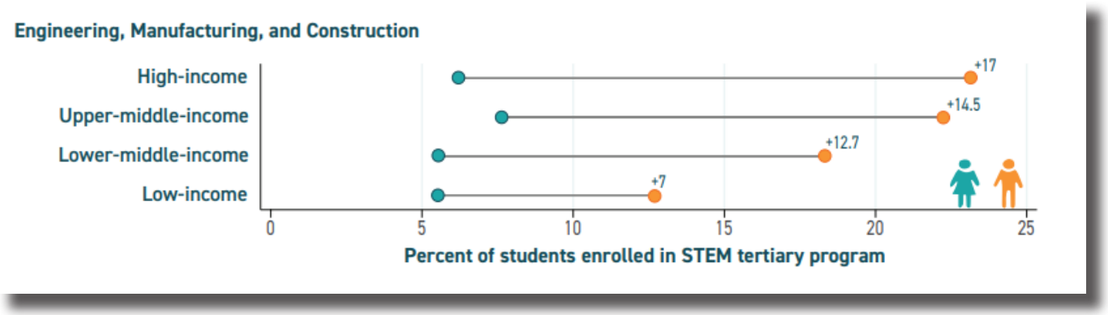


Figure 2. Global percent of students enrolled in STEM tertiary program (2015-2019)



At Delft University of Technology, the proportion of male students (70%) is also much higher than the proportion of female students (30%) (Feiten En Cijfers, n.d.), and female students are mostly distributed in the Industrial Design Engineering and Architecture faculty. Moreover, recent statistics regarding elective courses of Industrial Design Engineering, such as Mechatronic and Design Engineering for the academic year 2022-2023 (Q3), reveal a gender imbalance, where only 30% of the students enrolled in these courses are female.

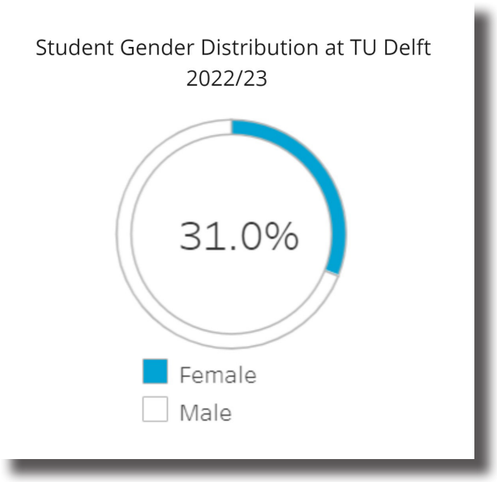


Figure 3. Student gender distribution at TU Delft 2022-2023

The male-dominated culture within STEM fields creates unwelcoming environments for women and the lack of visible female role models hinders girls' interest in STEM.

In 2021, a few countries, such as Norway and Latvia, over 50% of engineers were female. However, in most other countries, including in the UK and the USA, the percentage was rather low. In some countries, there has been a slight increase. In the UK, the percentage of female engineers rose from 13% to 14.5% in 2022. A similar trend in the USA, where the percentage of women engineers increased from 13% to 17% between 2019 and 2021 (Bosworth, 2022).

In the Netherlands in 2022, 43 percent of working female tech graduates were working in technical occupations, versus 65 percent of male tech graduates (Netherlands, 2023b).

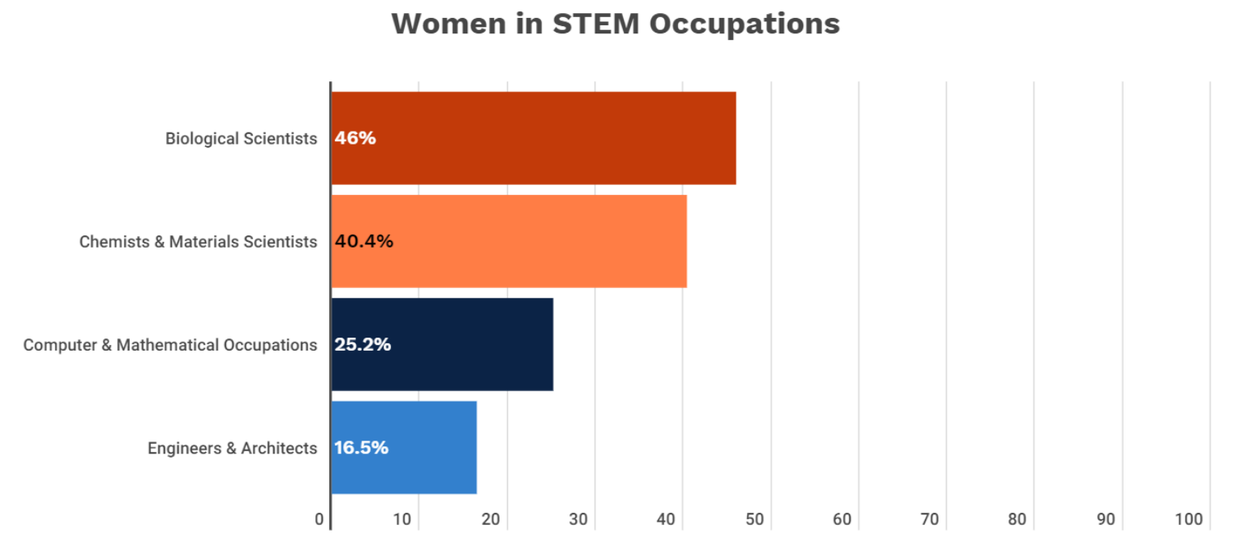


Figure 4. Global women in STEM occupations (2015-2019)

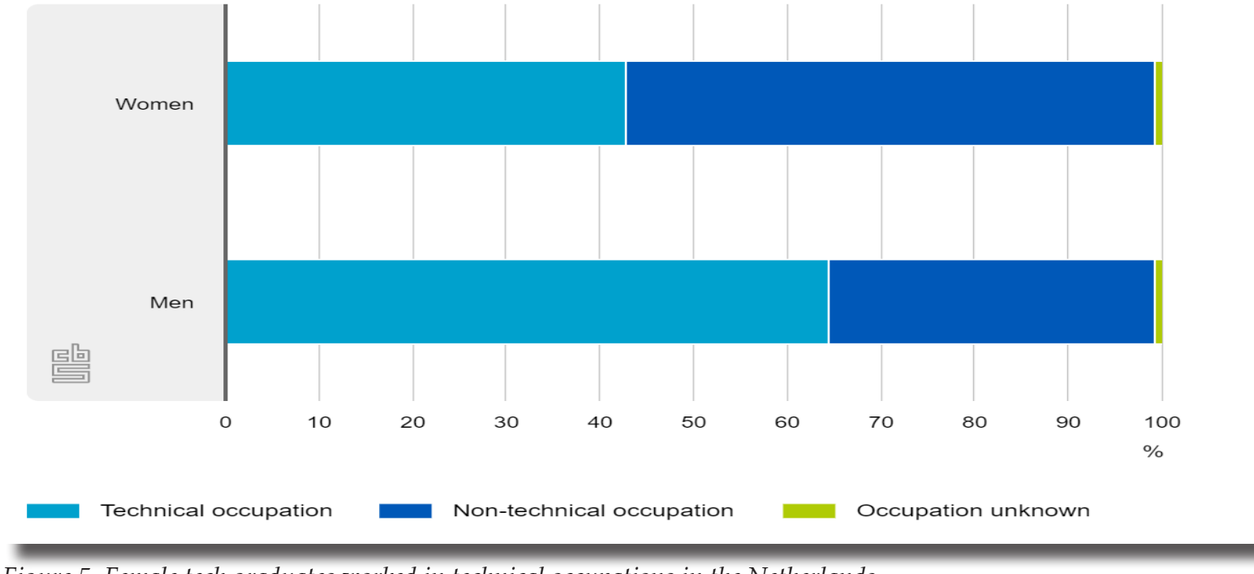


Figure 5. Female tech graduates worked in technical occupations in the Netherlands

1.2 Cities of Things Lab 010

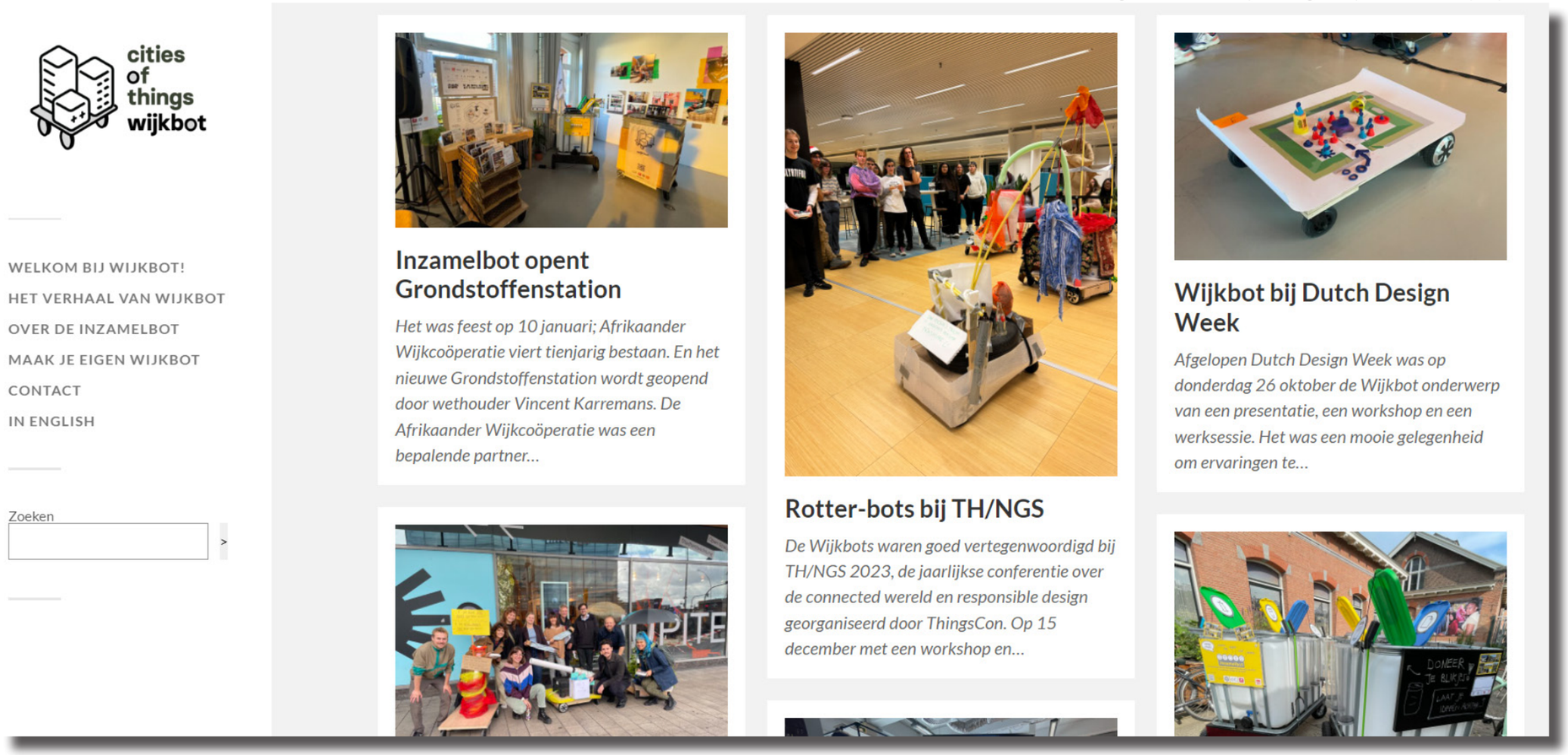
The Cities of Things Lab 010 project has several objectives. Where citizens are involved in designing, developing, owning, maintaining, and supervising the city bots. The project also seeks to position Rotterdam as an innovative city in the coexistence of smart technologies and people. The lab aims to educate professionals in applying design methodologies for a digital future where citizens play a key role (City of Things Lab010 - Cities of Things, 2022). Cities of Things Lab 010 host the workshop with the Wijkbot kit to Wijkbot is the tech module with hacked* second-hand "hoverboard" and off-the-shelf components. (Wijkbot – Hoodbot – Co-design Toolkit for Neighbourhood Robots, n.d.).

This inspire me to start research on educational robotic toolkit, thus the initial questions are:

1. Why does the educational robotics toolkit and engineering field currently lack attractiveness for female students?

2. What are the barriers or challenges that hinder female students' participation in the engineering environment?

Figure 6. Cities of Things Wijkbot related project



Chapter 2. Gender Dynamic in Engineering

Context Analysis

This chapter undertakes an analysis of the current literature addressing challenges and potential solutions related to the underrepresentation of female students in the field of engineering.

Gender dynamics
(noun)

The ways societal views of gender shape relationships and behaviours.

2.1 Purpose and methodology

The primary aim was to identify the current situation and analyse existing solutions (approaches and products). A systematic review of academic databases, reputable journals, and relevant scholarly publications was conducted for this study. The search strategy involved using keywords such as "toolkit for robotic design", "female students robotic design", "toolkit for female students," and "engage female students" to refine the search results. The selected databases included academic websites, ResearchGate, and Google Scholar, ensuring a wide range of multidisciplinary sources. The articles chosen were those cited by over 100 references, with a publication date within the last 15 years, ensuring that my findings were relevant and current.

2.2 The factors that push girls away from engineering field

The field of engineering is currently facing a gender gap, with a noticeable lack of female students and professionals. This gap raises questions about what factors contribute to the field's lack of attractiveness for female students and the difficulty for females taking part in engineering. This disparity can be attributed to a complex interplay of societal, cultural, and *self-efficacy factors, collectively shaping an environment and career path that appears less inviting to females.

*Self-efficacy: The belief in your ability to achieve goals. It's not a general confidence but a task-specific belief influenced by past experiences. It affects your motivation, behaviour, and performance. High self-efficacy leads to greater effort and success, while low self-efficacy can hinder performance. It can be developed and influenced by social factors.

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I am not able to be an engineer

Many girls perceive engineering as providing fewer opportunities for creative development compared to other fields (Rusk et al., 2008). Girls are often more attracted to fields with higher concentrations of women, like health, education, and social sciences, due to a sense of belonging. However, this does not mean that they do not enjoy building and programming robots. (Michaeli et al., 2014).

Additionally, a significant factor contributing to this circumstance is the continued absence of visible female role models and mentors in the fields of robotics and engineering across generations. When girls do not have access to many female role models in these domains, it becomes challenging for them to envision themselves pursuing careers in engineering (Pedersen et al., 2021). .

Role models play a significant role in inspiring young girls to pursue STEM-related careers, “It was in my fourth semester when I met a female professor who was from the Electrical department, and she had a huge impact on me, because it was the first time I was witnessing someone who I could mirror myself in.” (Portley, 2023).

Girls should not do engineering, it is too masculine

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Traditional masculine stereotypes related to engineering can deter girls from pursuing engineering. Some workplaces within these fields may cultivate a prevailing masculine culture with demanding work hours. This can create unwelcoming or even hostile environments for women, particularly considering women might be pregnant and in childbirth (Saumyadi & Jayawardane, 2022b). Additionally, parental expectations, societal education norms, and peer influence often steer girls away from technical fields.

The mainstream toolkit to engage students in STEM education is primarily educational robotics toolkits. The way robotics and engineering activities are presented plays a significant role in shaping girls' attitudes. Traditional teaching approaches to robotics and engineering often fail to resonate with female students (Rusk et al., 2008). The early stages of education witness a common tendency among teachers and parents to underestimate girls' mathematical capabilities, starting as early as preschool. This underestimation influences girls' confidence and engagement in math-related activities throughout their academic journey (AAUW, n.d., 2020). Moreover, existing educational robotics toolkits in these fields are typically marketed toward boys or packaged in a manner that appears more masculine, which can discourage girls from participating. Gendered messages embedded in tools and materials further contribute to the perception that robotics is not welcome of girls (Buchholz et al., 2014). An analysis of existing products will be discussed in Chapter 2.3.

Consequently, girls may not always have equal access to quality STEM education or opportunities to engage with robotics and engineering in a way that sparks their interest or makes them feel included (Bystydzienski et al., 2015). These stereotypes may lead to the perception that these fields are more suitable for men. Women doubt their abilities when pursuing these fields, thinking they may not belong in them. (Dasgupta & Stout, 2014).

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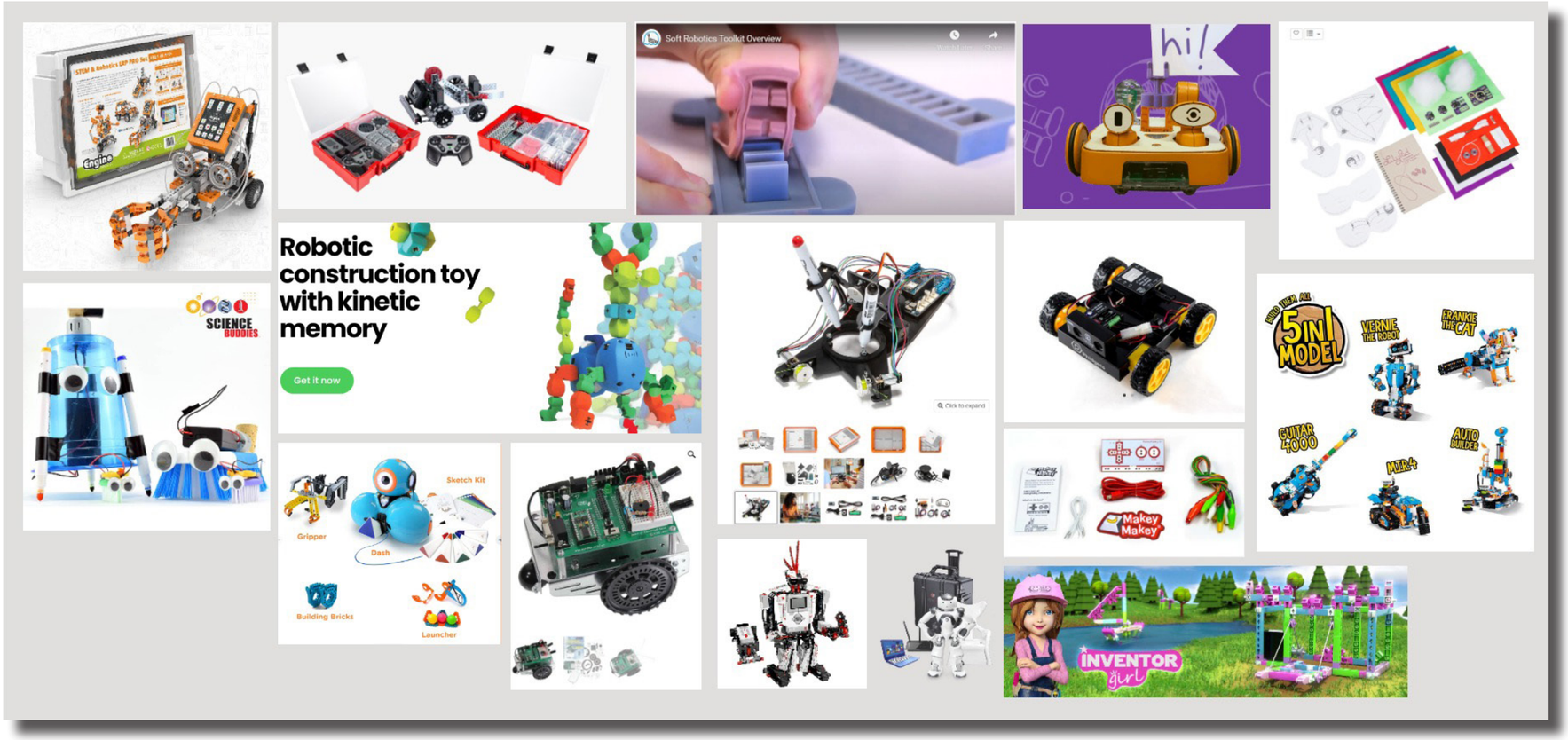
2.3 Exploring the possibilities in educational robotics and programming toolkit

The existing toolkits of the robotics design offer several advantages. Firstly, they cultivate essential problem-solving skills by promoting creative thinking and providing diverse approaches to challenges. Secondly, they bridge the gap between theory and practice, enhancing participants' grasp of fundamental concepts through hands-on experience. Furthermore, these endeavours encourage continual learning based on real-world feedback, fostering cognitive abilities from logical reasoning to spatial awareness.

Nevertheless, certain drawbacks persist. Several educational approaches involving robotics or specialised kits can be costly, potentially limiting access to students and institutions with budget constraints. Visual programming languages, while beginner-friendly, may not offer the depth of coding skills provided by text-based languages, limiting students' ability to tackle complex, real-world applications. Gender imbalances and societal biassed impressions of the toolkit are significant concerns, influencing girls' experiences and perceptions.

Figure 7. Different educational robotics toolkits



Is a construction toolkit the only option?

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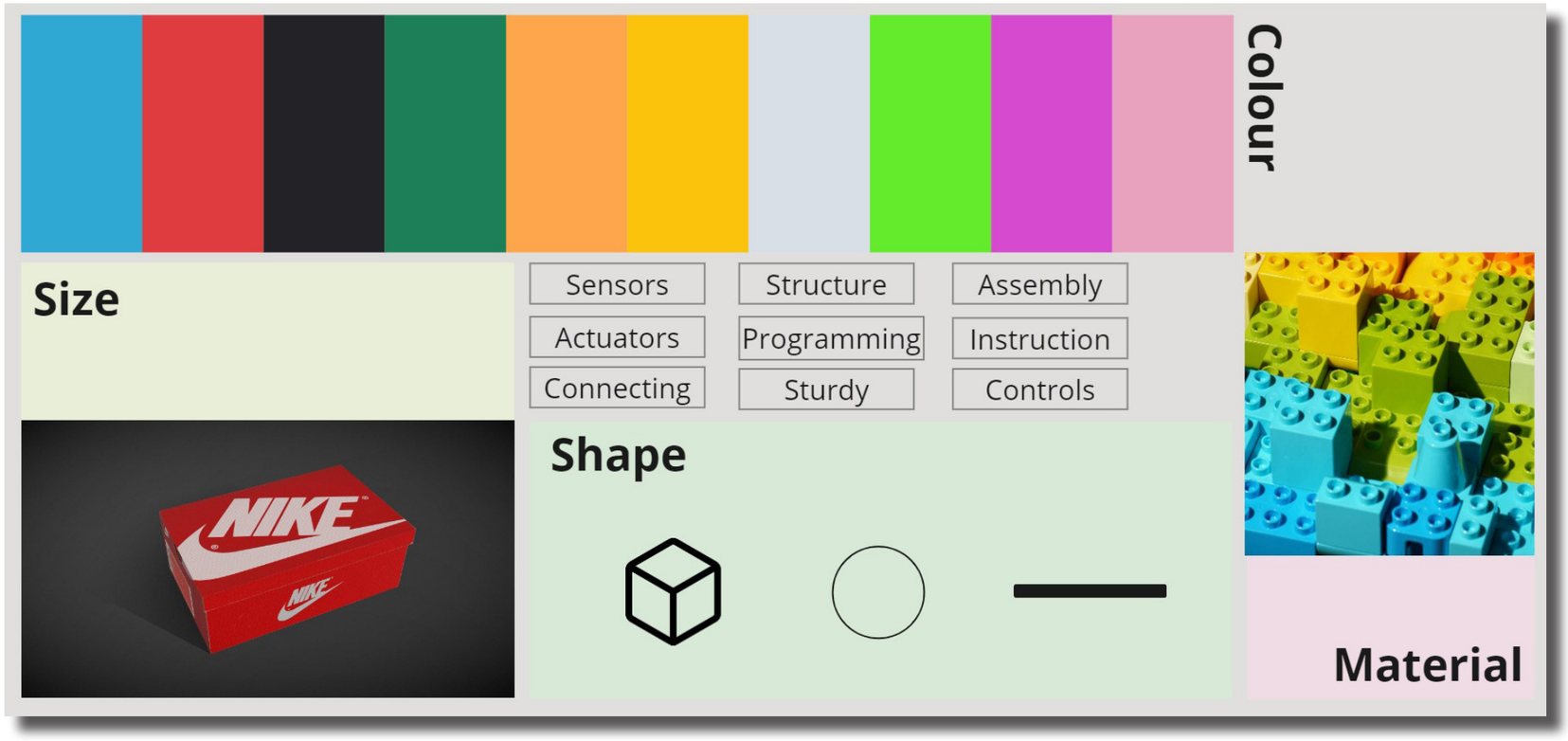
While construction brick kits enhance students' understanding of theoretical concepts through hands-on activities. The incorporation of craft materials into toolkits represents a significant transformation, especially in fields like educational robotics and programming, which are often dominated by conventional construction bricks. This change promises to make STEM learning more inclusive and engaging for all, but especially for girls (Rusk et al., 2008). Craft materials empower girls to take ownership of their projects, stimulating creativity and personal expression. Their flexibility and adaptability cater to diverse learning preferences.

Furthermore, the launch of Lilypad Arduino initiated a new trend for connecting electronic components with conductive thread. E-textiles are one of the popular applications among female users, attracting participation from girls and others in the class who are not typically drawn to computational activities (Kafai et al., 2014).

Soft robotics components can be integrated with various materials, such as fibre crafts which have been associated socio-culturally with underrepresented people in STEM, especially women and girls.

Figure 8. Representation of construction toolkit



2.4 Reasons for the underrepresentation of female engineering students

According to the findings from Chapters 2.2 and 2.3, I highlighted the nine main reasons that contribute to the current absence of female engineer students.

- Traditional teaching approaches in these fields make girls not feel involved.
- Parental expectations, societal norms, and peer influence.
- The lack of visible female role models and mentors.
- Masculine stereotypes in engineering.
- Family responsibilities.
- Girls are often more drawn to fields with a higher proportion of women.
- Some workplaces in these sectors have a prevailing masculine culture and demanding work hours.
- Limited access to quality STEM education and opportunities.
- Existing products and marketing are typically oriented toward males.

2.5 Research gap and problem definition

I gained insights from the literature research and identified two gaps: limited research on gender learning in STEM for ages above 18 and a scarcity of studies on the male perspective. I conducted surveys to address these gaps. One focused on the educational robotics toolkit, utilizing experiences of female Industrial Design Engineering (IDE) bachelor students (aged 18 to 21). IDE female students can express their self-perception as either designers or engineers. Some feel involved in the design-oriented course and may prefer to be called designers. This preference might explain why IDE bachelor female students are less likely to choose the technical-oriented elective course. Therefore, it is valuable for this project to explore their experiences and opinions.

Additionally, involving these female engineers holds the promise that they can serve as role models, inspiring the next generation of female engineers.

The other survey aimed to understand the male perspective on the current situation in the engineering field. Involving both males and females in crafting the solution creates awareness of the responsibility that everyone plays a role in this situation. It is crucial to emphasize that this thesis does not aim to generate conflict between genders. Instead, its message has the ambition of shaping a world where everyone can choose what they want to do based on their interests, free from gender stereotypes. Furthermore, I defined the design goal of the toolkit based on this message.

To conclude, I formulate the research question and define the problem:

How can a toolkit make students feel involved and broaden people's image of robotics?

Chapter 3. Listen To Both

User Research

The user research aims for three goals. Firstly, to understand the implementation of the STEM education workshop in real scenarios, I interviewed TU Delft Science Center coordinator and MakerSpace Delft manager. Secondly, to bridge the research gap where most gender learning research focuses on ages before 15, with only a few extending until age 18. Thus, I conducted an online survey to gather the using experience on the existing robotics toolkit from female IDE bachelor students (age 18 to 20). Last but not least, to understand the plurality of perspectives towards the design of a gender-inclusive robotics toolkit. I conducted another online survey to understand males' opinions. Involving both males and females in crafting the solution creates awareness of the responsibility and conveys the message that everyone plays a role in this situation.

3.1 Interview experienced STEM education organisations

User Research

Purpose and methodology

The interviews aim to gain insights from both successful and less successful experiences in the realm of educational workshops. Moreover, to understand the challenges and findings from the workshop design perspective. The main topics were "What are your experiences, challenges, and findings from hosting/designing workshops?" and "When female students use the material you offered during the workshop, where do they perform well, and where do they struggle?". TU Delft Science Center coordinator participated in an online interview and I conducted an in-person interview with Makerspace Delft manager.

Result and discussion

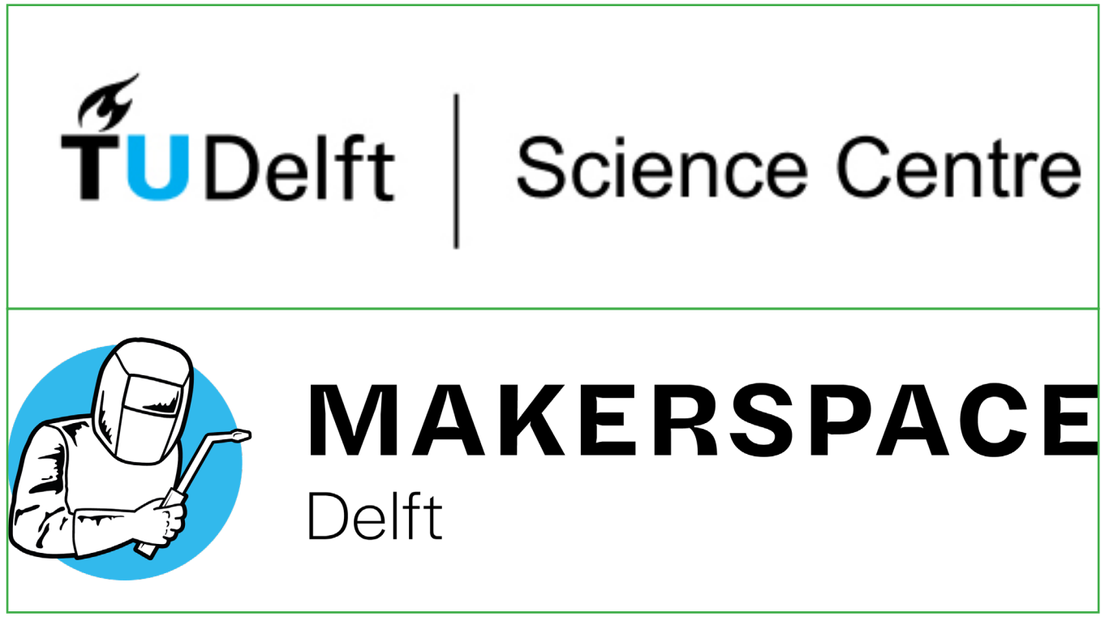
General characteristics

TU Delft Science Center has hosted numerous STEM workshops for primary and secondary schools, with workshop lecturers comprising an equal gender distribution of TU Delft students. Makerspace Delft, a non-profit organisation, provides a co-working hands-on space for everyone. Workshop topics range randomly, with a focus on building machines like 3D printers.

Experience and Observation

The TU Delft Science Center coordinator observed that the girls have a strong preference for hands-on activities. Additionally, female lecturers play a crucial role in boosting the confidence of girls in workshop settings. The Makerspace Delft manager noted that the presence of female volunteers attracts more women to the group. These findings underscore the significance of female role models, aligning with Pedersen et al.'s (2021) research, which highlights that limited access to female role models in robotics and engineering poses a challenge for girls envisioning themselves in these fields.

Figure 9.



3.2 Survey-What do you think about the robotics toolkit

Purpose and methodology

This survey serves as a foundational assessment of the current levels of interest, knowledge, and engagement among female bachelor students in robotics. It also aims to identify the potential barriers or challenges that female students encounter when using robotics toolkits. Moreover, understanding their views on increasing opportunities for female students to learn and engage with robotics can be valuable for promoting robotics education among this demographic. The survey incorporates the Likert scale, multiple choice (allow multiple answers), open-ended questions, and demographics, and I also ask about their willingness to participate in further prototype user testing. In total, 16 female students responded.

Result and discussion

General characteristics

The respondents' ages ranged from 18 to 22, Industrial Design Engineering bachelor's female students. Their average interest in robotics is 4.69 out of 7.

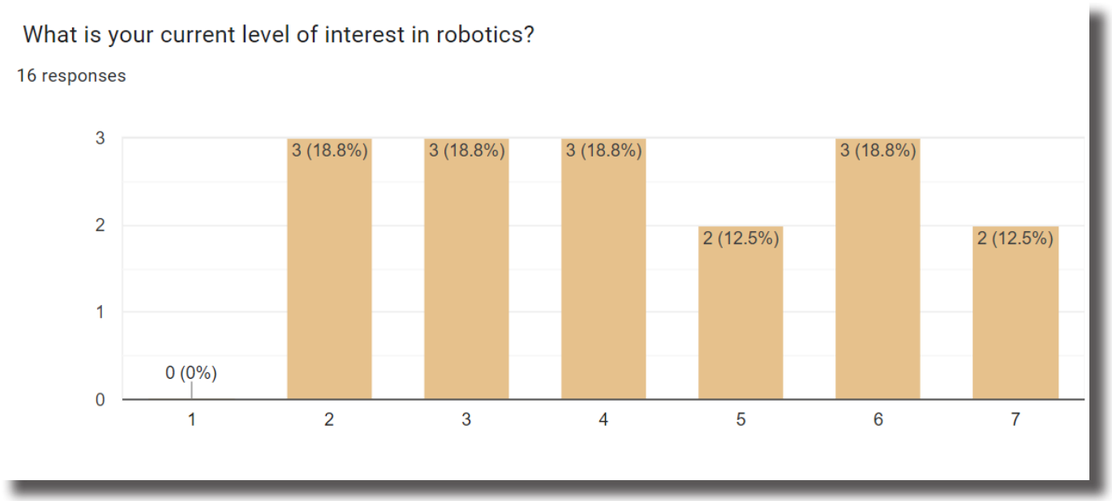


Figure 10. Questionnaire result-level of interest in robotics

Experience and Observation

6 out of 9 respondents with a below-average interest level have never used a robotics toolkit.

Experienced respondents with below-average interest levels indicated that they encountered challenges related to understanding the components and programming of toolkits. This finding aligns with Rusk et al. (2008) research, which suggests that traditional teaching approaches to robotics are often presented in a way that does not make female students feel involved. Surprisingly, one respondent did not face any challenges as she followed the manual; however, her interest level remained below average.

Notably, just one respondent had prior experience with robot toolkits in middle school and continued access to other robot toolkits in high school. This observation is similar with the findings of Bystydzienski et al. (2015), who proposed that girls may not consistently have equal access to STEM education or opportunities for involvement in robotics and engineering that can ignite their interest.

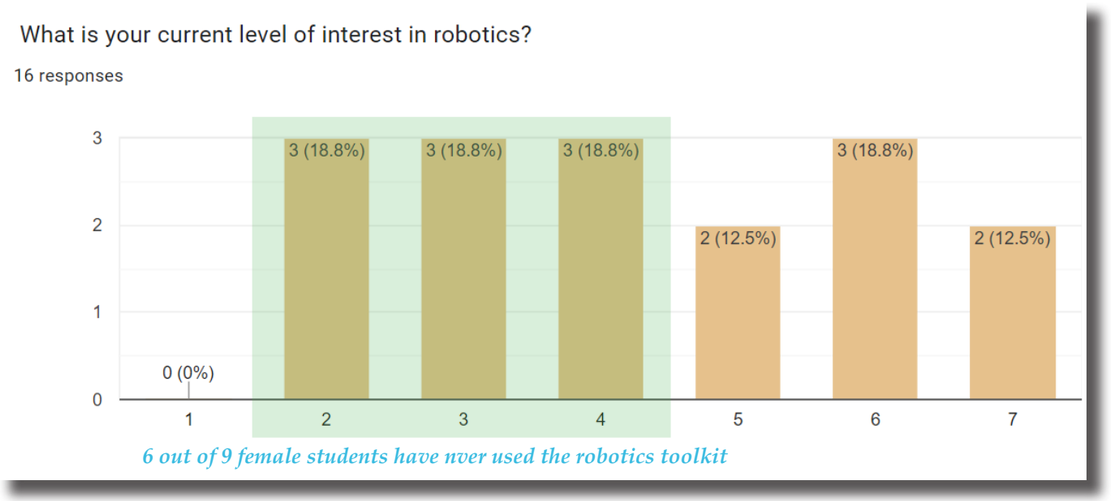


Figure 11. Relationship between the experience and the level of interest

Collecting solutions

Ease of use, affordability and the purpose of robotics toolkits are important to the respondents. Non-experienced users prefer beginner-friendly activities with clear instructions. Individuals with experience in robotics toolkits point out the need for clear guidance when they encounter problems and emphasise the importance of an appealing design. Additionally, experienced users enjoy the assembly part best when using the toolkit.

It is worth mentioning that the result of this question differs from Rusk et al.'s (2008) research, which emphasises that toolkits with craft materials can engage girls more. As shown in the bar chart, "Being able to work with different materials" is less important for female students.

urthermore, all respondents believe in providing more opportunities for female students in robotics education. A

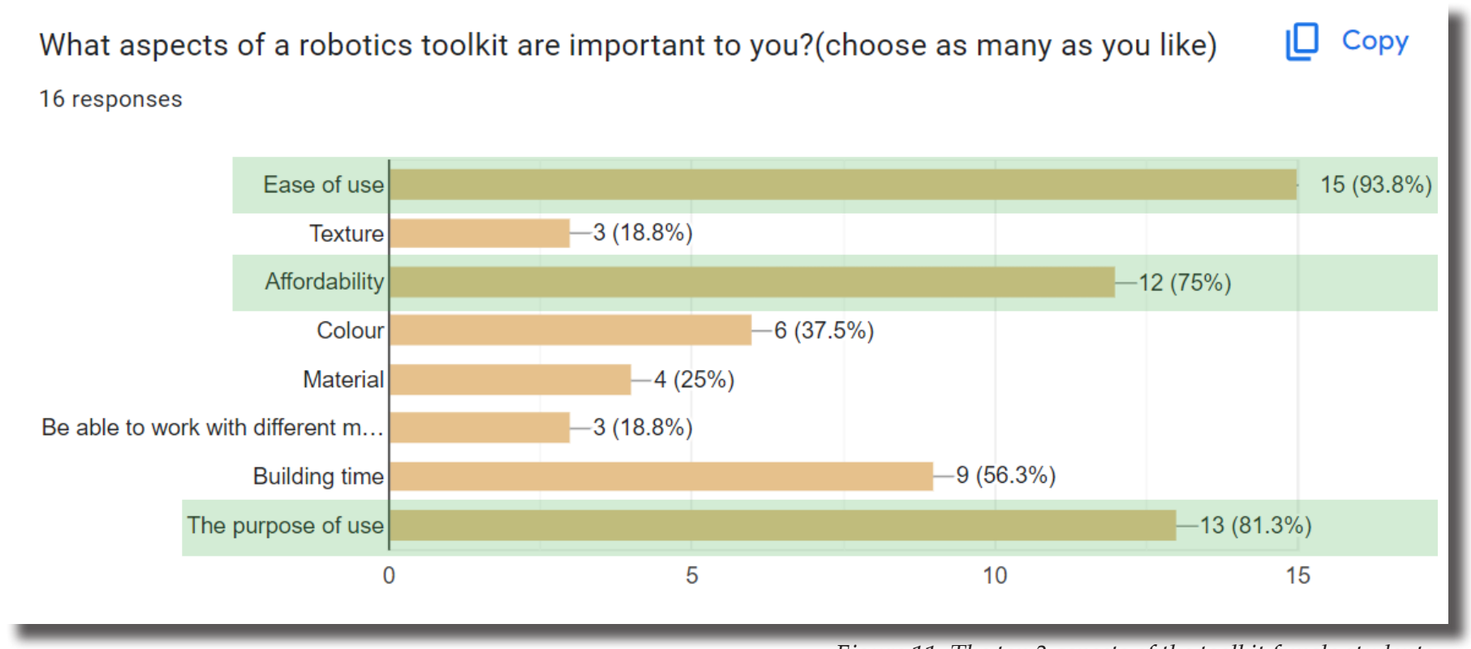
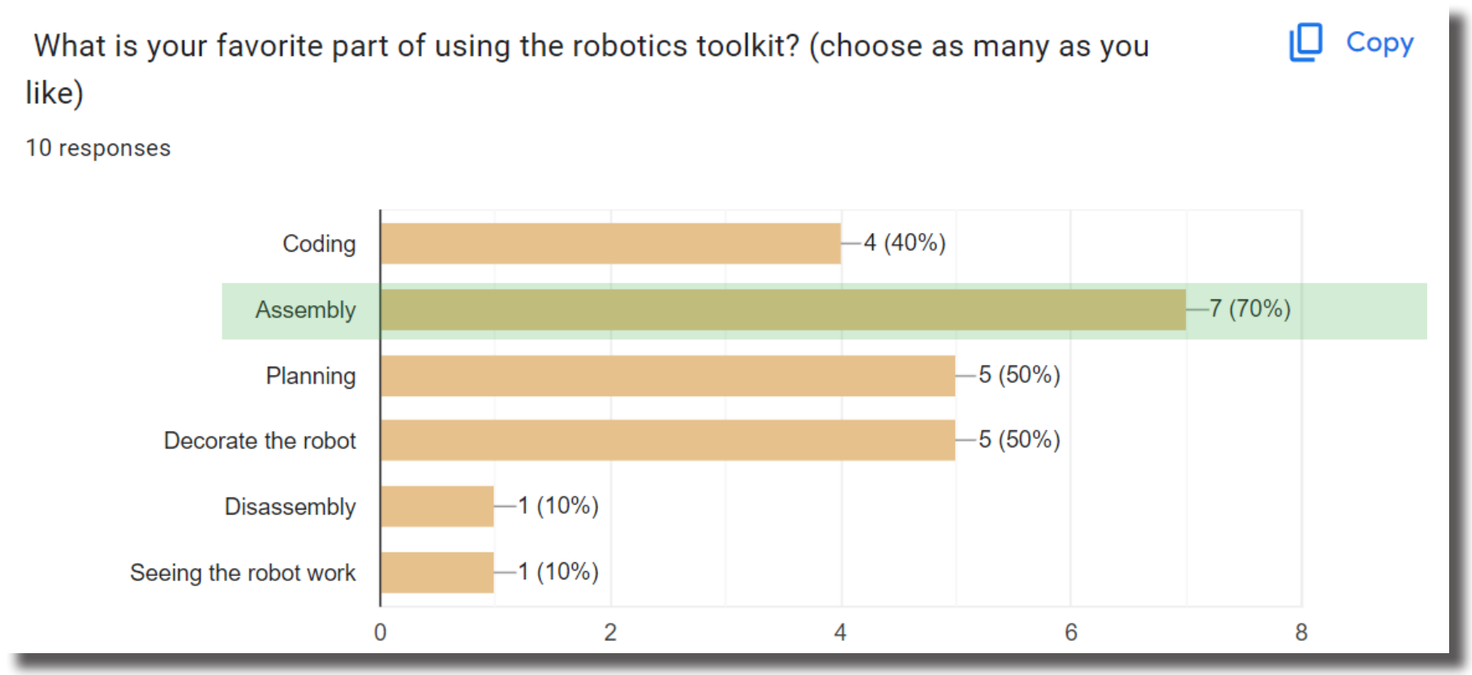


Figure 11. The top 3 aspects of the toolkit female students

Figure 12. Female students favorite part of using the toolkit



3.3 Survey-Listen to men

Purpose and methodology

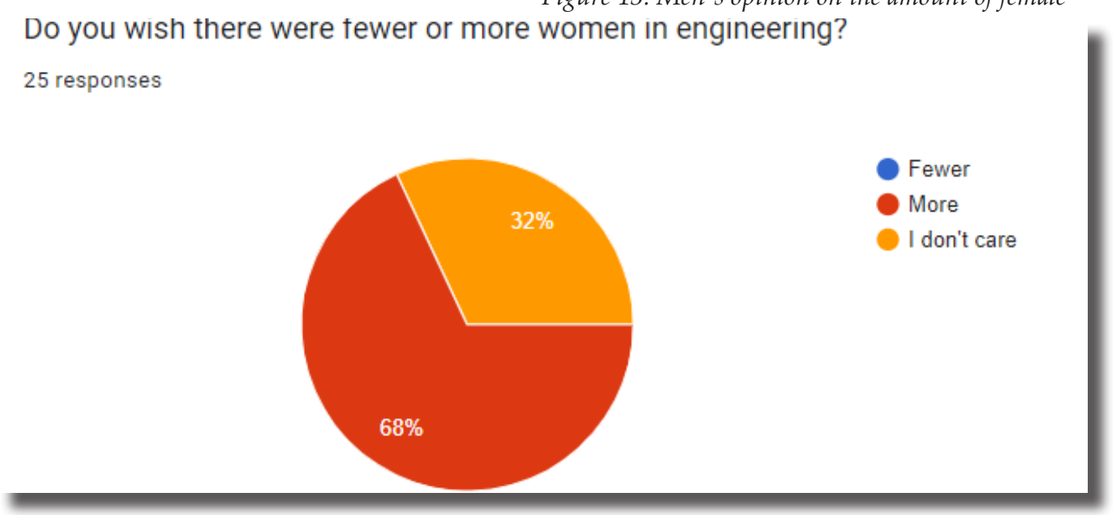
This survey assesses the level of awareness among males on this topic, whether they seek change or prefer the status quo. Moreover, gather their reasons behind and opinions. It contributes to the final design, aiming for inclusivity without excluding any opposing groups. The survey consists of multiple choice (allow single answer), open-ended questions and demographics. In total, 25 men responded.

Result and discussion

General characteristics

The respondents' ages ranged from 21 to 41, the majority of them who study, have studied and are working in the engineering field. 68% of respondents are eager to have more women in engineering, 32% of them do not care about the amount of women in engineering.

Figure 13. Men's opinion on the amount of female



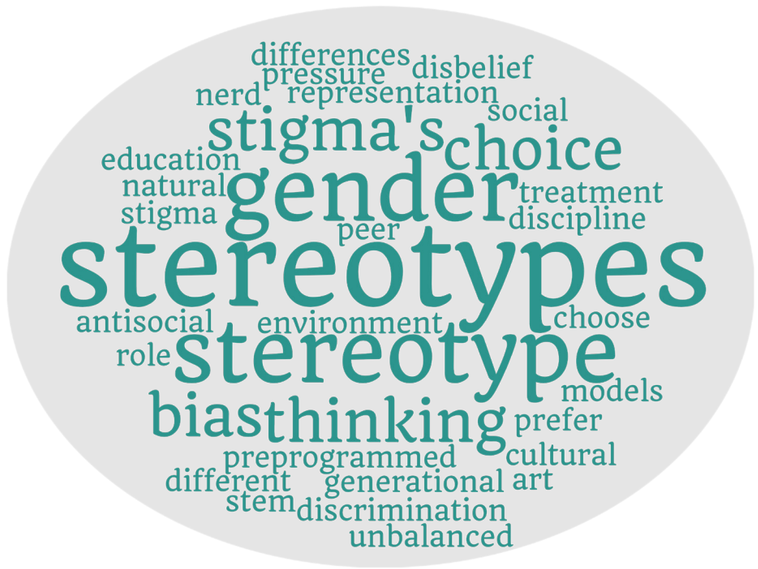
Perception and awareness

Individual performance matters, personal choice, diverse perspectives, and the gender ratio are four clusters of the argument that they wish for more women or do not care. By asking the question "Why do you think there are fewer women than men in engineering?", 20 out of 25 people identified gender stereotypes in engineering for boys as a significant factor contributing to the underrepresentation of women in engineering. Additionally, stigma and bias around female engineers were mentioned as possible reasons for the gender disparity in the engineering working environment. The result shows that men perceive engineering is boring and technical for women.

Collecting solutions

Respondents stressed the importance of increased visibility for female role models through hiring and leadership promotion. Breaking down gender stereotypes, treating individuals equally in education, and providing competitive salaries are considered crucial. Improving workplace conditions, easing entry into the field, and challenging societal attitudes are also emphasised. The findings stress the need for a multifaceted approach, recognizing the interconnected roles of education, workplace, societal perceptions, and economic factors in promoting gender equality in engineering.

Figure 14. The wordcloud of Men's opinion on the current situation



3.4 Conclusion

In conclusion, this chapter encompasses an exploration of gender dynamics in the context of STEM education, particularly in the field of engineering. By adopting a broad perspective that embraces both male and female viewpoints, the research underscores the importance of inclusivity and shared responsibility in crafting effective solutions. Insights from TU Delft Science Center and MakerSpace Delft highlight the significance of female role models. Surveys indicate varying levels of interest and challenges for female IDE students, emphasising the need for clear guidance and appealing designs in robotics toolkits. Male professionals in engineering express diverse views on gender representation, but there is agreement on the importance of challenging stereotypes, promoting equal education, and providing visible female role models.

Chapter 4. Moving Beyond Gender-Based Patterns

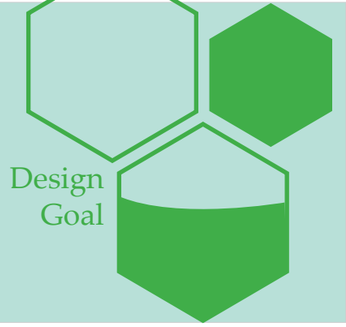
Design Goal

Chapter 1 provides the context for studying the "underrepresentation of women in engineering". To comprehend the reasons behind this phenomenon, Chapter 2 conducts a literature review and existing product analysis, where research gaps are identified. Subsequently, these identified gaps become the focal point of investigation in the User Research presented in Chapter 3. This chapter combines the findings from prior chapters to formulate the design goal. Furthermore, I define the design guidelines to develop the concepts.

Gender
(noun)

Gender is the social and cultural roles and expectations tied to an individual's perceived or assigned sex, including various identities and expressions.

4.1 Design goal



It is important to mention that the concept is suitable for the students facing similar barriers, regardless of gender. I aim to facilitate students' exploration of diverse perspectives during the ideation process, encouraging the incorporation of unique viewpoints and fostering creative thinking. The designed concepts will be used in the early phase of the robot design process. Before starting the research, it is essential to ensure that groupmates are on the same page and know what they are going to do.

Target audience

The target audience primarily consists of non-experienced students in robotics. Additionally, it is worth noting that even experienced users could have similar requirements as them. Hence, if this concept can effectively address the challenges encountered by non-experienced users, it also holds the potential to benefit experienced users.

Concept effect

I created the scale graph to make an assumption on how the concept affects the users. The three criterias are based on the user research and the design goal, which are Interest level, Diverse robot knowledge and active in discussion.

Figure 15. Before using the toolkit

Before using the toolkit

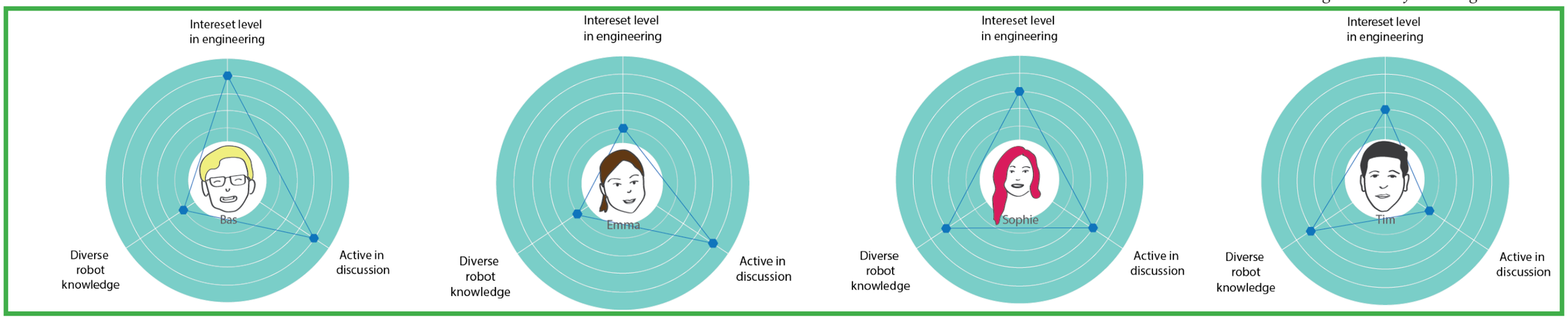
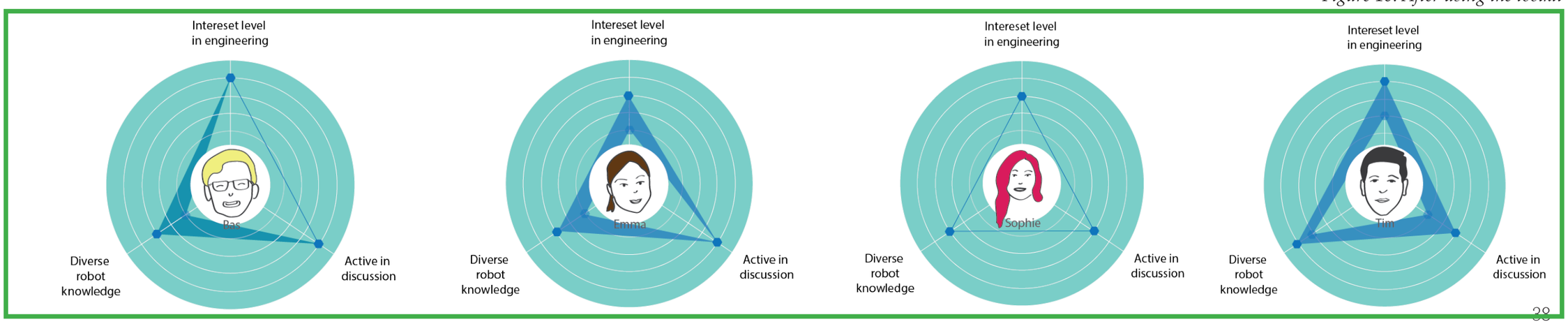


Figure 16. After using the toolkit

After using the toolkit

.



4.2 Co-creation workshop

Design Goal

Purpose and methodology

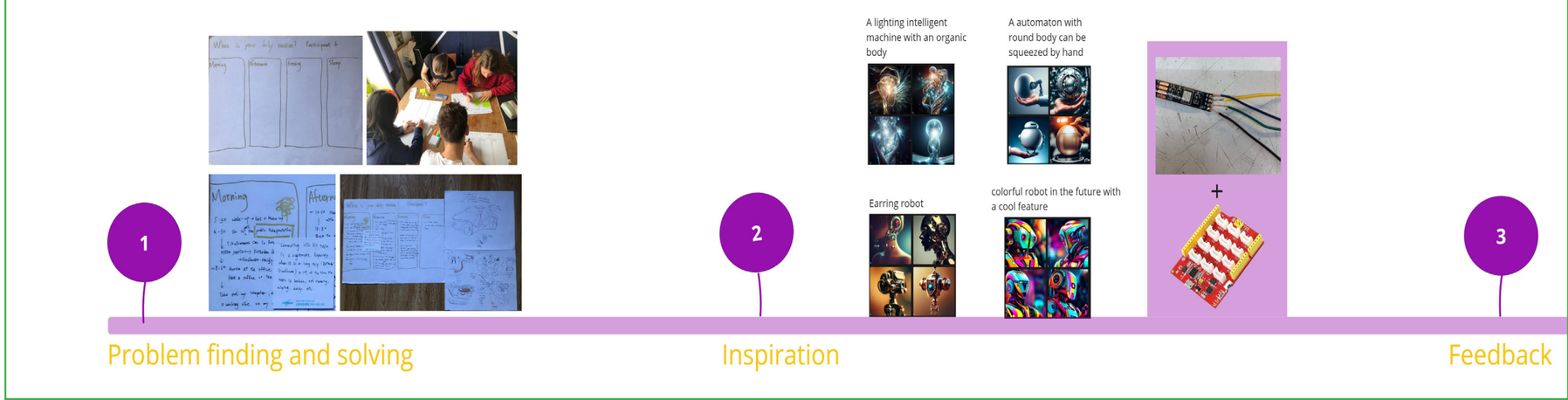
To understand why and what inspires people during ideation activity, and to define how the toolkit guides people in thinking from various angles. 5 co-creation workshops were held with 10 university students. The insights from previous chapters were synthesised into a co-creation workshop setting. This workshop aims to address the following questions:

1. What kind of robot is needed for daily life?
2. How do they perceive electronic components and pictures?
3. Why do people get inspired by certain things?

Setting up the workshop, there are three sessions. In the first session: Problem finding and solving, participants can either write or draw on the post-it then stick it to the canvas, the canvas has four time slots to guide people discovering the designing possibilities via their daily routine. The next session: Inspiration, I introduce how to change the LED light colour from different circuit combinations and the AI generated robot pictures. I expected this session to bring the participants' interest on technical stuff and give them new ideas on adding more features to the design. Along with this, I collected their opinion on how they think of the LED light strip circuit and AI generated robot pictures during Feedback sessions. Results of the workshop were further translated to the design guidelines.

Figure 17. Co-creation workshop

Figure 18. The agenda of Co-creation workshop



Result and discussion

General characteristics

The workshop involved 10 participants (5 females and 5 males) aged between 18 and 30, with 9 participants having an engineering background and one from business management. It's noteworthy that only one participant (with an engineering background) has experience using a robotic toolkit.

Observation and takeaway

I identified the five clusters based on the feedback regarding how participants perceive the materials offered in the workshop:

Aesthetics

The colour combination is unappealing, evoking a sense of displeasure. For the hardware, their initial reaction was one of being overwhelmed, finding it chaotic and not at all user-friendly due to an excessive number of holes. Additionally, the shapes are overly sharp, contributing to the overall lack of aesthetic appeal.

Past experience

Most of participants oncern about breaking it arise due to the parts being too small. The product's appearance is unfamiliar, making it challenging to establish a connection. The initial use proved highly frustrating, leading to a lack of motivation to continue trying.

Figure 19. Electrical components

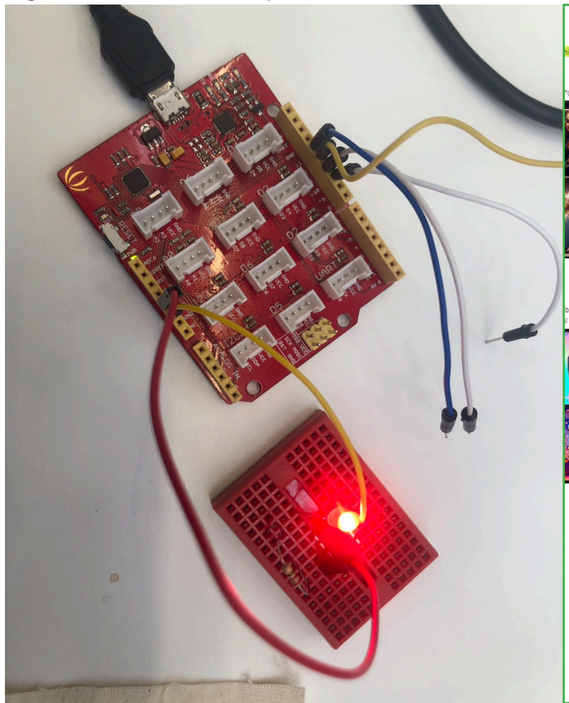
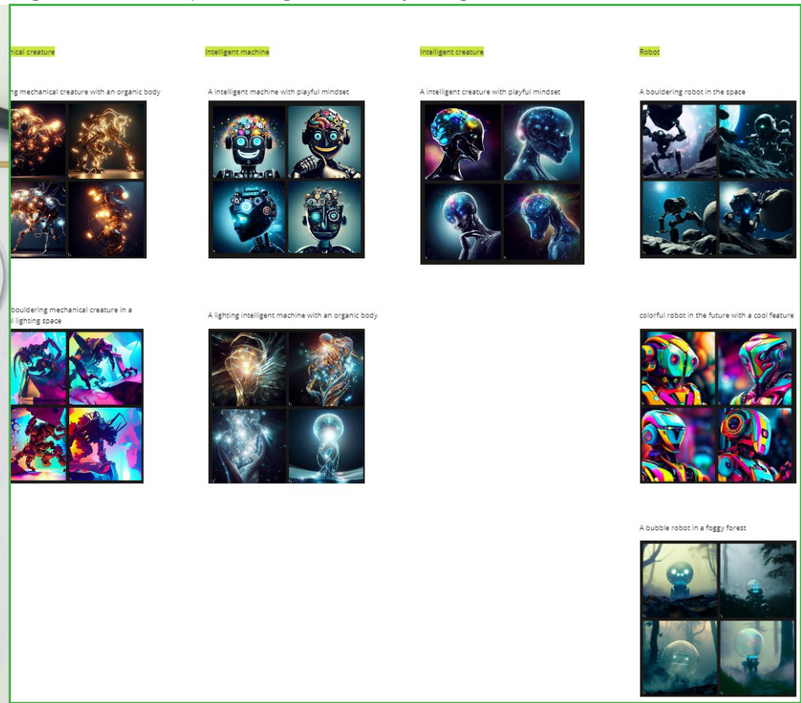


Figure 20. Robot pictures generated by Bing.create



Design Goal

Usability

Lack of clarity on where to assemble everything, with no apparent logic for them. The initial hurdle to get started is perceived as too high. There is a lack of understanding about what they are. Emphasis is not on the hardware but rather on prioritising human interaction and the value it can offer people after use.

Connection

Participants in the workshops designed a diverse range of robots, including transportation robots, alarm robots, assistant robots, and time-freeze robots. This finding indicates that when the assignment originates from daily life, individuals can establish more connections and generate diverse ideations.

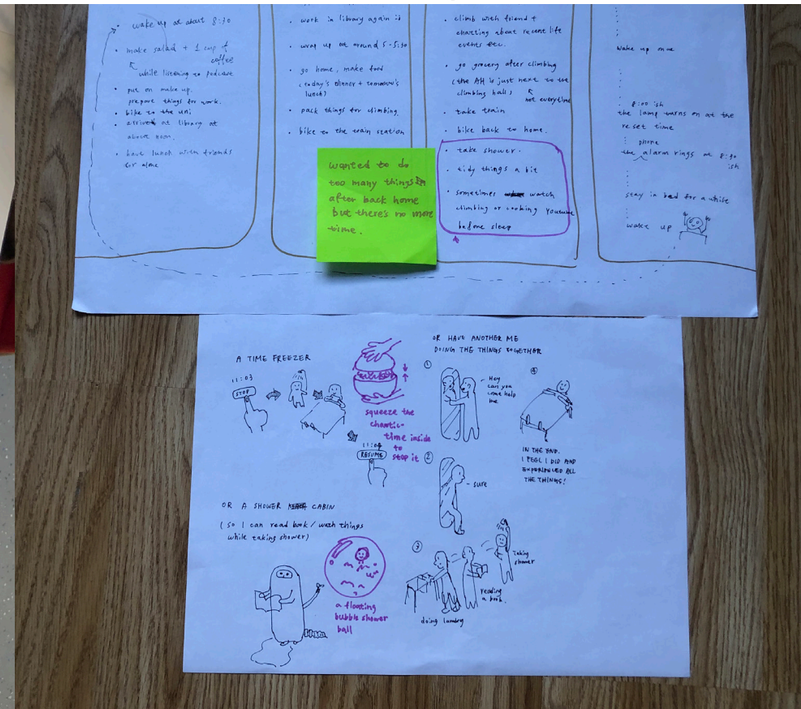
Inspiration

Most participants indicated that they did not feel inspired by the concrete electronic components as they were not familiar with them and do not have feelings for them. However, through AI-generated pictures, they could identify robots that caught their eyes, delve into the details, and then find inspiration.

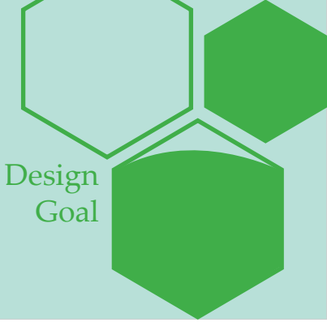
Figure 21. Co-creation workshop

Figure 22. Co-creation workshop

Figure 23. Co-creation workshop



4.3 Design guidelines



According to prior research, I defined design guidelines to tackle the problem mentioned in Chapter 2.5. There is three categories, which are attract users, build connections and create involved feelings.

Attract users

Provide creative development

Creative development involves the opportunity for artistic expression, inspiration for problem-solving, and the freedom to generate novel solutions.

Visual appeal

The appearance plays a significant role in attracting attention or creating a positive impression.

Ease of use

Ease of use implies that the design and functionality are intuitive, making it straightforward for users to understand and operate without encountering difficulties.

Build connections

Friendly topic assignment

When design tasks are connected to real-life scenarios, users can more effectively establish connections and generate ideas. The direct link to daily life serves as a rich source of inspiration, encouraging a thoughtful consideration of contextual aspects during the ideation process.

Create involved feelings

Collaborative

Users can work together with others to achieve a common goal. Collaboration involves people actively participating and contributing their skills and knowledge. It emphasises communication and teamwork, in terms of this, having a diverse perspective.

Good balance between simplicity and complexity for information

Everyone can have a common point while discussing but can also provide their ideas based on the knowledge they already have then boost the group discussion.

Chapter 5. Turning Ideas into Concepts

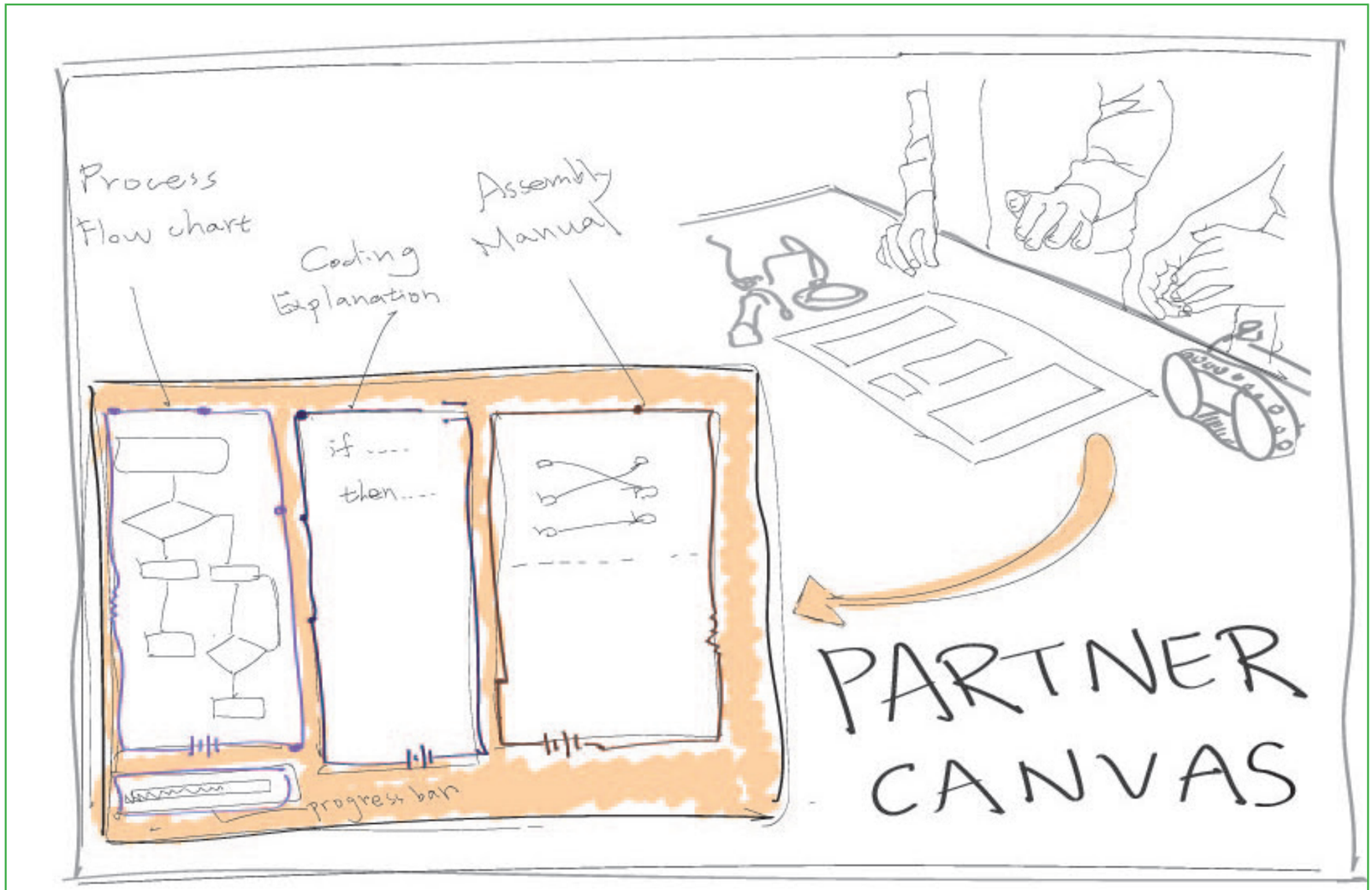
This chapter introduces the three concepts by aligning the design guidelines. Furthermore, I selected the final concept together with 3 IDE female students by using the Harris Profile.

5.1 The concepts

Partner Canvas

The design aims to assist users in effectively organising and structuring their process, starting with a flowchart to provide an initial overview. This Canvas design features a layout organised into three distinct sections: a process flowchart, a coding explanation, and an assembly manual. The subsequent section delves into the essential coding framework, offering users detailed explanations. Simultaneously, basic assembly instructions to guide users through the practical implementation of the outlined process. Each section includes both pre-filled and empty spaces, providing flexible room to accommodate various robot designs.

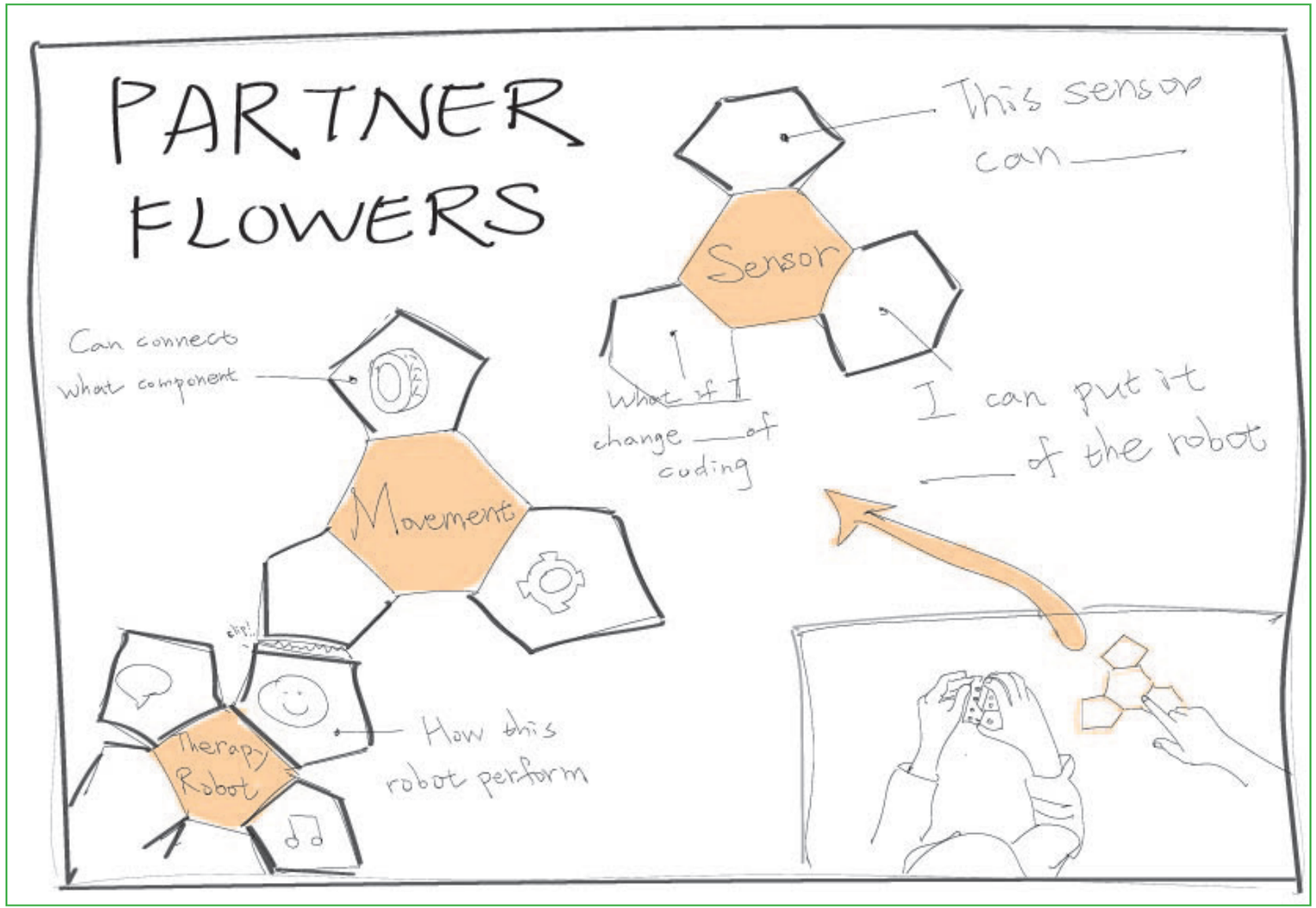
Figure 24. Concept 1-Partner Canvas



Partner Flowers

The design aims to assist users in structuring ideation and enabling them to consider different idea combinations. The concept comprises multiple pieces that can be disassembled and assembled. It consists of three piles of cards: one for the types of robots, another for the components, and the last for detailed design aspects. When the concept is assembled, the first pile offers inspiration to users regarding how their robot will perform. The next pile introduces the components required to achieve the desired performance. The final pile focuses on detailed design, guiding users through implementation by asking relevant questions.

Figure 25. Concept 2-Partner Flowers



Partner Board

The design aims to assist users in organising the process and enabling them to identify the steps they may lack in the process. The Partner Board concept proposes an interactive experience involving pebbles and a board. The pebbles can be attached to the board using magnets. Initially, users write down the steps they are taking and categorise them on the board. Horizontally, there are four categories: components, code, function, and error. Vertically, the design illustrates the relationships between each category, indicating whether they are connected or have no connection.

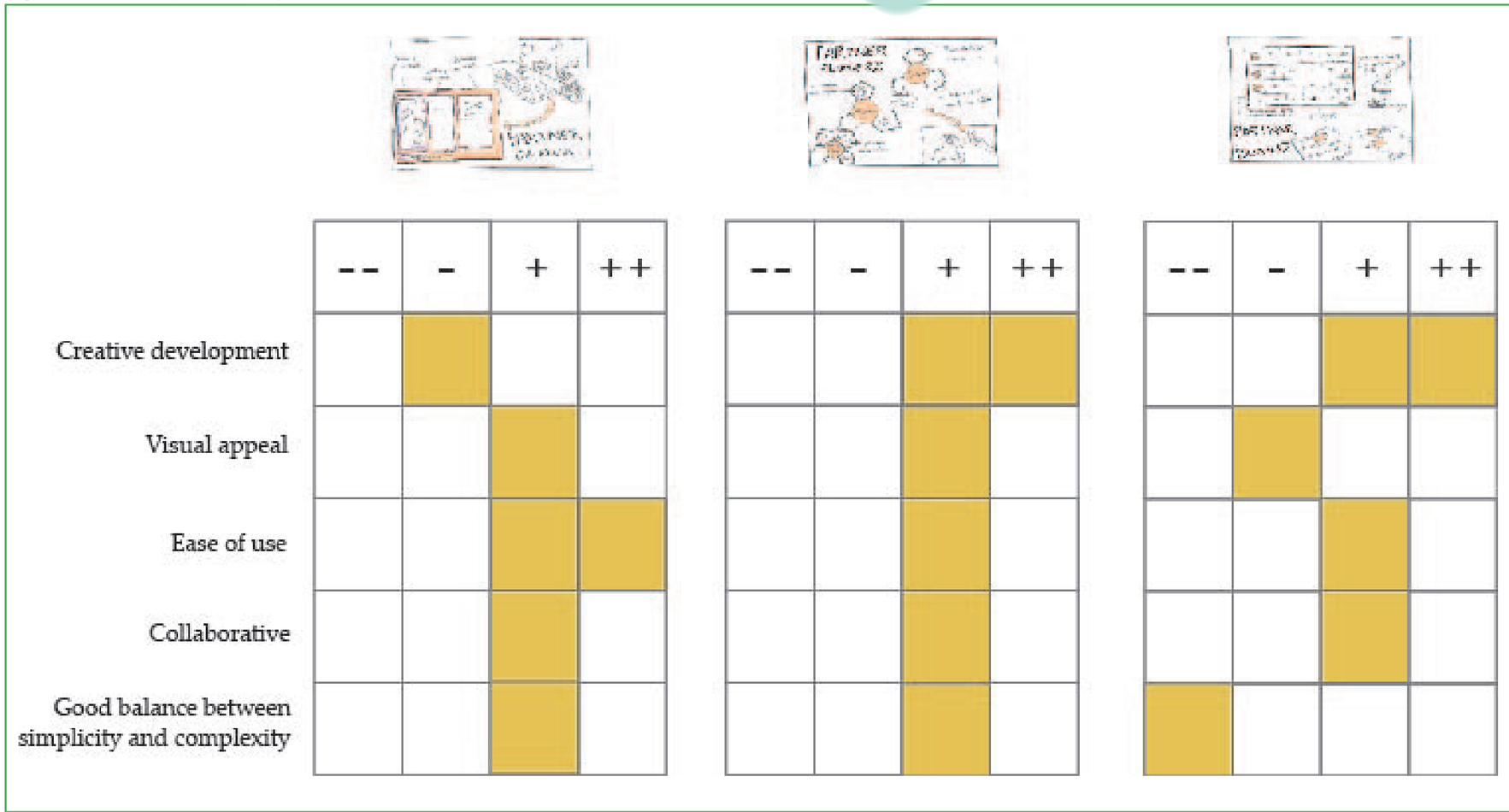
Figure 26. Concept 3-Partner Partner Board

5.2 Concept selection

I selected the concept for the next development phase through discussions with three female IDE bachelor's students who willingly participated in concept discussions based on a previous survey. Interestingly, the simplicity-complexity balance of the Partner Board scored the lowest, as they pointed out the overwhelming number of tasks associated with this concept. We then compared the design concepts against the project design guidelines in the Harris profile, as illustrated below.

The Partner Flowers has been chosen due to the most positive score. Surprisingly, the discussions brought up an interesting feedback: "Why are the forms of the instructions usually so flat?". I will incorporate it into the initial shape iterations.

Figure 27. Result of Harris profile



Chapter 6. HiveMind Development

The chapter presents the final design, Concept 2-Partner Flowers, I conducted the pilot user testing for testing the first iteration. Next to this, I conducted more user testing to iterate on the physical components and user interaction. Based on its purpose and shape, I named the final design HiveMind. Lastly, I integrated a game with HiveMind to enable group members to actively participate in discussions, fostering a process of knowledge exchange and ideas sharing.

Hivemind
(noun)

A group of people who share their knowledge or opinions with each other, regarded as producing collective intelligence.

6.1 Pilot user testing and the iterations

The initial iteration aligns with the insights from the concept selection session, introducing a non-planar element to captivate user interest.

The first ball involves identifying the type of robot, with five categories - assistant, companion, delivery, household, and medical. These are chosen for their relevance to daily life. The second ball explores how robots perform functions, using icons for visual guidance.

The third ball delves deeper into design considerations, such as sustainability for environmental impact or techniques like 3D printing for assembly.

Figure 28. The first iteration

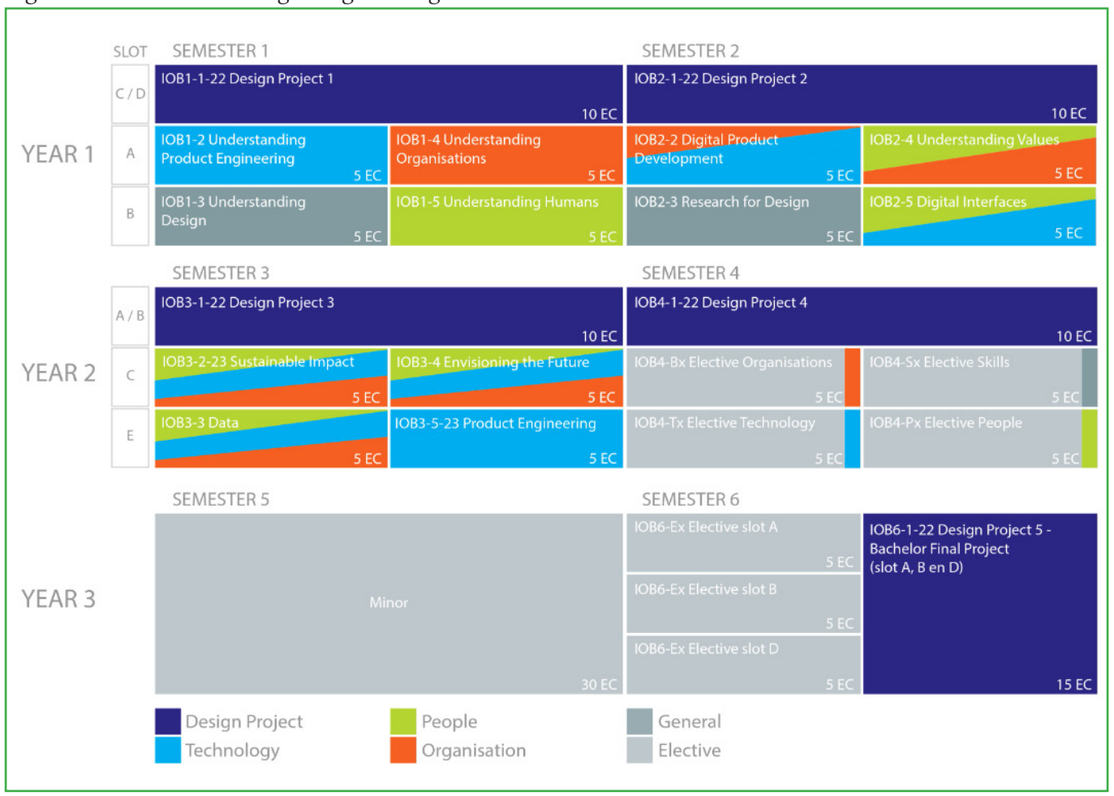
Purpose and methodology

After the first iteration, I conducted a pilot user testing to determine in which IDE bachelor course the design would be implemented. I conducted semi-structured interviews with a total of 15 IDE bachelor second-year students, as second-year students have one year of experience and are about to start elective courses and minors in the next semester. The insights from this testing serve as the guiding direction for further iterations.

In terms of this, I conducted user testings to refine the design in terms of form, user experience, and user scenario. The aim of the pilot user testing is as follows:

1. To collect user feedback on whether this concept effectively aids in the course
2. To gain insights into the expectations of students regarding the interaction with the course and the coach

Figure 29. Industrial Design Engineering bachelor course curriculum



Results and discussion

General characteristics

The participants consisted of 5 male students and 10 female students and 1 coach from DP3 course.

Findings and conclusion

Pilot user testing

In general, they mainly use online Miro board for group discussion. Thus, they are excited to have a physical toolkit they can interact with. The majority of the participants indicate that the toolkit does spark interest in robotics through implementation in the DP3 course. It is important to highlight that I observed that in the scenario where the toolkit comprises three separate entities, it results in the isolation of group members from collaborative discussions and interactions, as each member operates independently. Therefore, I merged the three balls into one so the communication between groupmates becomes better.

I decided to implement my design in Sprint 1 of the DP3 course (second-year bachelor) since it is a robot designing course that involves group projects, and Sprint 1 is the very first group work involving ideation. It would be valuable to verify if the percentage of female students exceeds 30% in the elective course Mechatronic and Design Engineering, as mentioned in Chapter 1. Additionally, the Digital Interface (first-year bachelor course), another candidate I did not choose, is an individual project that focuses on programming; thus, this course does not align with my intention for the design.

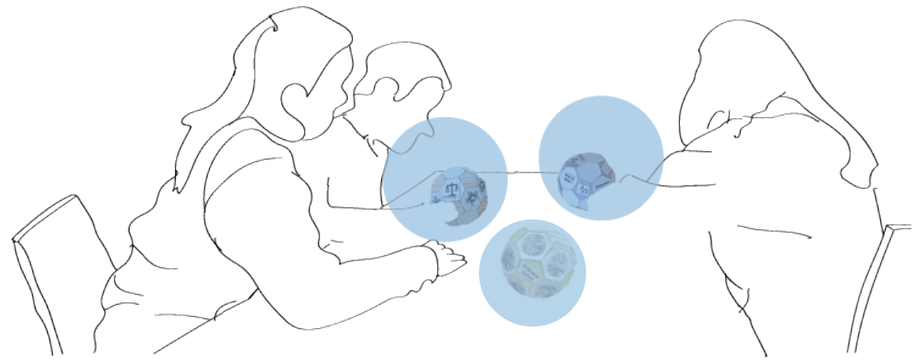
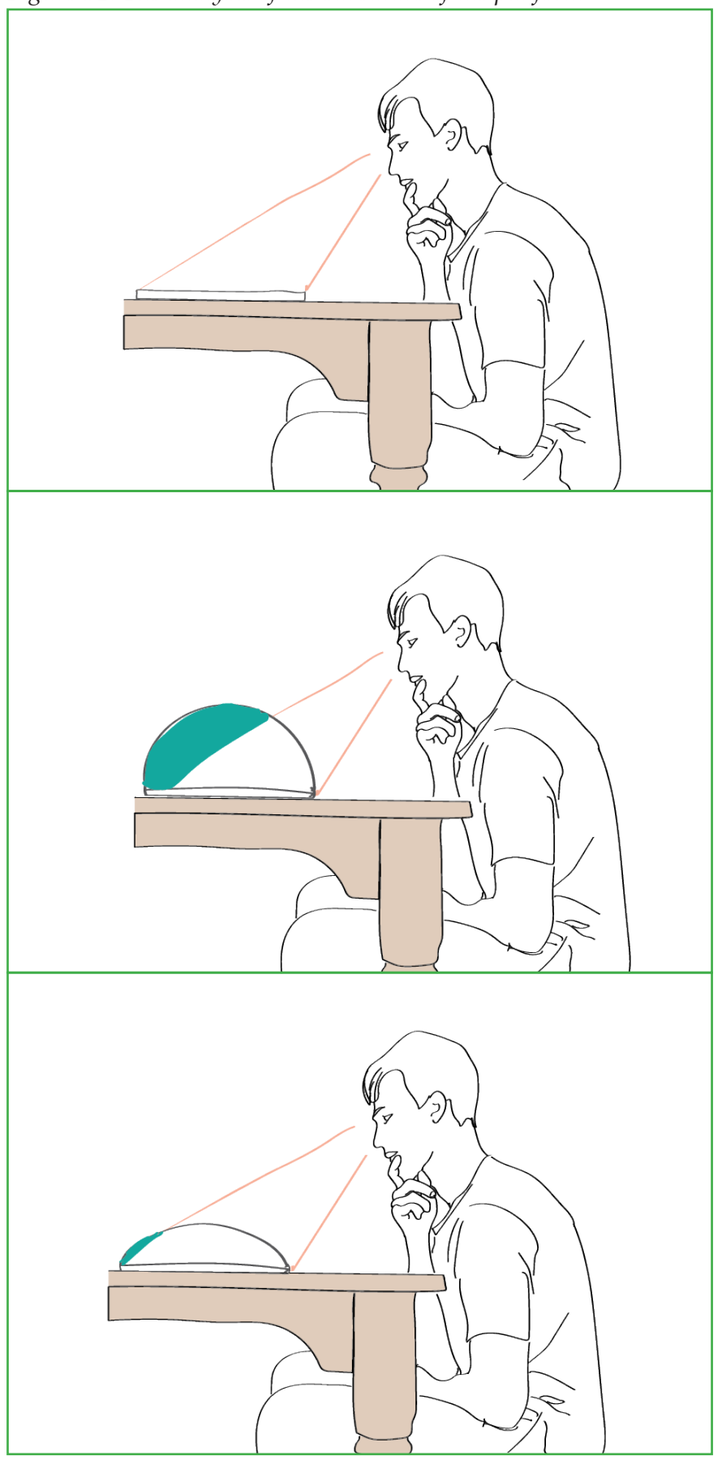


Figure 30. The concept from three isolated focus points to one focus point

Development

When the design adopts a commonplace plane, users are overwhelmed with an excessive amount of information, leading to a sense of frustration. Moreover, this approach fails to effectively cultivate the user's interest in engaging with the toolkit, as noted in the discussion of concept selection. When the surface curvature adopts a spherical shape, characterised by excessive convexity, the efficiency of information exchange during group discussions is diminished. This configuration is an obstacle for group members, hindering the fluidity of their discussions. Thus, the final design is a platform with a small curve.

Figure 31. The analysis of the curvature of the platform



I improved the design based on the insights from previous research, the three criterias are: hands-on interaction, inspiration and group discussion.

Hands-on interaction

I was inspired by the findings from Chapter 3.2 questionnaire, which highlighted that students enjoy the assembly part of toolkits. In terms of this, the iteration goal was to improve practical interaction, focusing on modules with easy assembly and manufacturing requirements. Therefore, ensuring a similar shape and size for each pocket to a one-size tile in any pocket. Thus, I replaced the pentagon with a hexagon. Additionally, I designed the curvature of the platform to form a circle with a radius of 1200mm. This adjustment aimed to create a more uniform and visually appealing toolkit.

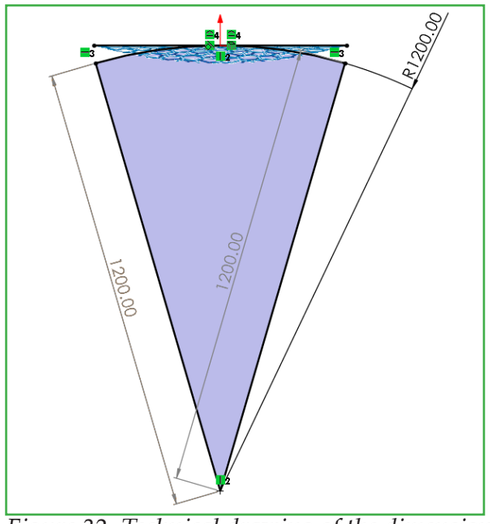


Figure 32. Technical drawing of the dimension

Inspiration and group discussion

The next phase is to boost group discussion, amplify the interest, and broaden the existing original impression of robotics. The requirement was to establish a common topic for groupmates to focus on. I added the questions to the tiles and designed a game. Additionally, to enhance group members' interaction, they can express their opinions using the token. Meanwhile, the token-tile serves as a focal point for other group mates during discussions.

During the game, players need to finish three tasks based on the provided options:

1. Select a robot that has inspired your design.
2. Select a feature you intend to add to your design.
3. Select a purpose or design direction for your robot.

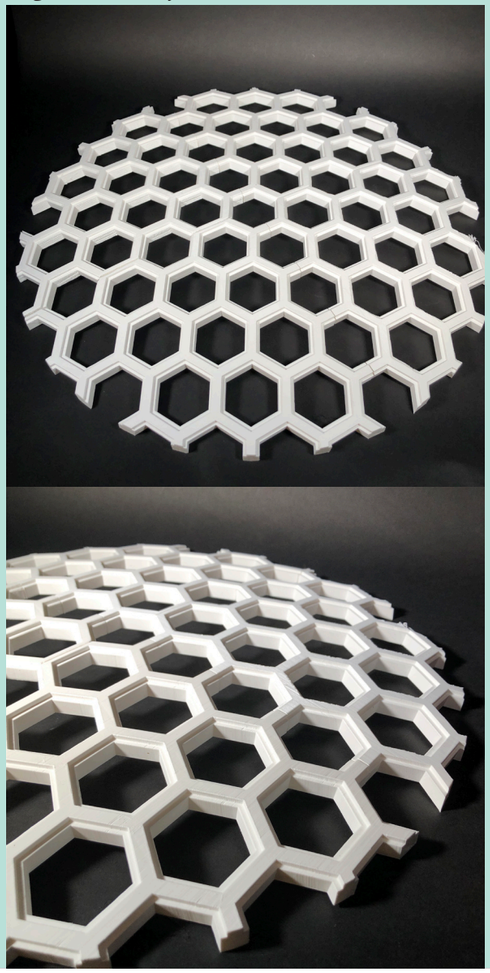
6.2 HiveMind overview

HiveMind

The frame

A curved platform with the hexagon pockets.

Figure 33. The frame



The task-tile (red, mint, grey)

The three tasks users need to complete are:

1. Select a robot that has inspired your design.
2. Select a feature you intend to add to your design.
3. Select a purpose or design direction for your robot.

Figure 34. The task-tile

The option-tile

The options for each task.

Figure 35. The option-tiles

The empty-tile

Players write or draw their options.on it.

Figure 36. The empty tile

The token

Players secure the token on the tile.

Figure 37. The token

6.3 HiveMind Game

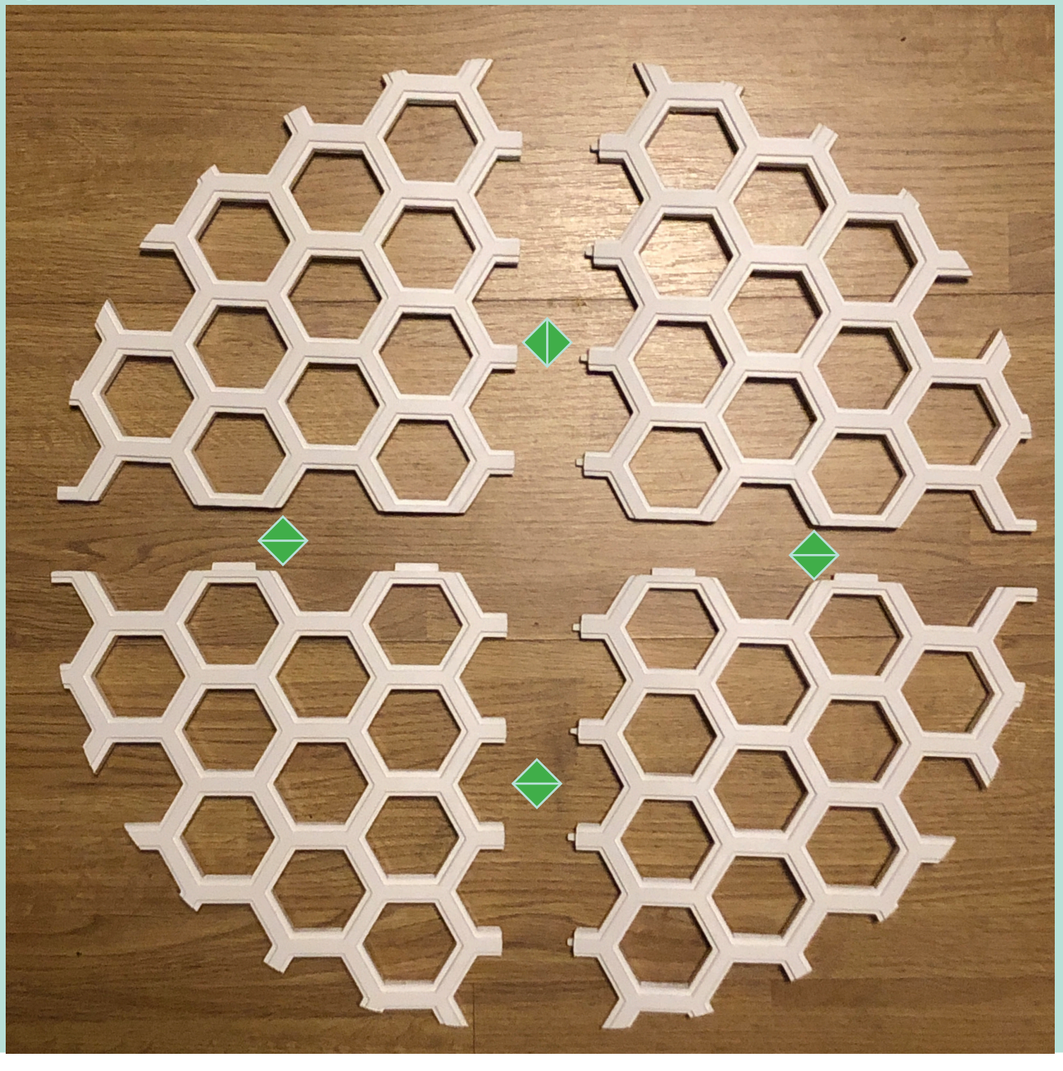
I designed the HiveMind Game to foster creative thinking and teamwork. Players begin with their own ideas and then collaborate with groupmates to develop a final concept for the group. The game encourages players to listen to others' ideas, engage in discussions, and make compromising decisions. There are four steps guiding players, with each step contributing to the development of the assignment. The example below is a robot design assignment for the IDE faculty at TU Delft.

Set-Up

Prepare the Platform

Assemble the platform according to the provided layout.

Figure 38. Assembly instruction



Distribute Components

Provide each participant with 3 tokens for decision-making.

Figure 39. Three tokens

Initial Tiles Placement

Set up the tiles on the platform according to the provided layout. Keep empty tiles piled on the side, ready for use.

Figure 40. Initial tiles placement layout

HiveMind

Gameplay

Step 1: Talk about your idea in the group

Individual: Write down a sentence to describe the robot you want to have/design for the Industrial Design Engineering faculty (TU Delft). Think about the moment (morning, afternoon, evening) you are in the faculty, what problem you have had, and not being solved yet. Can be anything that comes to your mind.

Step 2: Finish three tasks (red, mint, grey)

Individual & Group: Read out loud the question on the colour-tile and finish the task on it. Start from the red, mint and to the grey. Secure the token on the tile to lock your choice, explain why the choice relates to your robot.

- Secure the token on the other's token if you have the same choice as your groupmates.
- You can draw or write your choice on the empty tile from the pile, then secure your token on it.

Figure 41. Step 2

Step 3: Different combination from the token-tiles

Group: Move the tiles together to cluster total 3 combinations

- Move the non-token tiles to the side.
- Discuss in the group to decide which token-tile from each task.

Figure 42. Step 3

Step 4: Ideation

Group: Draw one final concept together with the groupmates based on the combinations.

Chapter 7. Evaluation

This chapter elaborates the objectives and methods used in the evaluation process. The evaluation gives an overview of the user's experience on the HiveMind Game's rule flow and the knowledge of robotics. I conducted user testing through semi-structured interviews and a list of vocabulary served as a tool in these interviews to validate the prototype of the final concept.

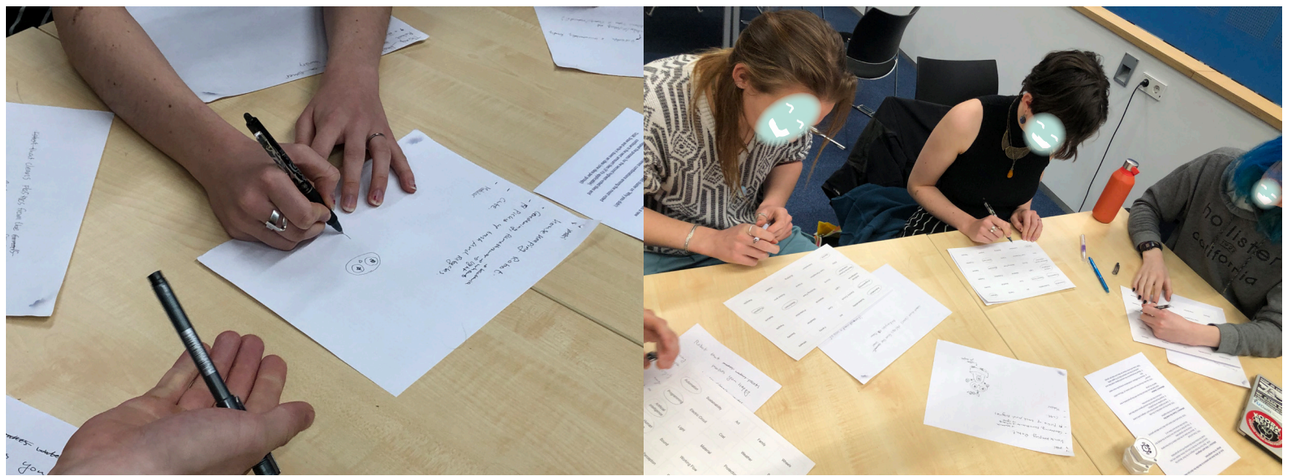
7.1 Purpose and methodology

The objective of the interview is to determine whether participants' perceptions of robots become more diverse after engaging in discussions facilitated by the toolkit. Moreover, to understand the effectiveness of HiveMind in both text and drawing. I conducted an evaluation test with a group of 4 students: one female (age 20, Nano Biology), and three males (age 21, Computer Science; age 19, Industrial Design Engineering; age 23, Aeronautical Engineering). This group was selected randomly from those who sit nearby in the IDE faculty, 3 of them are friends of each other. Evaluation testing consists of two parts. The first part involves participants using the toolkit to complete the robot design assignment. I conducted a semi-structured interview in the second part of the evaluation.

Firstly, I provided the toolkit and the toolkit's game rules to the participants, who then commenced the game without my involvement. After finishing the assignment, participants are asked to individually select vocabulary cards, ensuring that they follow their own thoughts without being influenced by other participants' answers. The participants circled the vocabulary

The goal is to understand how they perceive robots both before and after the group discussion, examining the words that come to mind when discussing “robotics”. Subsequently, to comprehend the impact of the toolkit on them, I asked the following question: Why do you think you have a different answer? Why did you choose these words?

Figure 43 Evaluation user testing



7.2 Results and discussion

The final robot concept drawn by the users was heavily influenced by the pictures offered by the toolkit. This goes against the intention of the design where the user has to come up with their own robot based on their association with robotics.

Figure 44. Evaluation user testing results

From the results of the vocabulary list, all participants add different words after playing the HiveMind Game. In the interview, I asked two main questions: Why do you think you have a different answer? Why did you choose these words? All of the participants indicated that they got inspired by playing the game. Also, they like the interaction with HiveMind, including securing the token and moving the tiles.

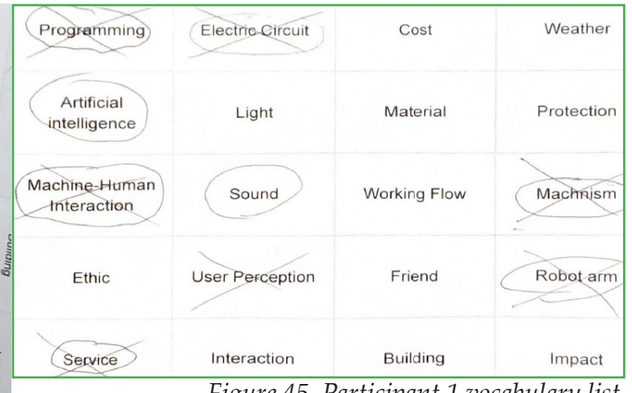


Figure 45. Participant 1 vocabulary list

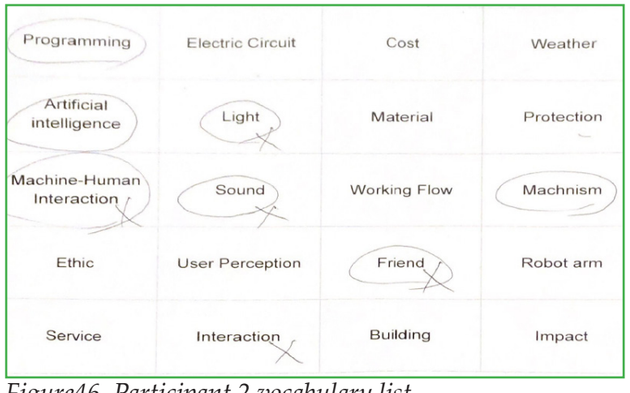


Figure46. Participant 2 vocabulary list

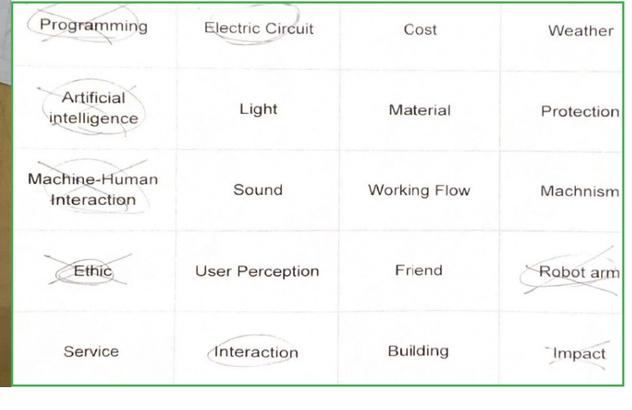


Figure 47. Participant 3 vocabulary list

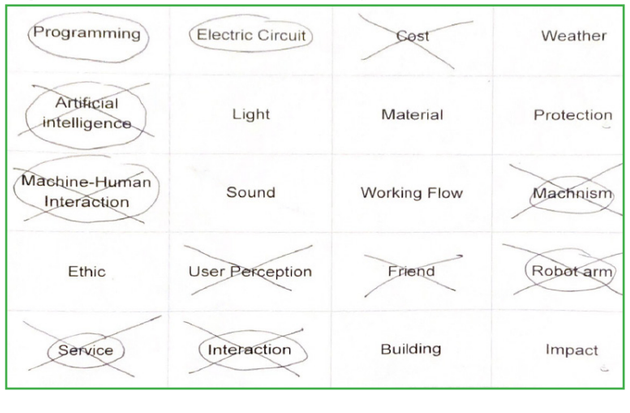


Figure48. Participant 4 vocabulary list

7.3 Conclusion

To conclude, HiveMind is effective with words when users think of robotics but may not be as suitable for drawing.

The results of the interview from the second part of user testing show that participants' understanding and the words they associate with robotics broadened. In the interview, it was evident that the users associated new words with robotics and developed a new perspective on robotics, one that is less stereotypical. The HiveMind Game proves valuable when integrated into group discussions, functioning as an effective icebreaker. Through the HiveMind Game, users find comfort in expressing their opinions. Its success lies in fostering shared understanding among group members. HiveMind is useful to guide the users through the steps and organise their thoughts which will help and spark the group discussion. Additionally, for non-experienced users having examples of robots may help them to develop concepts or spark new creative ideas.

Figure 49. Evaluation user testing

Chapter 8. Conclusion And Recommendation

This chapter provides comprehensive findings of this thesis. Next is the discussion of the HiveMind future work.

8.1 Conclusion

To conclude the problem defined in Chapter 2.5: How can a toolkit make students feel involved and broaden people's image of robotics? The conclusion is as follows:

Each learning stage requires a tailored toolkit to supplement the learning process and provide continuous support. This support is multifaceted, addressing various aspects such as learning new concepts, maintaining student motivation, ensuring consistency, and fostering positive group dynamics.

For students, the toolkit should serve as a catalyst for sparking meaningful discussions. It becomes essential to understand how to trigger and boost these discussions effectively. One aspect to consider is whether gender differences play a role, or if each individual's unique characteristics and experiences influence their engagement. Exploring the impact of past experiences and current peer reactions on the learning process can provide valuable insights into tailoring the toolkit to cater to the diverse needs of learners.

In essence, a toolkit designed should not only facilitate the acquisition of new knowledge but also address motivational aspects, consistency in learning, and the dynamics of group discussions. By understanding the nuances of individual experiences and considering potential gender differences, the toolkit can be refined to be a more effective and supportive resource.

Therefore, continually reshape the perception of robotics, in order to introduce engineering in a way that consistently captures students' interest.

8.2 Design recommendation and future evaluation set up

For the future work, I will explore diverse workshop formats and try out different game rules to elevate the overall experience. My goal is to keep participants actively involved and foster a diverse understanding of engineering. Moreover, the questions made are used for robot design. But the questions can be changed to use for any other subject besides robot design.

Another interesting evaluation could be reverse engineering, where the thinking process is reversed while playing the game. Testing what would happen if they answered the tasks in a different order: would they feel confused or become more interested in the game? Additionally, observing whether the ideas they generate differ in style could provide valuable insights. And evaluate the situations in which the pictures drawn by users can break away from the stereotype of robots.

As part of my future evaluation, I want to design an A/B test during workshops. One group utilising the toolkit and another one without it. This direct comparison will provide insights into the toolkit's impact on learning outcomes and participant engagement, guiding adjustments.

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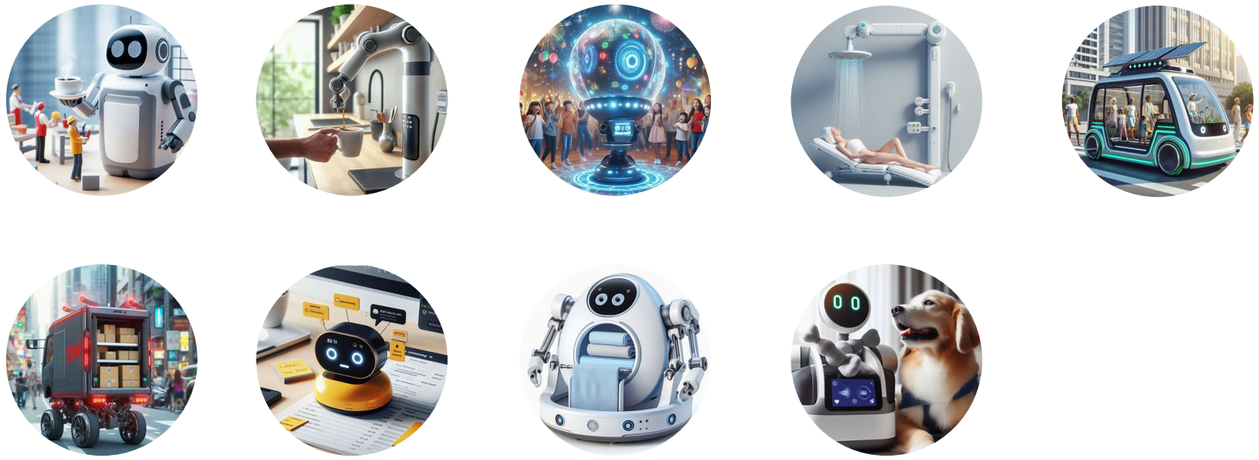
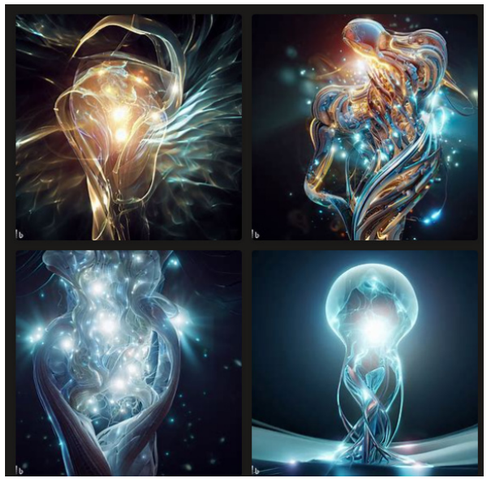
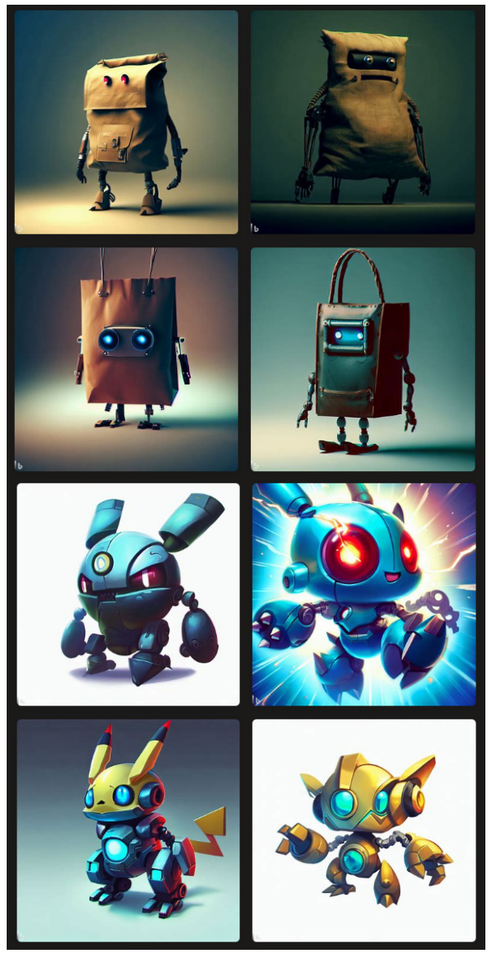
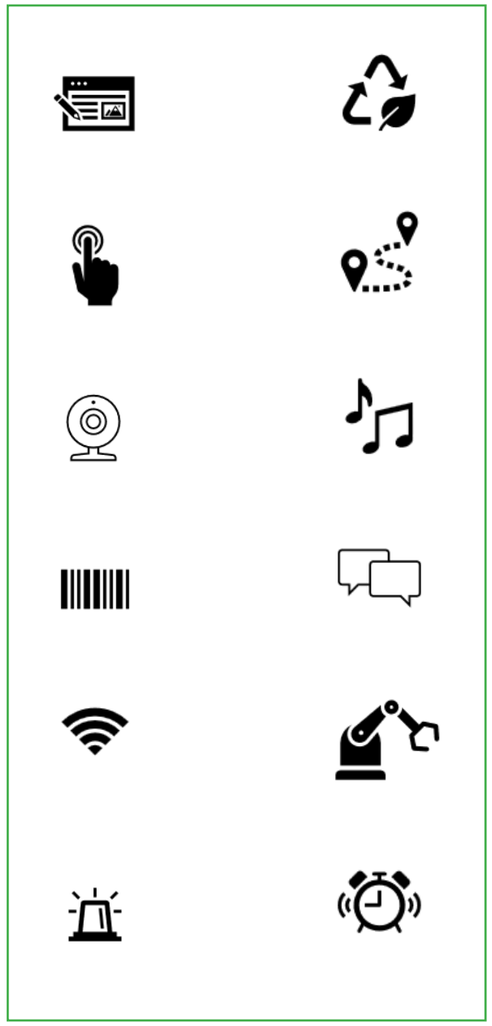
Appendices

Appendix A Pictures for the HiveMind options



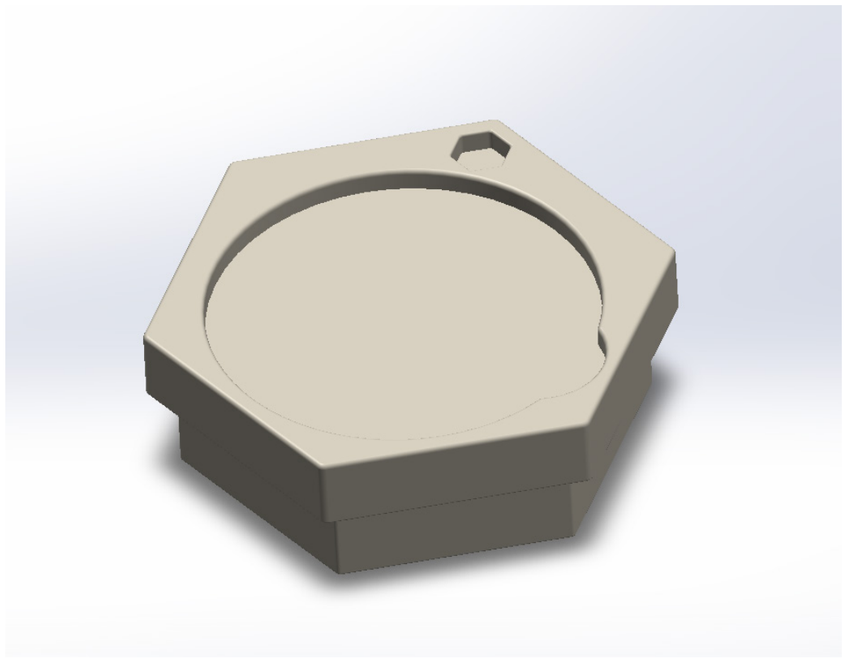


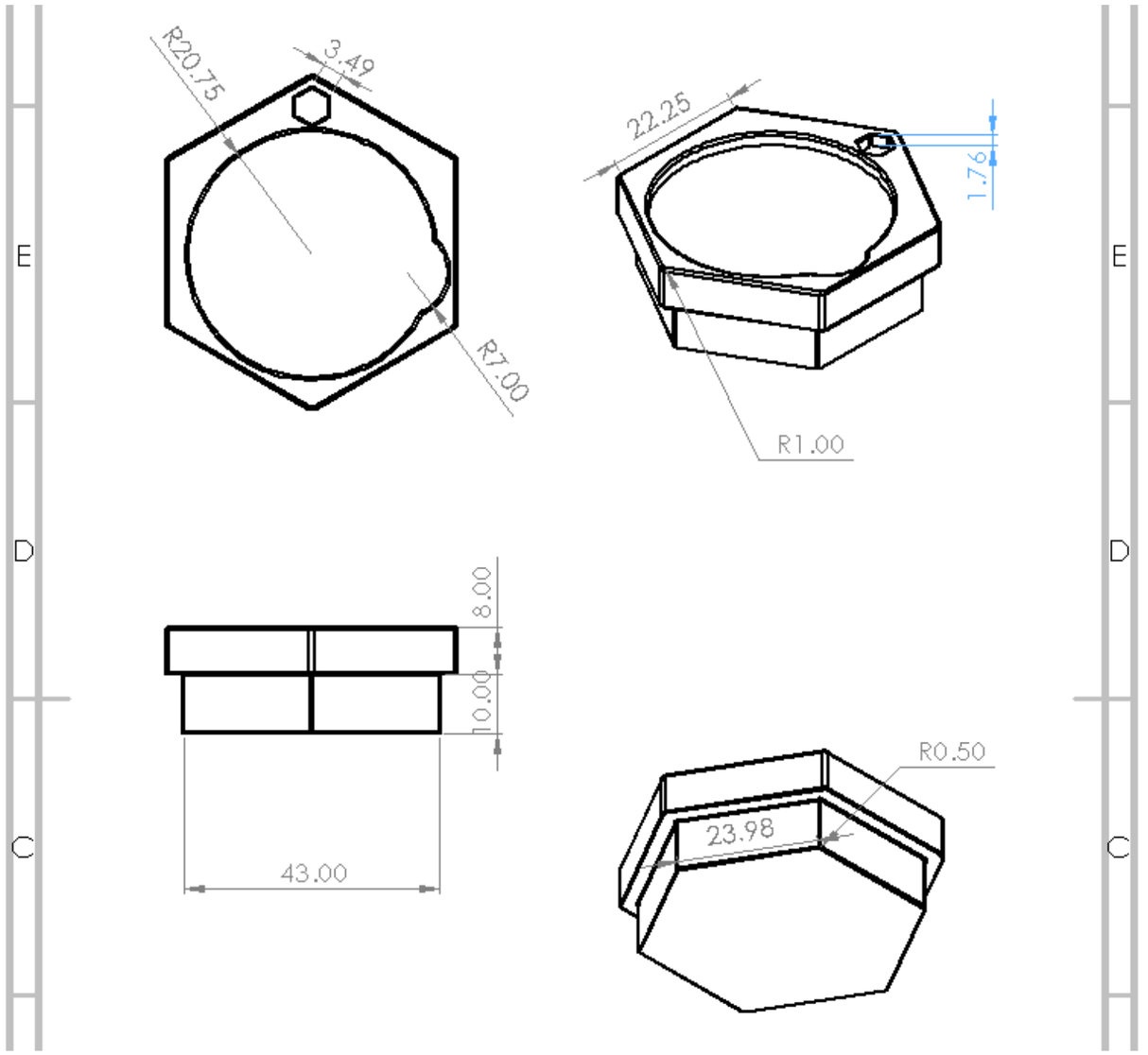




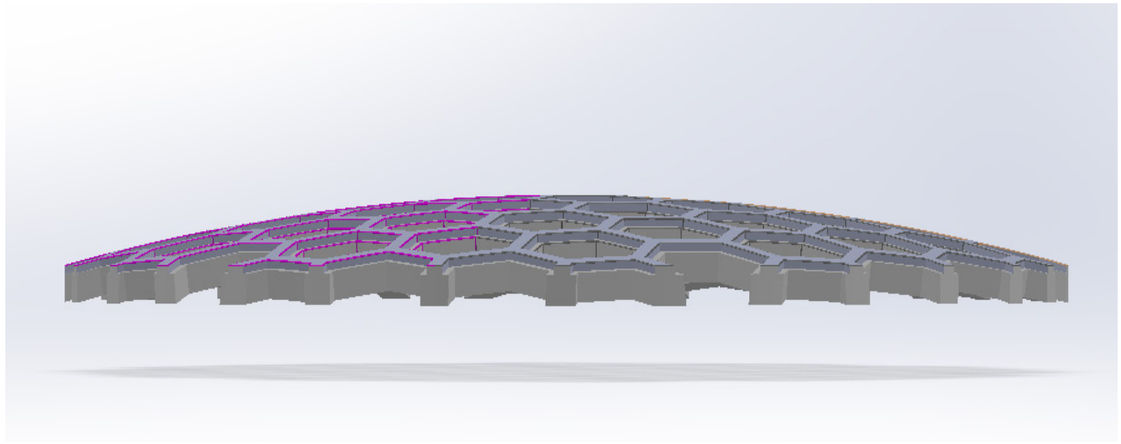
Appendix B 3D CAD model

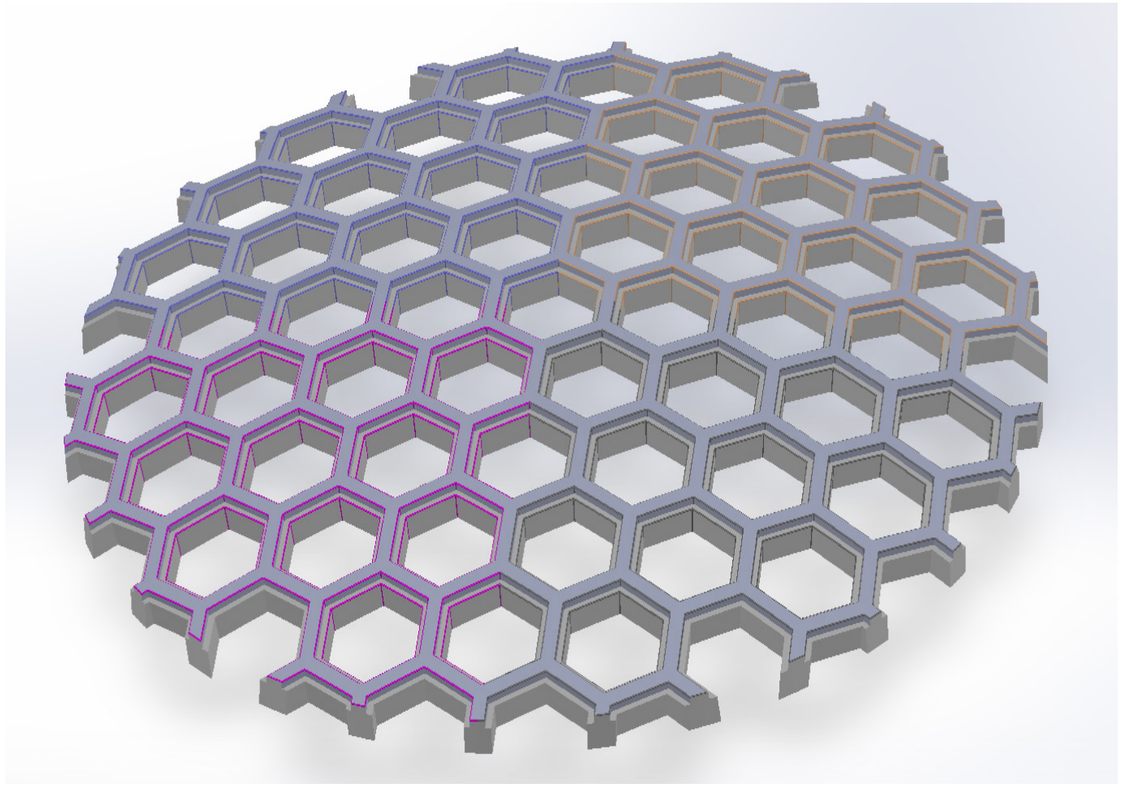
The tile (unit: mm)

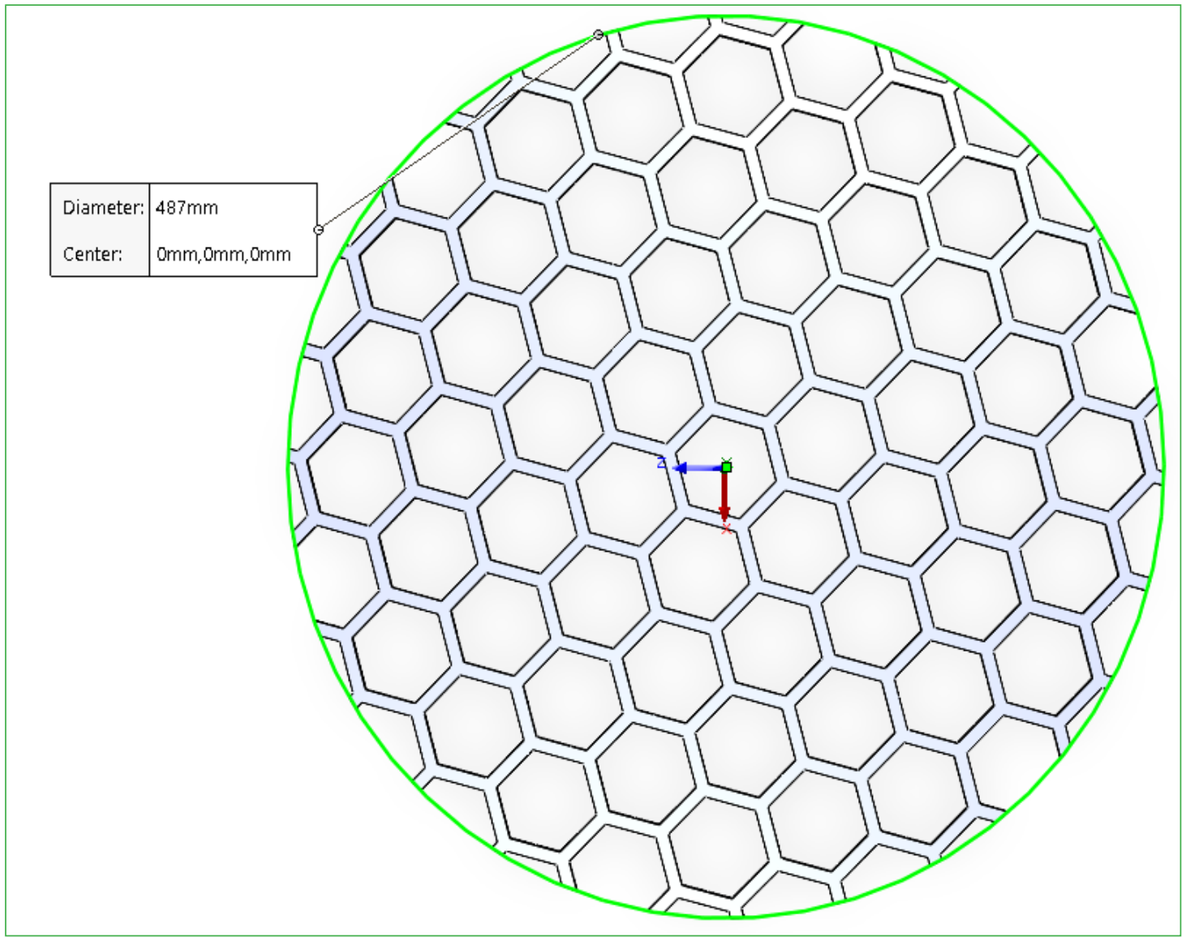




The frame (unit: mm)







Appendix C Project brief

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Liu
initials: F.Y. given name: Fang-Yin
student number: 5485908
street & no.:
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD ○ DfI ○ SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ○ Honours Programme Master
specialisation / annotation: ○ Medisign ○ Tech. in Sustainable Design ○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Tomasz Jaśkiewicz dept. / section: DCC
** mentor: Adrie Kooijman dept. / section: DE Technical Support
2nd mentor:
organisation:
city: country:
comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

chair: Tomasz Jaśkiewicz date: 12 - 07 - 2023 signature:

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 30 EC
Of which, taking the conditional requirements into account, can be part of the exam programme: 30 EC
List of electives obtained before the third semester without approval of the BoE:

★ YES all 1st year master courses passed
○ NO missing 1st year master courses are:

name: date: - - signature:

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ○ APPROVED ○ NOT APPROVED
Procedure: ○ APPROVED ○ NOT APPROVED
comments

name: date: - - signature:

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 07 - 07 - 2023 05 - 12 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

-Context-
Historically, engineering has been a male-dominated field. However, female students demonstrate comparable participation in mathematics and science courses during secondary education (Balakrishnan & Low, 2016). Despite higher global enrollment and graduation as well as great performances in mathematics and science test scores, women are less inclined to choose Science, Technology, Engineering and Mathematics (STEM) majors. Only 7 percent of women globally opt for engineering, manufacturing, or construction, in contrast to 22 percent of men (The Equality Equation: Advancing the Participation of Women and Girls in STEM - the World Bank Group, Page 8, 2021).

Additionally, the male-dominated cultures within STEM fields create environments that are unwelcoming and unsupportive of women. The limited representation of female scientists and engineers acts as a barrier to girls' interest in STEM, as the lack of visible role models hinders their aspirations in the field. In terms of this, STEM fields are frequently perceived as masculine, leading to the underestimation of girls' maths abilities by teachers and parents, starting as early as preschool (AAUW, n.d.). According to multiple researches, there is no inherent cognitive or biological differences between genders in maths problem solving ability ("Think Again: Men and Women Share Cognitive Skills," 2014). Encouraging female students to pursue careers in engineering is crucial for achieving gender diversity and promoting equal opportunities.

Robotics has the ability to engage in real-time interactions with humans, making it a captivating area of study. The dynamic nature of robotics often piques people's curiosity, making it a tool for learning human behaviour from a unique perspective. Utilising robotics can be an effective tool for exploring the relationships between female students and the engineering field. This approach seeks to bridge the gap between technology and everyday life, empowering individuals to explore and interact with robotics in their own contexts.

-Stakeholders-
TU Delft, the students, and Cities of Things Lab 010 are the primary stakeholders in this project. At TU Delft, the proportion of male students (70%) is also much higher than the proportion of female students (30%) (Feiten En Cijfers, n.d.), and female students are mostly distributed in the Industrial Design Engineering and Architecture faculty. Cities of Things Lab 010 aims to make development of robots accessible to all citizens, not just professionals and encourages people to engage in hands-on experiences. The Wijkbot kit from Cities of Things Lab 010 will be involved in this project.

-Opportunities-
The goal of this project is to bridge the gap between female students and the robotics design engineering environment. It aims to create a more inclusive and supportive space for women in engineering, harnessing the unique perspectives and talents that females bring, which may lead to innovation and progress.

space available for images / figures on next page

image / figure 1: Collage of the vision for this project

The Tech Modules

image / figure 2: The Wijkbot toolkit from Cities of Things Lab 010

-Research question-
This project aims to explore the possibilities between female perspective and engineering knowledge, with a focus on university students. Fewer females study engineering. In some cases, they are interested in but afraid they are not able to manage it so passively reach out to it or do not know how to share/express their ideas.

The main research question would be: How to increase the active participation of female students in engineering studies?
-Sub-research question 1-
What does the robotics design and engineering field currently lack attractiveness for female students?
-Sub-research question 2-
What are the potential barriers or challenges that hinder female students' participation in the engineering environment?
-Sub-research question 3-
What are the reasons that make female engineering students choose engineering studies?

While preparing the assignment, I interviewed three engineers and two non-engineers who have experience working with engineers. All of them indicated that images and visuals are effective tools for communication. Therefore, the possible outcome will focus on the transmission of vision, and convert ideas into visuals for communication and exchange of ideas. The Wijkbot of the Cities of Things Lab 010 can be utilised as a technical tool during workshops or interviews to facilitate the exploration and understanding of the culture-sensitive design aspects from a female perspective in the technology field.

ASSIGNMENT **
State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

By incorporating female perspectives, the project aims to create a more inclusive and supportive environment for female students and promote their active involvement in the technology and engineering domains.

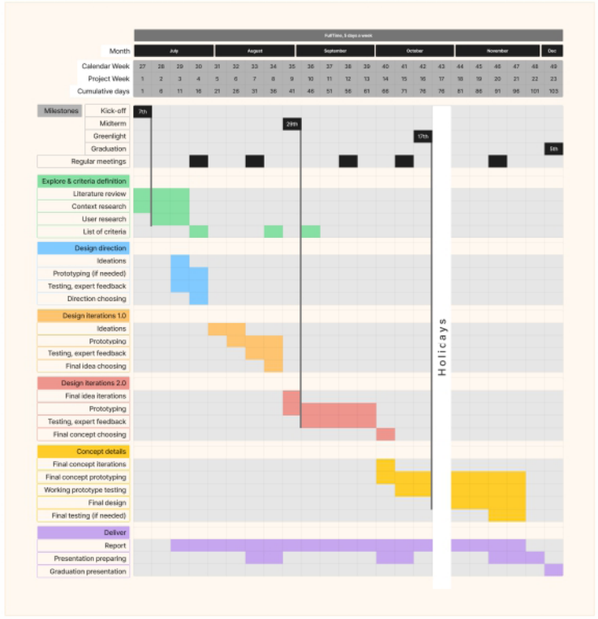
The potential concept is expected to focus on a product with two main features:
--User-friendly: Coding skills and robotic knowledge are not required at a professional level for using this toolkit. And it is necessary to involve the theory roots and design experiments for the users to reach out to the engineering world.
--Knowledge dissemination: Users are able to share their thoughts with a wider audience.

The end result will be a working prototype of the robotics design guiding with a focus on learning and creativity activities. The toolkit will include the elements related to the robotics design, such as programming, assembly, etc. Its main goal will be to serve as a visual expression tool, empowering female students to share their thoughts and ideas using this technical toolkit. By using these elements for the purpose of conveying ideas, they will experience a sense of achievement. This achievement will serve as a catalyst, instilling in them the belief that they too have the ability to contribute to the engineering field. By providing a supportive and inclusive environment, the toolkit will encourage female students to embrace their potential and envision a future as active participants in engineering and related disciplines.

It is important to note that a toolkit is not limited to a single purpose or use but can be applied in various ways depending on the needs and preferences of individuals.

meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 7 - 7 - 2023 5 - 12 - 2023 end date



I am adopting the research through design methodology, which involves utilizing design directions to concentrate on crucial research topics and seek expert feedback to ensure the successful development of the product. The project will go through three iterations: Design Iteration 1.0, Design Iteration 2.0, and Concept Details. Each iteration will progressively narrow down the solution space. Also in each phase, there is a desire to initiate prototyping or visualizing ideas for the purpose of discussion and learning from them. In the feedback session, I tend to host a workshop or individual interview to improve the design. In the first round of each session, female students will participate, and in the subsequent rounds, male participants will be added to test the communication function of the concept. During the Concept details phase, a selected concept will develop further and focus on creating a high-quality working prototype.

I think it is more interesting to approach the solution from an engineering perspective while considering the female perspective. The context research will begin by exploring "What does the engineering field currently lack attractiveness for female students?" rather than concentrating on "What can the female perspective bring into the engineering field?"

I will execute my graduation project on a full-time basis, and have a holiday week in October which is my birthday week! Meeting with the graduation committee will be planned every 2 weeks to present the progress and discuss the important parts of the project at that stage.

of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

I studied Aerospace Engineering for my bachelor's degree, there was a significant disparity in the ratio of males to females in the faculty. In my experience, I have found that in my faculty, both men and women perform equally well. Also, I was teaching kids how to program and I observed exceptional talent and logical ability from both boys and girls. This has made me very curious about why there is such a significant disparity in participation between men and women in adulthood in the engineering field.

My interests are embodiment design and robotics, I enjoy sharing my knowledge with others, and my passion for these subjects motivates me to explore this project. Additionally, I'm really into hands-on projects and rapid prototyping.

I hope that through this project, I can design something that will allow female students to participate more in the engineering field. And in the near future, give a positive impact on the next generation, where more young women feel confident and empowered to enter the engineering field.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.