PROMOTIVATE

Design for social dynamics to promote sustainable behavior in secondary schools

Master thesis
Tao Chen

Design for Interaction
TU Delft
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Preface

Coming to TU Delft to study design was a bold decision I made back then. I was looking for a new experience and am lucky to end up in the Netherlands. Here I met different people from all over the world in this foreign country who love design as much as I do. It was eye-opening to see how big and deep the design is as a discipline within this Industrial Design Engineering faculty. It really fascinates me that so many creative and interesting projects are going on every day and the impactful outcomes are delivered to make a difference for society. There is no doubt that as a member of this prosperous industry, I want to keep going and contribute to a more flourishing one. This graduation project put an end to my study in academia but start a new exciting journey to the future.

For this graduation project, if I can use three words to describe it, they will be 'longest', 'toughest', and 'most devoted'. I have never been spending such a long time, 6 months, fully on one single project before. Since it's required to work on it individually, I had to take charge of every detail in every aspect of the project, where I encountered countless different challenges along the way. Now I survive from it and it has helped me to grow as a designer who can face challenges and seek opportunities alone. I hope you, my dear reader, will go through this journey with me in the report and take something out if it's just a small idea, a piece of thought.

When I started my project six months ago, the society was still under the influence of COVID-19 and the restriction it brought with it turned this project even more difficult. At this point, I want to take the opportunity and thank everyone who helped me through this graduation project:

To my supervisors Stella and Marina, I want to thank you for your mentorship through the project, continuously inspiring me from a fresh perspective, and giving me the room to grow. This project would certainly be a different one without you.

To Lina, Natalia, and the ENERGE team, thank you for allowing me to collaborate with such a sweet team and sharing insightful knowledge and thoughts with me through this project.

To my family, especially my mother, thank you for always being there for me. I cannot be more grateful to you for your selfless support. And I could not have done my study here in a foreign country far away from home.

To the members of ID StudioLab, with special regards to Aadjan and Ianus, thank you for providing me with a space to work and helping me to find participants.

To the secondary school students and many other people who supported me throughout the project and participated in the design sessions and the prototype tests: Thank you for being there. I could not generate a better design without your experience and knowledge.

To my friends who accompanied me along with my study, thank you for taking the journey together with me. It was a wonderful study experience that we share our memories with. I hope you enjoyed it as much as I did.

Tao Chen

22.03.2022, Delft

Executive summary

ENERGE is a research project working on managing energy consumption at the school level for sustainability. It is looking for solutions that extend data interactions to the field of behavioral change while taking both energy use and people's comfort into account.

This graduation project explores how to communicate information related to indoor climate and energy to motivate secondary school students to save energy through social dynamics at school. The final design of this project is a digital application that promotes sustainable behavior among students.

In the exploration phase of the project, extensive user research including co-design sessions with users and literature review into the topic of social dynamics between students and their attitudes towards sustainability helped to understand users comprehensively. It revealed most students don't have the motivation to contribute to energy conservation for the school. Yet, there is intensive social interaction within student cliques which is a potential means to motivate students to engage with sustainability. Further research through context study of the technical infrastructure and literature review into indoor climate science and its relationship with users narrowed down the solution space for the next defining phase. Based on the exploration, the design goal was defined and followed by the iteration phase. A series of design prototypes, based on the information communication method, was created and tested with the participants to inform the final design.

The final concept PROMOTIVATE is an interactive application that motivates secondary school students to act on sustainable actions in the school context. It features group-based competitions, sustainable actions, and information related to indoor climate and energy. The application enables students to take action and contribute to sustainability at school through teamwork in a competitive manner.

A clickable application was evaluated with participants using qualitative methods of observation and interviews, and quantitative methods of survey. It is experienced as motivating and encouraging for participants with an easy-to-use interaction. Participants were motivated and encouraged by diverse features of the final concept. The practical information provided in the application related to detailed descriptions of the energy-saving actions was clear for participants. They also motivated each other in the group.

The design research and practice conducted in this project prove that social dynamics can play a big role in engaging users with the topic of energy conservation. Furthermore, it showed that the information on indoor climate and energy can be used to evoke motivation and confidence, which offers interesting directions for future work. To be more specific, the research suggests the potential for further development of the functioning system that links to the energy use data and the indoor climate data in ENERGE data dashboard to make sustainable actions more down-to-earth.

Glossary

Co-creation (or Co-design)

A design methodology that generates ideas and concepts by collaborating with stakeholders, which usually can generate unexpected insights for solutions.

Design goal

A design goal describes the aim for a design work with no limitation of the solution space.

Energy use data

The energy use sensors detect electricity.

Greenhouse gas emissions (GHG)

CO2 emissions from human activities that causes climate change.

Indoor climate data

The indoor climate sensors detect CO2 concentration, temperature, humidity, sound, light.

Message tailoring and framing

A communication theory that explains how to communicate proenvironmental behavior messages.

Research through Design (RtD)

A design methodology that creates design concepts and prototypes which embody research questions, and which then are tested out as interventions.

Self-Determination Theory

A psychological theory that describes human's fundamental needs - Autonomy, Relatedness and competence.

The Grounded Theory

A theory that collects and analyzes qualitative data to construct theories based on data. There are two processes of defining data i.e. initial coding and focused coding.

User Experience Questionnaire (UEQ)

A commonly used questionnaire to measure the user experience and the usability of interactive products.

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1 Introduction

In this introduction, I will give a general overview of the project and its context. This includes a description of the project ENERGE, and the scope of this project. Moreover, the chosen design approaches and their corresponding plan through the design process will give an overview structure of the project.

1.1 ENERGE

The ENERGE research project is a multidisciplinary effort collaborating with secondary schools in the northwest European region that aims to develop efficient and effective energy-saving strategies, under the circumstances of the aging existing school buildings and time-consuming modification or construction of new schools. More importantly, the EU aims to be climate-neutral by 2050 – an economy with net-zero greenhouse gas emissions (2050 Long-Term Strategy, n.d.). The Netherlands, for instance, has to reduce greenhouse gas emission (GHG) by 36% by 2030 in relation to their 2005 levels (EUR-Lex - 32018R0842 - EN - EUR-Lex, 2018). EU building energy directives and climate actions to 2020 – 2030 underpin this necessity as well (National Energy and Climate Plans for 2021–2030 under the EU Energy Union, 2020). ENERGE addresses this need using targeted physical interventions that combine a data-enabled platform and building sensors (e.g. electrical, thermal, etc.) with behavioral and social studies as well as new educational approaches that enable schools to engage in energy and GHG mitigation.

ENERGE will be demonstrated in twelve schools (Fig. 1) in France, Germany, Luxembourg, Ireland, the Netherlands and the UK. It will engage and enable management, teachers, students and maintenance staff (entire school ecosystem) to reduce energy consumption by developing a new web-based platform tailored to different stakeholders within the school ecosystem. Teaching modules were developed into several units and activities to introduce students to the topic of personal energy consumption in the home and in the classroom and give a real-world context to ideas about energy conservation and be aware of energy efficient solutions for the home.

The development of the ENERGE platform (Fig. 2) is done by means of co-design sessions with teachers and students and the development of tools to help the team explore relevant data interaction scenarios. The team got insights regarding their interactions with energy, their comfort and everyday experiences from earlier user research studies. It's found that the social dynamics and dilemmas appear and play an important role in the relationship between students themselves and with teachers or other school members and their attitudes and actions towards the environment.

The next step for ENERGE is to extend the data interactions to the field of behavioral change. To improve students' sustainable behavior, What does it take for them to take ownership and responsibility to manage the energy of the school building and their personal comfort?

Fig. 1* - Gymnasium Haganum, one of the TUDelft ENERGE NL school partners

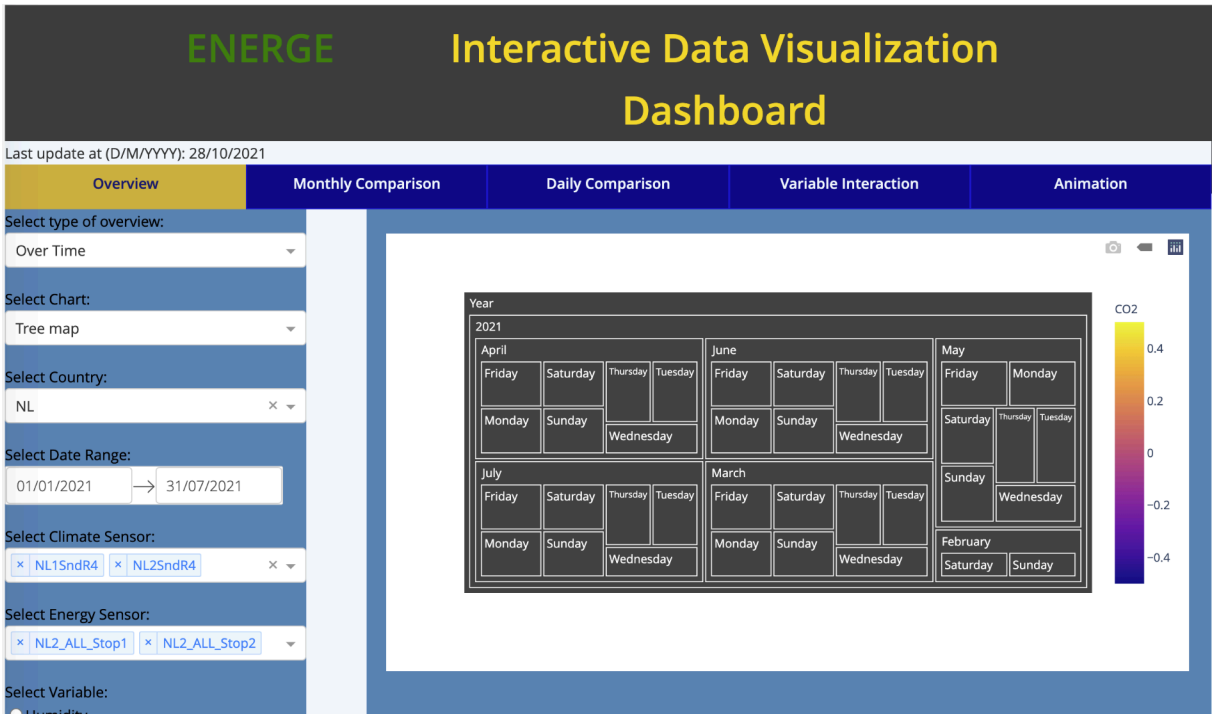


Fig. 2* - The platform that shows indoor climate data collected in the schools

*Fig. 1: https://studiolab.ide.tudelft.nl/studiolab/eu-energe/energe-committee/
*Fig. 2: https://energe.io.tudelft.nl

1.2 Project brief

The aim of the project is to conserve energy at the school level. The solution will take both energy use and people's comfort into account.

This graduation project, as a part of ENERGE research project, will take advantage of the activities done in the prior research, namely co-design sessions with stakeholders, and investigate the social dynamics in school and indoor climate as well as information communication. As students were involved most in the prior stage with richest empirical data, I chose they to be the target group of the project whom will be dug deeper. The social and technical infrastructure in the current secondary school ecosystem will be considered and investigated to provide a context and design for usage scenarios that could increase the positive impact of the intervention on behavior. The role of data will be researched in addressing social interaction regarding sustainability and personal comfort in students.

> **How to communicate indoor climate data and energy use data with students in a way that is meaningful and takes into account social dynamics in the management of energy use and comfort at secondary schools?**

The indoor climate data here means CO2 and possible other variables considered in ENERGE, such as temperature, humidity, sound and energy use including electricity and gas.

The main focus of this project is on indoor climate and energy consumption related information visualization and interaction with students that has a meaningful impact on behavior on sustainability in secondary schools. The outcome will be an interface that communicates this information with students in the secondary schools, and helps them to manage their energy use and comfort, which in the end can be used as inspiration and reference for ENERGE.

1.3 Approach

Co-creation and Research through Design approaches will guide the project, and help me generate new design ideas and evaluate interventions as well.

Research through Design is creating design concepts and prototypes that embody particular research questions, and which then are tested out as interventions in real-world settings (Rozendaal, 2021). It can help designers reflect on their design activities (evaluative role) and explore new design spaces (generative role) (Lim et al., 2008; Wensveen & Matthews, 2014), which will be used in the iteration phase to develop proper interventions. The project touches upon Human-Computer Interaction (HCI). In Zimmerman's model for interaction design research in HCI (Fig.3), interaction design projects integrate three kinds of knowledge - the True knowledge of models and theories from behavior science, same as the Theory part in the plan; the How knowledge of technology, same as the Technology part; and the Real knowledge of people from anthropology, same as the Practice part, for designers to make the Right thing (Forlizzi et al., 2008). Due to the impact of Corona virus, it's relatively hard to gain enough knowledge about the problem and enough ability to generate solutions. Co-creation is a good remedy for it. And together with stakeholders, we can generate unexpected insights and ideas for solutions (Zijlstra, 2020).

The project consists of 4 phases: Exploration, Definition, Iteration and Finalization. The project approach is reflected in the overview of the project process (Fig. 4).

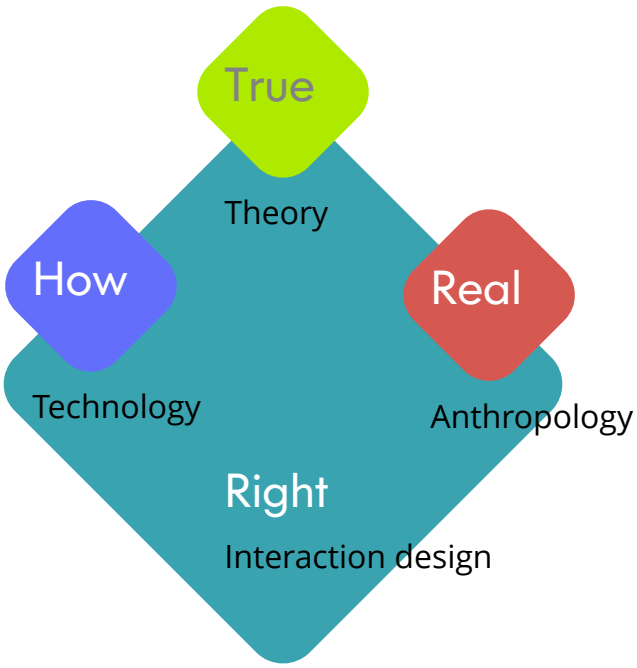


Fig.3 - A model of interaction design research in HCI

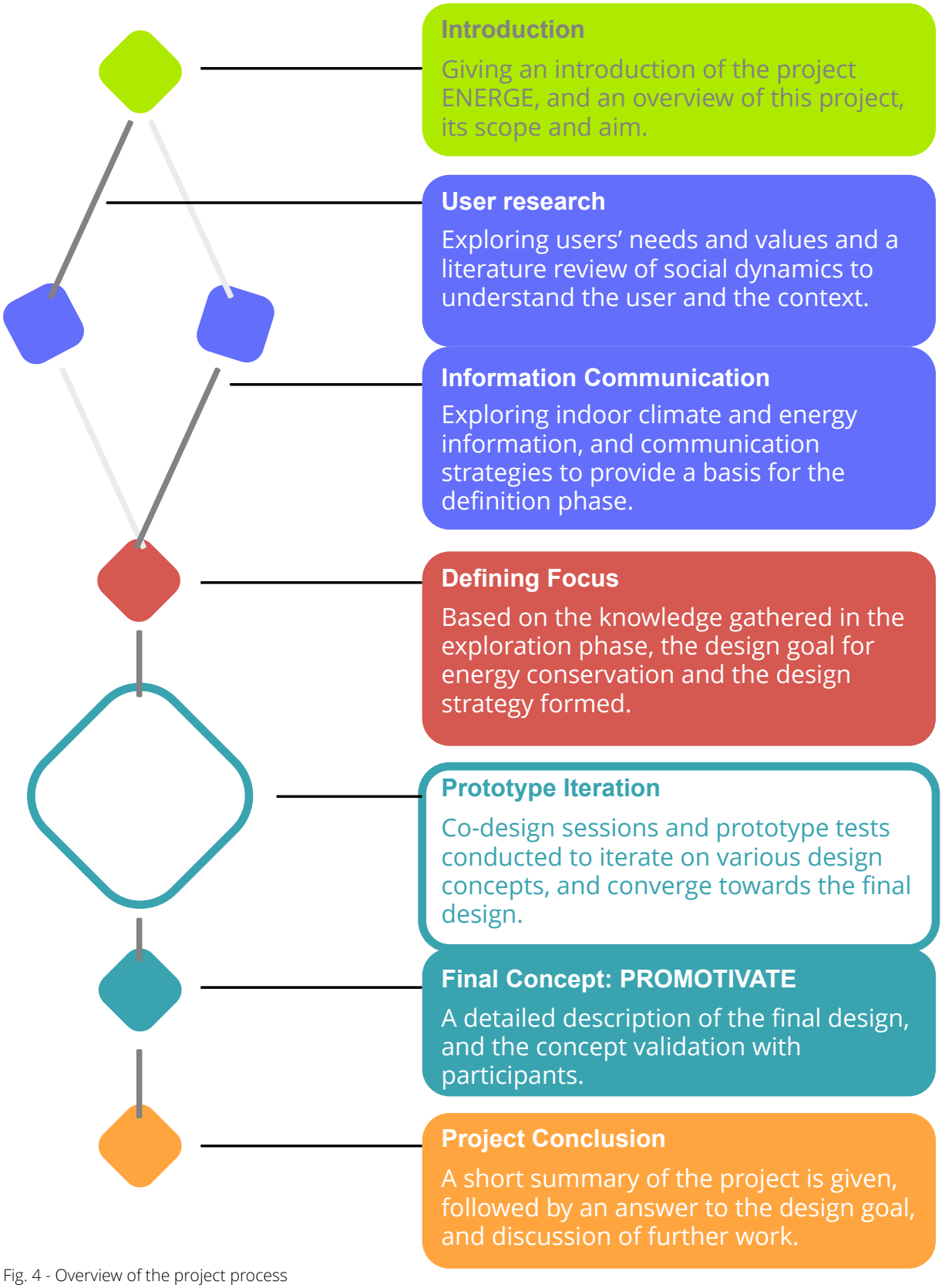


Fig. 4 - Overview of the project process

2 User Research

This chapter contains two parts of user research, the empirical and the theoretical respectively.

In the first four sections of empirical user research, I analyzed prior studies done by the ENERGE team including two co-design sessions and a workshop using the Grounded Theory. One more co-creative session with users was conducted to get empirical knowledge myself. The goal of these activities is to get a comprehensive understanding from users about their needs and values in terms of indoor climate and energy use in secondary schools.

The next two sections of theoretical user research explain the investigation of students' social dynamics including the social interaction between students and students' attitude and motivation towards sustainability.

Methods: the Grounded Theory, Co-creative session, Literature review

2.1 Prior study

The prior studies include two co-design sessions with a handful of stakeholders and a workshop with a large number of stakeholders.

The materials of two co-design sessions were provided including two transcripts and raw canvas made by stakeholders. The sessions were held online with students and teachers from secondary school partners in the Netherlands, from which I could identify key aspects that students manage energy use and comfort. Thanks to the materials, I could understand the context faster and save time on doing the user research. After gaining the knowledge from the prior study, I can go deep into the research.

Besides, I gathered live user data on the online workshop, where I was able to meet many stakeholders, i.e. students and teachers there. Students were asked to answer questions to communicate their thoughts on interacting with interventions. Given a large number of participants, reliable insights were generated that are helpful for my project.

The materials of two co-design sessions were analyzed together with the data gathered from the workshop using a qualitative data analysis method called the Grounded Theory. The Theory is introduced in Section 2.3 and the insights are presented in Section 2.4.

2.2 Co-creative session with users

To have empirical study myself and get a more comprehensive understanding from users, a co-creative session with users was conducted to understand more about their knowledge and experiences in secondary schools.

Four first-year bachelor students from IDE faculty, TU Delft (Fig. 5) participated in an online one-hour session using an online collaborative platform Miro. They still have the knowledge and mindset of secondary school students as they just left there.

Fig. 5 - In the co-creative session with four 1st year bachelor students

2.3 The Grounded Theory

Grounded Theory was used to analyze the qualitative data from the prior study. Grounded theory methods consist of systematic, yet flexible guidelines for collecting and analyzing qualitative data to construct theories ‘grounded’ in the data themselves (Charmaz, 2006).

The process of defining what the data is about is called Coding as Charmaz wrote (2006), which includes two steps, initial coding and focused coding. The initial coding is about the main concerns and values of the participants generated inductively. Focused coding represents any significant or recurring codes identified so that a theory could be constructed.

In practice, I used a computer-assisted qualitative data analysis tool called Obsidian to log all the original data and from there merge them into initial codes then focused codes. The graph view in Obsidian (Fig. 6) shows the connections between data and codes.

Fig. 6 - The graph view shows connections between original data (grey), initial codes (red) and focused codes (green)

2.4 Insights

In total, there are 53 original data logged, which produced 12 initial codes and 5 focused codes. Here only relevant codes are presented. For the rest of the insights, refer to Appendix 2.

A limitation was recognized that the input from the two co-design sessions are perspectives only from the students of the ENERGE community in their schools where motivated ones are. so it's biased as they don't represent the whole group of students.

In the co-creative session I organized, the result shows another view of stakeholders from the perspective of students, which isn't as negative as it was perceived in the two prior co-design sessions. So the impression and image of other stakeholders became more concrete and neutral.

Focused code 1: Motivated students' willingness to take more responsibility

Students who care about energy use and are willing to take more responsibilities can play a role in energy use management in the school but should collaborate with other stakeholders in a proper way.

The student council is a good example of students who have the motivation to serve schools and students but their efforts aren't fulfilled as they can't make an agreement with the school director.

> **Initial code 1: Students who care about should have more responsibilities and power**
>
> Generally speaking, it's neither appropriate for students to take control of the energy use as they wouldn't take things seriously, nor efficient if everyone in the class has a say about managing energy. But there are students caring about it who're willing to take more responsibilities and able to take action to contribute to energy conservation as well as the wellbeing of students.

‘I don't think students should really take control as they were just, well. Wouldn't take things like this serious.’

‘I would like more responsibility, but not too much.’

‘A student that manages the energy per class. So that would remind the teacher to turn off the lights, that would remind the teacher to turn off the heating in this case.’

Initial code 2: Student council has motivation but no power

The student council has the motivation to make the school more sustainable and should make students feel involved, committed, organized and sincere. but they can only advise the school and cannot make decisions. Besides, they have more power than average students.

‘Student body council has a lot of motivation. They want to make the school better. But I think they’re.. I believe they're only like the advisory council so they cannot really make any decisions.’

‘Council they can give you the feeling that you're actually contributing to some to this to making the school better.’

Focused code 2: Students' needs for comfortable temperature and fresh air

Students need comfortable temperature and fresh air most in the classroom.

They suffer from both high temperature and low temperature in summer and winter. And they have to find their own ways to cope with it. They also suffer from stuffy and smelly smells that can distract students due to poor ventilation.

Stakeholders who are close to students like teachers or teaching assistants usually open or close doors, windows or ask students to bring more clothes or wear clothes to deal with cold weather.

Initial code 1: Need for a better air quality in classroom to feel fresh

Students want to be in a classroom where the air is fresh like outdoor. Due to poor ventilation in the classroom, stuffy and smelly smells appear and distract students in class. There are empty classrooms available that can be used for class to have better air quality, as right now only a number of rooms are used the whole time. A few plants are available in some classrooms, yet they aren't helpful. In summer, students have more breaks and spend more time outside classrooms, like in the hallway and outdoors.

'The forest could be fresh, but like it's just like when you step outside.'

'I also tend to have like plants then like flowers, because stuffiness usually means like those are kind of smells bad and that's also quite distracting.'

'There are so many classrooms in our school and many of them are very empty, most of the time, so maybe that those classrooms can be used instead.'

Initial code 2: Student's ways to find comfort

In summer, students drink water and find shades to cope with the heat. In winter, they wear coats in the classroom.

Students change positions in a classroom to find comfort. Those who are sensitive to coldness can sit near the heating. Those who want a quieter environment sit opposite to windows.

‘Drink a lot of water and in the breaks, we'll just like try to find the shade and cool down.’

‘Before the pandemic, I have always I was always cold and OK put on our jackets on, so I was just freezing in the class.’

‘Because the heaters are at one side of the room. “the cold students”, they can sit at a heating time.’

Focused code 3: Sustainable will but unsustainable consequence

Students have the ideas to save energy and use it efficiently that they can learn from ENERGE teaching modules. But what happens in reality is that energy is wasted while others are ineffective. On the one hand, the heating is at a high level that causes the too hot temperature in the room in winter. On the other hand, it's hard to get rid of the heat and stuffiness in summer by opening windows.

> **Initial code 1: Some solutions for comfort are wasting energy while others are ineffective**
>
> It's an energy waste in winter when the heating is at a high level that results in too high temperature in the room. Then people have to open windows to cool down but it's not useful since windows can only be open small at one side of the room.
>
> it's hard to get rid of the heat and stuffiness in summer. Opening the windows doesn't really help as it's said above that it can only be open very small at one side of the room.

'Some teachers find it too hot when the heating's are turned up in the cold times, winter. teachers would just tell students to open the window even while the heating is at its highest level.'

'Every radiator has their own knob you just turn it up and you hope that, you know, you get the right temperature on the right.'

'It's like usually only one windows open or like it's opening is very small and usually it's not really enough to get rid of the stuffiness.'

Focused code 4: Scenarios that students want to interact with interventions

There are three scenarios where students want to interact with the interventions, which are in classrooms during class (Fig. 7), in the canteen at lunchtime and in the hallway between classes (Fig. 8). And Students want to interact with it in a group.

Fig. 7* - A scenario in class

Fig. 8* - A scenario in breaks

*Fig. 7: https://www.welkomophetstreek.nl/college/open-lessen-college/
*Fig. 8: https://www.liag.nl/en/projects/het-streek

2.5 Social interaction between students

Kohnstamm distinguished particular informal peer groups called ‘cliques’ that represent small groups hardly ever exceeding seven people in a class based on social background, the extent of sexual maturity and attitude towards school (1997). The members of cliques have intensive social interactions and several cliques constitute a class with the rest few adolescents.

Adolescents care about their roles and positions in the cliques and classes (Postma & Stappers, 2006). They also have different motivations towards sustainable energy use in formal groups like the student council. The design should call on this type of social interaction in the schools.

2.6 Students' attitude and motivation towards sustainability

The sustainability consciousness of students dips from entering adolescence till the age of 18-19 (Olsson & Gericke, 2015). As it shows in Fig.9, in all three sustainable development dimensions including environmental, economic and social knowingness and behavior, the ninth graders have significantly lower sustainability consciousness than those of sixth and twelfth graders. Uitto and Saloranta also found that adolescents have little interest in environmentally friendly action in their schools (2010). Although the studies were conducted in Sweden and Finland, not in the Netherlands, they have values of reference in my opinion since they are close to the Netherlands geographically and culturally.

In addition, education for sustainable development (ESD) certification leads to a more obvious adolescent dip in the sustainability consciousness among students compared to schools without this certification. The overall dip in sustainability consciousness of the adolescent age group is likely due to the normative teaching tradition and a lack of understanding of the needs of different age groups (Olsson & Gericke, 2015). Within the big ENERGE project, teaching modules about energy literacy are provided to partner secondary schools. I expected it has a positive impact on students' attitudes towards sustainability consciousness since the human-centered design is implemented.

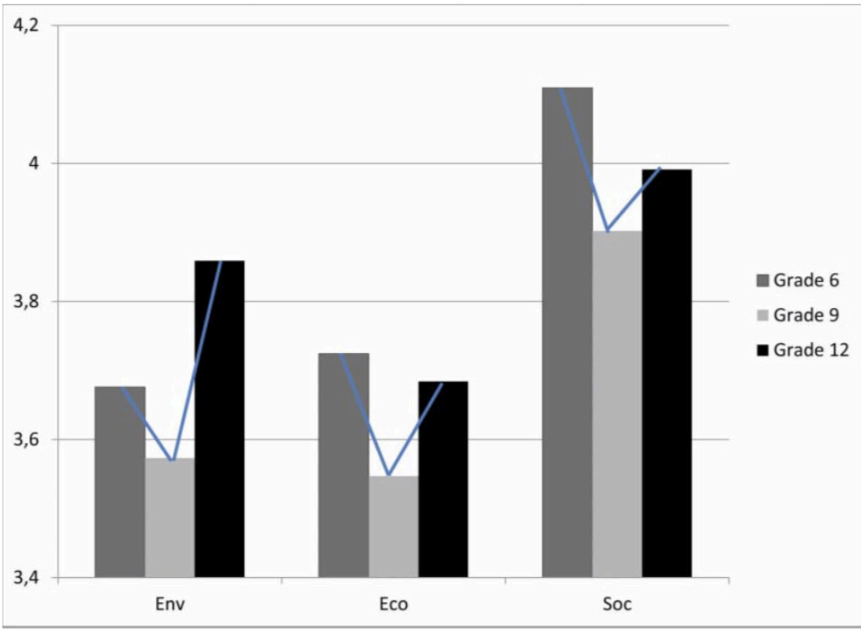


Fig. 9 - Mean values of sustainability consciousness, showing that the ninth graders' mean values are significantly lower, in all three sustainable development dimensions (environmental, economic and social knowingness and behavior), than those of sixth and twelfth graders

According to the Self-Determination Theory, a kind of motivation - autonomous motivation is defined that applies to everyone when people experience volition or self-endorsement of actions (Deci and Ryan, 2008). People also have intrinsic aspirations, namely affiliation, generativity, personal development, that associate with greater health, well-being and performance (Kasser & Ryan, 1996; Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004). So the situation of relatively low interest in sustainability among major adolescence is not unchangeable. There is a great possibility that their sustainability consciousness will be raised to the extent of motivated students under proper pedagogy and a better understanding of students' needs. Another evidence from neuroscience gives an exciting fact that adolescence has greater flexibility in adjusting intrinsic motivations and goal priorities (Crone & Dahl, 2012).

2.7 Chapter conclusion

In this chapter, we explored the world of secondary school students through different ways and methods, both from an empirical as well as a theoretical perspective. We empathized with the students about the context they are in, the needs and values of them regarding comfort and sustainability, and social interactions within students and between students and other stakeholders.

From the user research, it's found that on the one hand, most students have adequate consciousness and knowledge of sustainability but need to be motivated and encouraged to act on it. On the other hand, a number of motivated students couldn't act on it successfully when working with other stakeholders.

Besides, one more issue is that energy waste happens when seeking comfort, and unfortunately it leads to discomfort, which becomes a lose-lose situation. However, it is mainly due to the present infrastructure of the particular school.

It seems to be an impactful opportunity to design for the social interaction in students and think about how to trigger the chemical reaction between students of different motivations to conserve energy. And to save energy proactively, the scenarios of breaks and lunchtime are better to implement interventions.

3 Information Communication

This chapter explores two parts, information and communication.

In the first part of four sections, a factual system will be introduced which explains the interrelationship between the information of indoor climate variables, factors influencing indoor climate, and its effect to give a context of social and technical infrastructure in the school ecosystem.

The second part of the three sections explains what information of indoor climate and energy can be communicated. Then it is followed by how to communicate this information to promote sustainable behaviors. And some strategies for designing visualizations are provided.

Methods: Co-design with users, Context study, Literature review

3.1 Sensor distribution

There are climate sensors and electricity use sensors installed in the two collaborating secondary schools within ENERGE project. The climate sensor detects CO2, Temperature, Humidity, Light and Movement in several rooms, which can be seen in Fig.10. The electricity use sensors detect electricity of lights or outlets in KWh. They also detect in different scales from a whole building to a whole floor to rooms, which can be seen in Fig.11.

This information can be used when I need specific climate or energy data to design prototypes. Unfortunately, the energy consumed by heating isn't detected. The electricity consumed by devices or equipment other than lights and outlets such as mechanical ventilation seems not being detected as well.

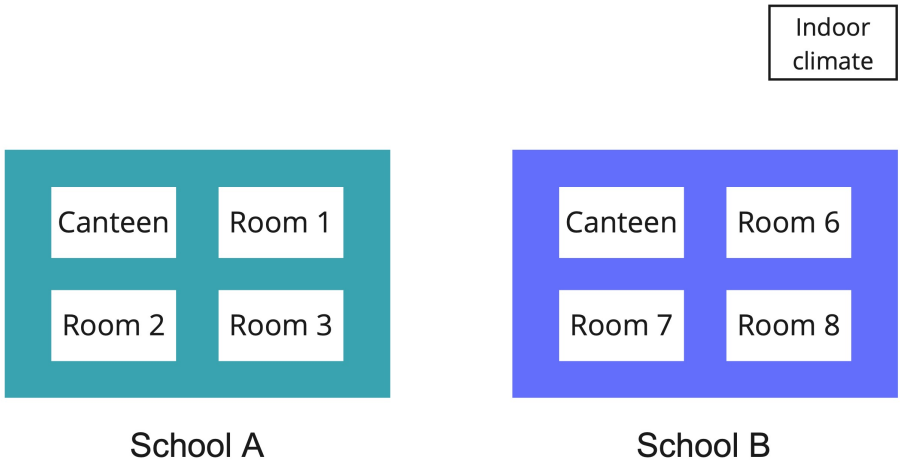


Fig. 10 - The location of climate sensors in targeted schools

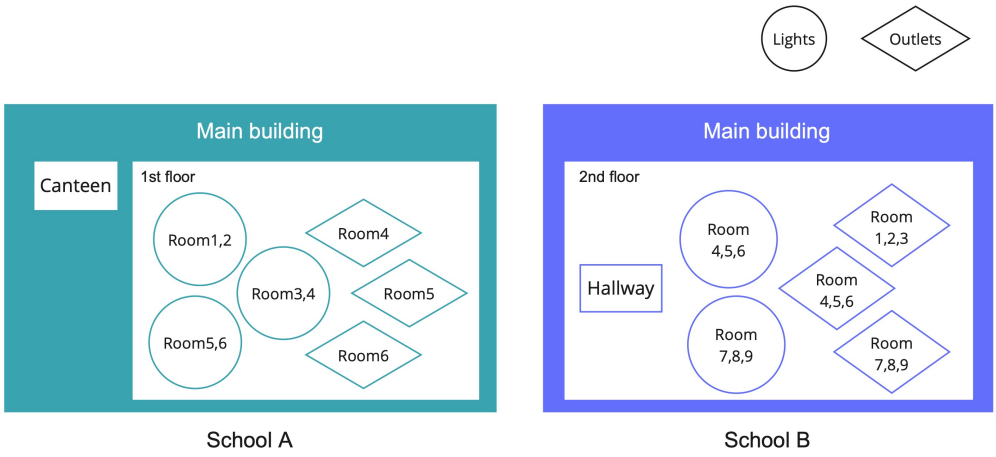


Fig. 11 - The location of electricity sensors in targeted schools

3.2 Relevant indoor climate variables for users

Among all the indoor climate data detected by sensors installed in the school, e.g. CO2, temperature, light, sound and humidity, CO2 and temperature appear to be important indoor environment quality (IEQ) variables, related to student health and/or academic performance (Haverinen-Shaughnessy et al., 2015). So heating, ventilation, and air conditioning comprise the fundamental operational strategies for adjusting the school environment. It coincides with an insight from the user research in Section 2.4.

On the Interactive Data Visualization dashboard* developed by ENERGE team, CO2 concentration and temperature are also displayed. According to the Dutch regulation of 'Fresh School 2021' (RVO, 2021), CO2 concentration below 800 ppm is very good. In practice, CO2 alarms in classrooms are used in some EU countries to give a warning when CO2 reaches inappropriate levels in a classroom (Kephalopoulos et al., 2014). If its level is too high, it will have a negative effect on health and learning performance like symptoms of headaches, dizziness, difficulties concentrating, unpleasant odor (Myhrvold et al., 1996). The cause varies from occupancy of the classroom, activity level of the attendees to airflow meaning the effectiveness of the ventilation system and opening windows and doors (Golshan et al., 2018). A good advice for ventilation practice could be to ventilate classrooms before the school day starts then again for the duration for each break, in all seasons (Kephalopoulos et al., 2014).

As for temperature, in winter temperature between 18°C and 25°C is acceptable. In summer, a temperature below 27°C is acceptable. Another guideline for healthy environments within European schools suggests comfortable temperatures in school classrooms should be maintained throughout the year between approximately 20°C and 26 °C (Kephalopoulos et al., 2014). Besides, a higher comfort temperature for the children compared to adults is expected based on the lower metabolic rates observed in the school children (Havenith, 2007). So I believe adolescence also have a higher comfort temperature than adults. The adverse effect of a high temperature is increasing fatigue and reducing concentration, academic performance, and learning of students (Melikov et al., 2012; Andersen & Gyntelberg, 2011). The opening of windows can provide an improved temperature reduction over mechanical ventilation, which is advice for practice (Mydlarz et al., 2013).

*Interactive Data Visualization dashboard: https://energe.io.tudelft.nl

3.3 Factors influencing indoor climate

In thermodynamics, there are terms like 'exergy' describing useful work and 'anergy' describing waste. Lundström (2016) added a new term 'intergy' in his energy-sensitive interaction design that is context- and need-dependent, changing dynamically over time. I used them to categorize the factors influencing indoor climate in secondary schools. Among them, the context- and need-dependent and changeable factors, e.g. windows or heating, are important as they really affect indoor climate, while the other two kinds of factors are unchangeable and the effect of those are inevitable, e.g. the weather or the infrastructure of the school building. Fig.12 gives an impression about the context- and need-dependent and changeable factors in secondary school. These factors include doors and windows, the energy of heating and ventilation, place like outdoor and different indoor rooms, occupancy of a room, clothes users wearing, hydration from water or ice cream, and so on. **These identified factors can be used in the design when related factors affecting indoor climate need to be indicated.**

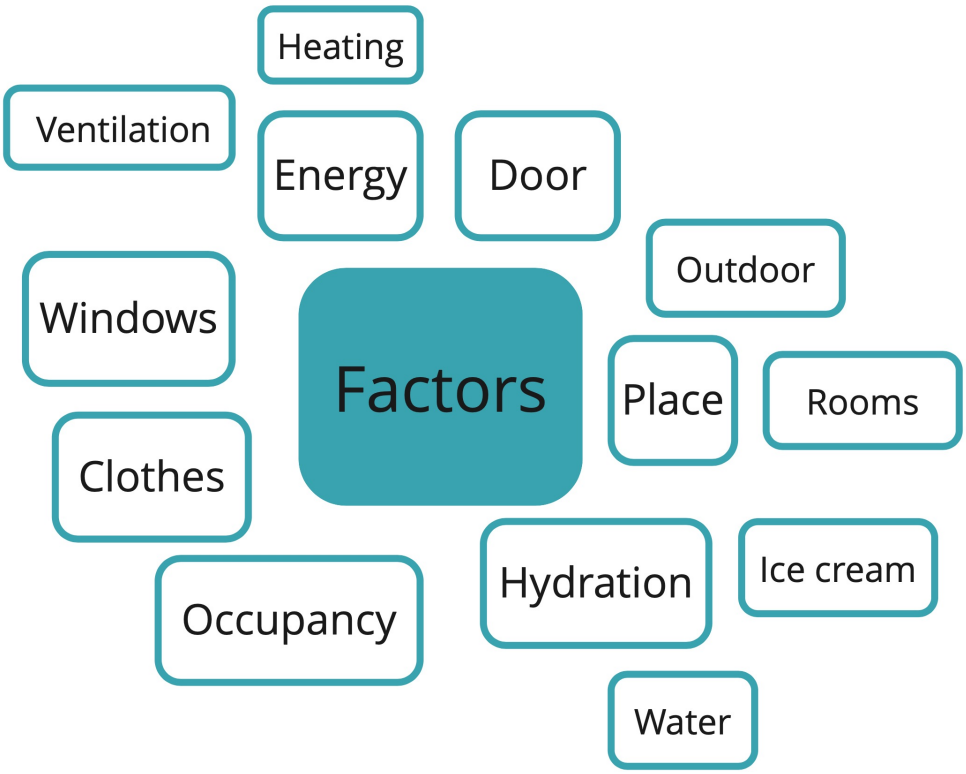


Fig. 12 - Some factors identified in the user research that influencing indoor climate in secondary schools

3.4 The system of indoor climate and the interrelationship within it

Factors influencing indoor climate are just a part of the system. To understand the whole system comprehensively, an image was made to show what it consists of and the interrelationship within it (Fig.13). All the factors described above can affect indoor climate including CO2, temperature, light, sound and humidity. The data detected by climate sensors will be compared and assessed which ends up with a defined quality of indoor climate along with the effect of that on people's comfort, health, performance etc. The indoor climate will be experienced by people directly as well. Then people have a perceived indoor climate quality, e.g. people feel temperature is too high or the air smells bad. After that, people will react and change the status of these context- and need dependent and changeable factors. Then the loop goes again.

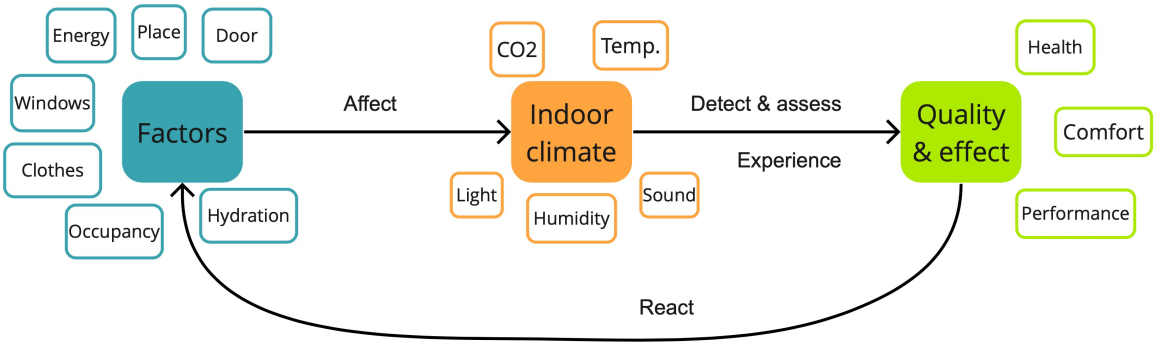


Fig. 13 - It shows what the context has and the interrelationship within them

3.5 Indoor climate and energy information

To communicate indoor climate and energy related information with users, I need to first identify what information can be provided. Several types of them are identified, e.g. indoor climate, indoor climate quality, effects on people's comfort, energy consumption, effects on sustainability in school, related factors and solutions (Fig.14).

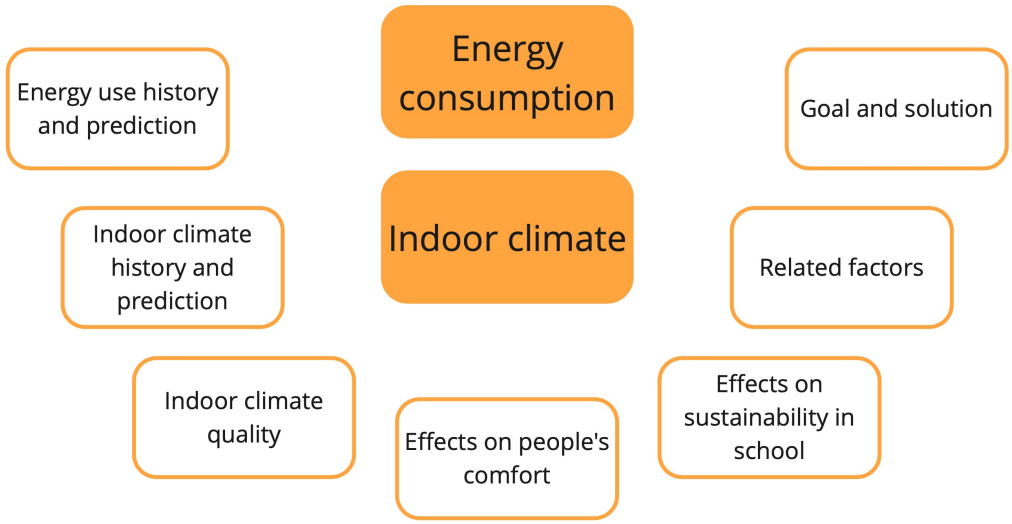


Fig. 14 - Several types of information related to indoor climate and energy consumption

3.6 Proenvironmental behaviours communication

In order to communicate information related to indoor climate and energy use with users and promote sustainable behavior, I studied how to communicate proenvironmental messages. There are two methods proposed by Pelletier and Sharp, i.e. tailoring message and framing message (2008). The former provides a process to communicate messages and the latter explains how to frame these messages.

Tailoring messages

Tailor messages according to proposed processes underlying behavior change. Three phases of behavior change are identified - a detection phase, a decision phase, and an implementation phase (Burkholder & Evers, 2002; Rosen, 2000; Rothman & Salovey, 2007).

The detection phase should communicate the messages that make people aware that a problem exists. Exposure to threatening information that presents the costs of failing to adopt a proenvironmental behavior will get more people's attention and motivate people to search for responses that reduce the fear (Devos-Comby & Salovey, 2002; Detweiler et al., 1999). Fear appeals should lead people to be positively biased in their consideration of potential solutions to an environmental problem (Das et al., 2003; de Hoog et al., 2007).

The decision phase should communicate information on the important actions that could be performed to reduce the risks. A shift from a consideration of the risk associated with the potential outcomes to a consideration of the potential solutions that need to be considered (Trope & Liberman, 2003). People become more sensitive to messages that emphasize a desired outcome and the benefits of adopting a specific behavior because these messages are now more congruent with the actions that could eliminate risk or the fear associated with a specific issue (Detweiler et al., 1999; Millar & Millar, 2000).

The implementation phase communicates when, where and how a specific behavior could be implemented. Frame message in term of goal and implementation intentions. Goal intentions specify what is wanted to be achieved and implementation intentions involve specifying the behavior that will be performed to achieve the goal (Gollwitzer, 1999).

In my project, if all the types of information described in Section 3.5 are categorized into phases of behavior change (Fig.15), indoor climate data and its quality, the potential effect on people and sustainability, and energy consumption are relevant in the detection phase. Other information i.e. related factors or goals and solutions are related to the decision phase and implementation phase. In order to communicate proenvironmental messages thus promote sustainable behaviors effectively, make sure types of information used when building prototypes cover all the phases.

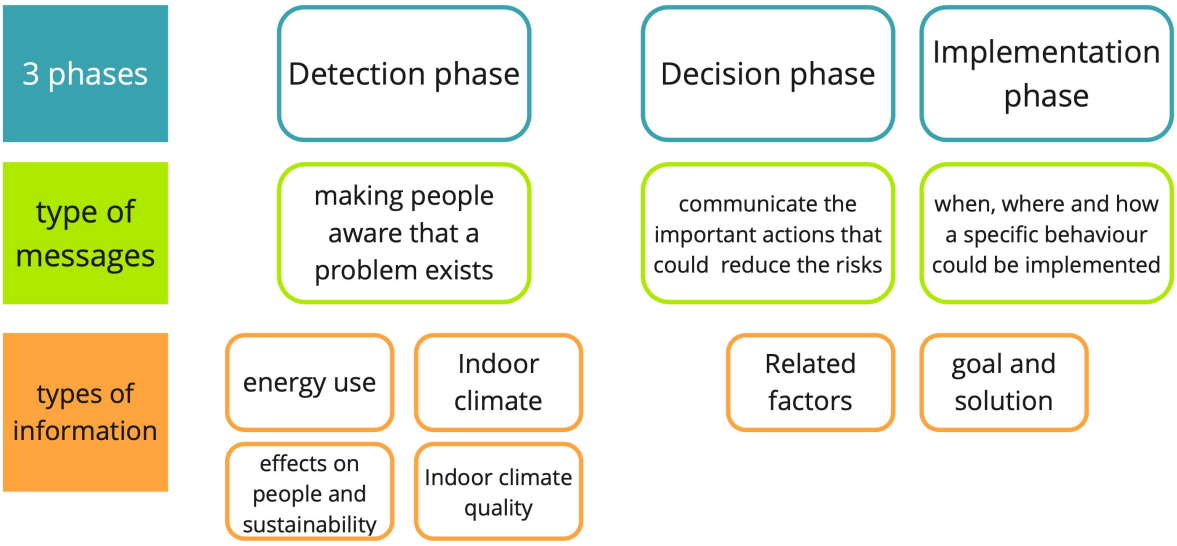


Fig.15 - 3 phases of tailoring messages and types of information categorized

Framing messages

Frame messages in terms of whether they serve intrinsic goals (i.e., health, well-being) (Pelletier & Sharp, 2008), which refers to the Self-Determination Theory in Section 2.6. Intrinsic goal framing leads to deeper engagement in an activity, deeper processing of the information related to an activity, more persistence (Vansteenkiste et al., 2004, 2006). But double goal framing that emphasizes both intrinsic and extrinsic goals resulted in significantly lower levels of outcomes compared with intrinsic goal framing.

To conclude, communicating the effect on people's health and performance is important and helpful to engage people in sustainable behaviors. And in Section 3.2 indoor climate not only affects students' comfort, but also health and performance. Hence, the effect can be communicated in the design prototype.

3.7 Visualization design strategies

Three strategies for designing visualizations of energy consumption were concluded (Pierce et al., 2008). Some of them can be adapted to visualize indoor climate too. Here only the most insightful one, creating incentives to conserve, is presented. The rest two strategies, providing clear and useful information or feedback and making consumption visible can be seen in Appendix 2.

Create incentives to conserve

There are social incentives and environmental incentives. The former one is to formalize competitions between individuals or groups or to make and commit individual pledges. The latter one is to use visual metaphors to create an emotional connection between users and the environmental impact of energy use. **For this project, both incentives can be used when designing for the scenarios during lunch break or between classes.**

3.8 Chapter conclusion

Through co-design with users and explorative literature research into information communication science, the knowledge of indoor climate and energy use system and its communication theory was gathered.

It's fascinating to see different factors in the system containing various information and how they affect the system, other factors thereof. Then the challenge is how to provide information and communicate them with users in different situations. Practical knowledge e.g. message tailoring and framing showed a potential design method to cope with the challenge.

My exploration also showed that on the one hand indoor climate affects people's subjective feeling of comfort, on the other hand, it affects people's health and performance in essence. And since communicating effects on people's health and performance are helpful to engage people more in activities, I think it should be addressed in the design to promote sustainable behavior.

4 Defining Focus

Based on two chapters of exploring users and information communication, I was able to build a basis for the next design phase of defining a design focus. After mapping all insights together, my design goal and interaction qualities were formulated. Then a design strategy and requirements were defined before entering the iteration phase.

4.1 Insights mapping

Fig.16 shows an overview of the important generated knowledge and insights. A similar framework was used to explain the logic of the context of indoor climate and energy.

The loop on the top about indoor climate starts from factors influencing indoor climate to relevant indoor climate variables to the qualities and effects on students then back to factors. The loop at the bottom is from identified factors to energy use to students then back to factors. Factors like using heating or mechanical ventilation can cause energy use; When students are informed of energy use, it can influence students' actions on factors related to energy use.

According to the insights from Tailoring messages, steps in the red color belong to the detection phase that makes students aware of existing problems. The rest steps in the green belong to decision and implementation phases that promote sustainable behaviors.

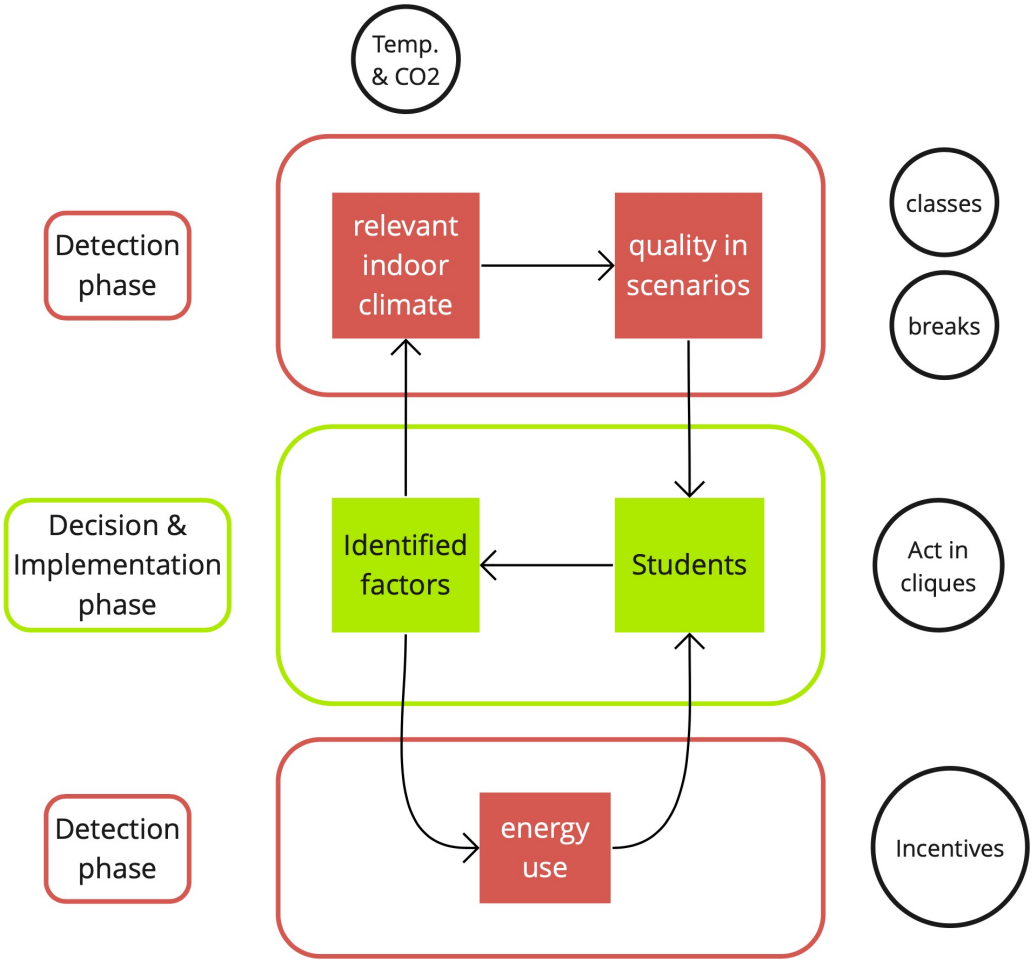


Fig. 16 - An overview of all the generated knowledge and insights

The main insights of each step will be articulated. First, the most relevant indoor climate variables to students are temperature and air quality. The temperature should be comfortable and the air should be fresh. Second, how the qualities of indoor climate affect students depends on different scenarios. It affects them more in class than during breaks or lunchtime. Third, students have intensive social interaction with their friends' groups. last, creating incentives to engage students to act on sustainability like conserving energy is a useful design strategy.

4.2 Design goal

To define the design goal, I looked back at my personal interest and ambition, which are sustainability related design direction and promoting behavior change by using data. Then I chose the direction and defined the design goal that is:

> **I want to make students feel motivated and confident in sustainable behavior when they are in breaks or lunch time in secondary schools.**

When & Where

I chose to work on the scenarios (Fig. 17) that are doable for sustainable behavior, which are the situations of breaks and lunchtime when students aren't studying in the classrooms. So the intervention won't affect users' study too much at school.

Fig. 17* - An image of the scenario of the hallway in a secondary school

Who

I see the students as a unity although their motivation toward sustainability varies. I want my intervention open to every student. So the social interaction between students can play a positive role. I would like students to be motivated and change behaviors towards sustainability ultimately.

*Fig. 17: https://myalbum.com/album/TYnAybY9VxeM

Interaction qualities

> **involved, motivated, purposeful, confident**

The descriptive keywords are meant to explain the qualities of interaction that future interventions should provide users with. Referred to the three phases in tailoring messages (Pelletier & Sharp, 2008) and some spheres of experience from METUX (Peters et al., 2018), I built a framework of four experience phases, namely Attraction, Interaction, Implementation, Reaction, for interacting with the interventions. For each phase, there are one or two specific interaction qualities accordingly. Fig.18 shows it with facial expressions adapted from PrEmo (Desmet & Laurans, 2017). The quotes are created to make it vivid.

First, users' attentions are drawn to the intervention and they feel attracted by it. Second, when interacting with interventions, users are involved and motivated to do something for sustainability that is related to their school and themselves. Then they are purposeful as they know what they can do from interventions and have confidence that they're capable of that since the information from interventions about sustainability actions are actionable and doable. Last but not least, they feel proud as the intervention gives positive feedback that they have contributed to sustainability through their actions.

In this project, I focus on achieving interaction qualities of the two phases of Interaction and Implementation that are Involved, Motivated, Purposeful and Confident since it's aligned with the design goal.

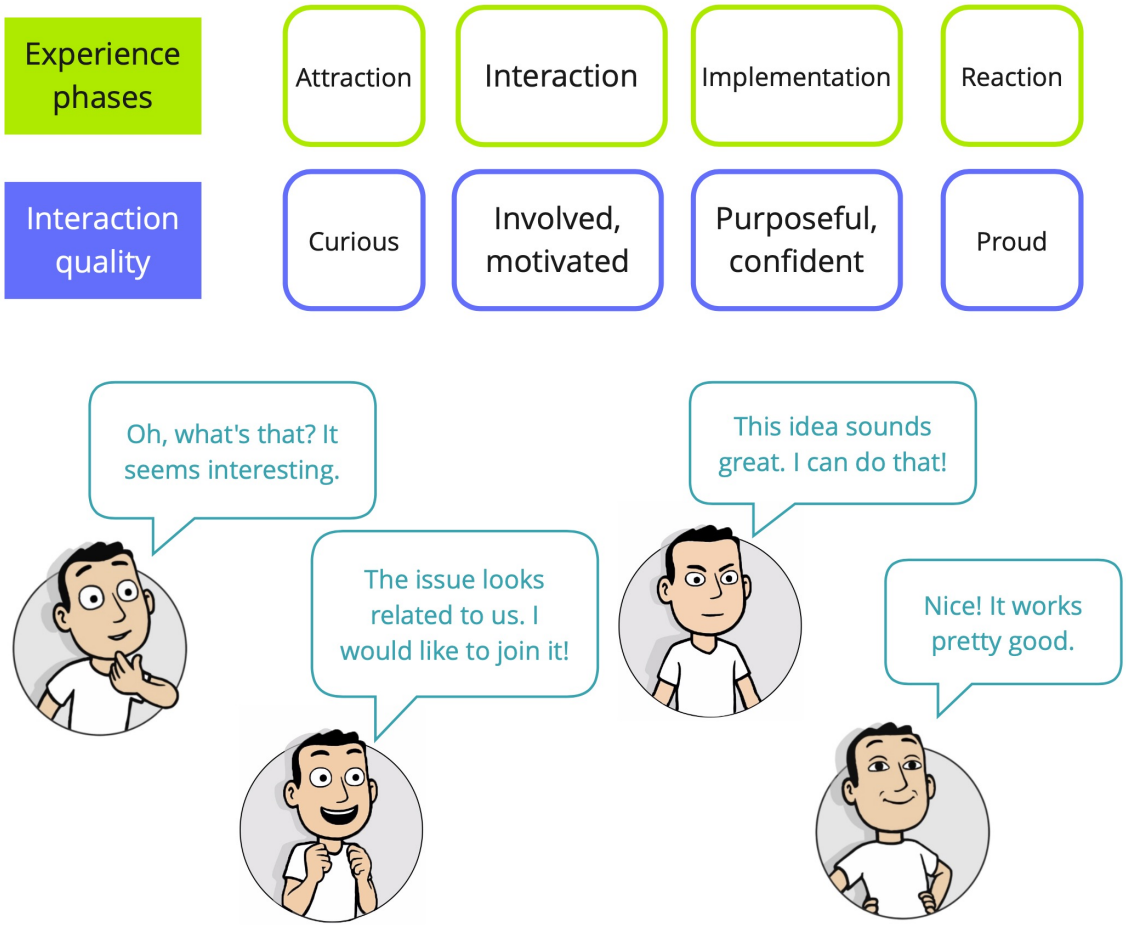


Fig. 18 - Interaction qualities in experience phases with illustrations adapted from PrEmo (Desmet & Laurans, 2017)

4.3 Persona

Considering the intensive social interaction among students and the students' attitudes to sustainability varies, two personas in one group are formed (Fig.19). They are Peter and Anna, both of whom are in a clique and usually stay together in the free time at school. Peter is a member of the student council who has lots of motivation to make the school more sustainable and is willing to take more responsibility. But Anna instead has a relatively low interest in sustainability. Besides, they have the general knowledge about saving energy and using it efficiently as they are taught in school.

Social interaction

They usually stay with the group in the breaks

Anna 17

Has low interest in sustainability

Motivation and responsibility

Peter 17
A member in student council

Has motivation to make school more sustainable

'I don't think students should really take control as they were just wouldn't take things like this serious.'

'Student body council has a lot of motivation. They want to make the school better.'

Fig. 19* - Two personas who have social interaction in school

*Fig. 19: Illustration designed by Freepik

4.4 Design strategy

In order to attract users at most to interact with the intervention, both comfort and sustainability can be considered in the design (Fig.20). On the one hand, with indoor climate related information, e.g. indoor climate data, indoor climate quality and its effect on people, it can attract users who concern about their comfort, which covers almost every student. On the other hand, sustainability related information, e.g. energy use data, its effect on sustainability in school, can help users who care about sustainability to contribute to that. Moreover, since the two parts above are in the same system, it's possible to see users who are interested in comfort and indoor climate at the beginning pay attention to sustainability and energy use, in which way the goal of promoting sustainable behavior can be achieved as well.

However, the scenario of interacting with indoor climate data is not limited to being in the situation of breaks or lunchtime as my design goal focuses on. It's very likely to happen in the class from the user research. In general, I see this design strategy as an inspiration for prototyping, may be useful for further development in ENERGE.

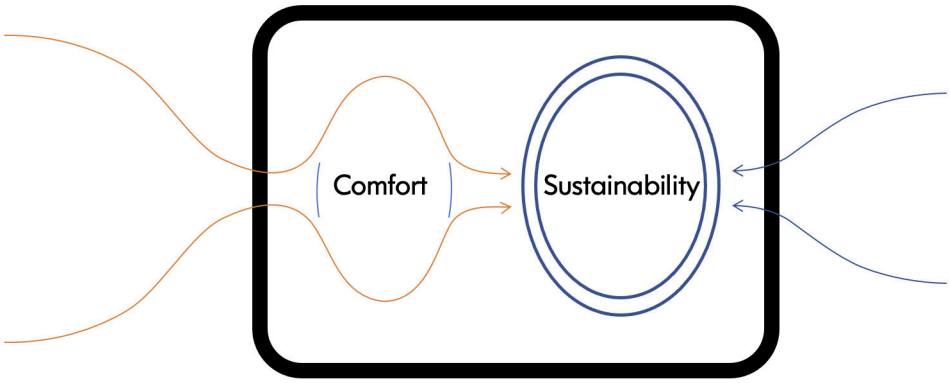


Fig. 20 - The design strategy that attracts most users to use the intervention

Requirements

1. Make use of indoor climate data and energy use data

2. Make use of social dynamics between students

5 Prototype Iteration

Based on the knowledge gathered in the exploration phase and the defined design focus, I was able to build a basis for the iteration phase. Guided by the design strategy and design goal, the co-creative session with users and two cycles of concept ideation, prototyping and testing were conducted to gather feedback and insights to the final design.

Methods: Brainstorming, Co-creative session, Research through Design, Prototyping

5.1 Brainstorming and ideation

From the same co-creative session with users, I got inspired from their brainstorming ideas of drawing attention and understood the types of information they want to know and the visual styles they prefer, which became inputs for the later ideation.

In the activity of brainstorming ideas of drawing attention, users were asked to brainstorm ‘How to draw students' attention during lunch in canteen/ between class in the hallway?’

Here is the cluster of ideas in Fig. 21. Four themes were identified, i.e. visuals, sound, events and bonus. Besides the visual part, using music, offering free food and holding events are also inspiring for my ideation.

Fig. 21 - The cluster of participants’ ideas of drawing students' attention

In the activity of ideating the data communication interface, users were asked to design the types of information they want to know and the visual styles they prefer. Two patterns were identified.

One of them is focusing on indoor climate effect on people and solutions (Fig. 22). Both of them chose the radial style. It might be because the radials I provided are at the top where they look at them first.

‘I thought it would be fun to just give concrete actions, students could take so that would be solutions and advice would like more direct. It would be like as far as you could do this right now to make this school more sustainable.’

Besides, it’s a good idea to have a visual character that can present information and interact with people like a smart agent.

‘Maybe some information they could interact with which asking questions or to somebody and not just plain information.’

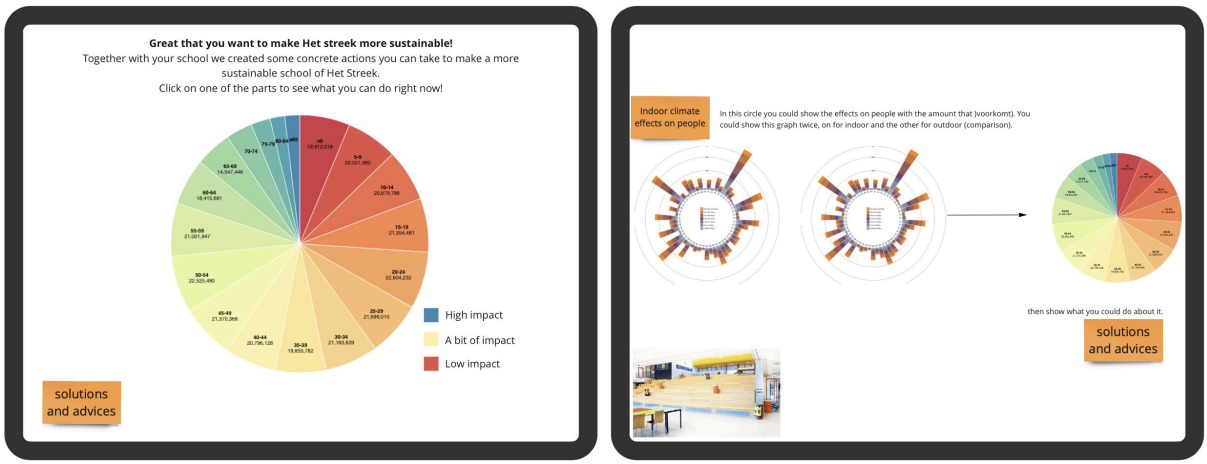


Fig.22 - The interface design made by participants

Based on adapted strategies for designing visualizations of energy conservation, together with my insights from literature, the ideas noted along the way and the input from the co-creative session, I brainstormed ideas of both social incentives (Fig.23), i.e. competitions and individual pledges, and environmental incentives, i.e. connecting behavior to environmental impacts.

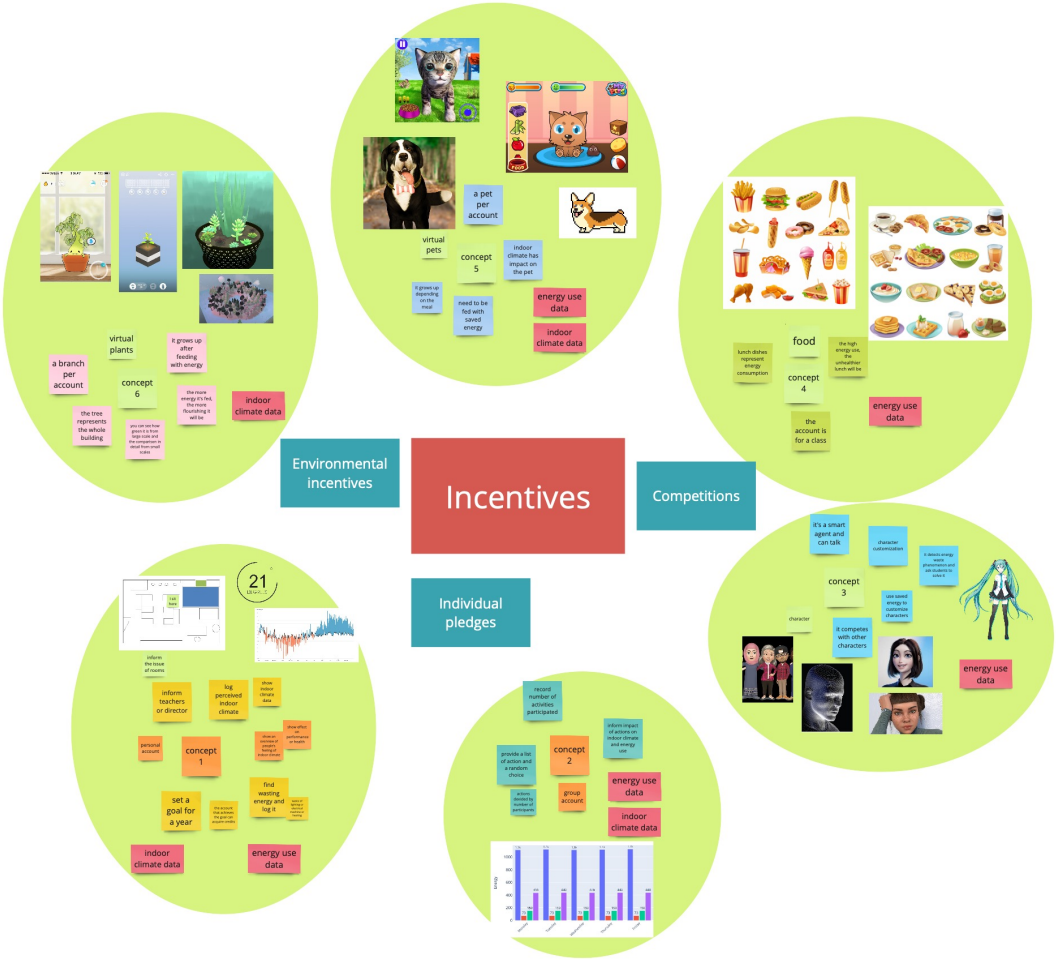


Fig.23 - An overview of brainstormed ideas

5.2 Design cycle 1

After brainstorming and ideation, six concepts (Fig.24) were generated from ideas of pets, plants, virtual characters and food to the basis of class-based, group-based and individual-based. The detailed information about indoor climate and energy use on the interfaces is based on the one I gathered in the exploration phase. Written scenarios of desired interactions were also developed together with some interfaces.

These concepts were tested with three design master students from Industrial Design Engineering faculty, where interfaces and a description of the concept as paper prototypes together with personas and scenario scenes were shown to collect quick and qualitative feedback about their perceptions of motivation and self-confidence.

The detailed explanation, interfaces and feedback of each concept can be found in Appendix 3.

Main questions to answer with the prototypes:

1. How does it affect participants' motivation and confidence in sustainable actions?

2. What parts from which concept do participants like?

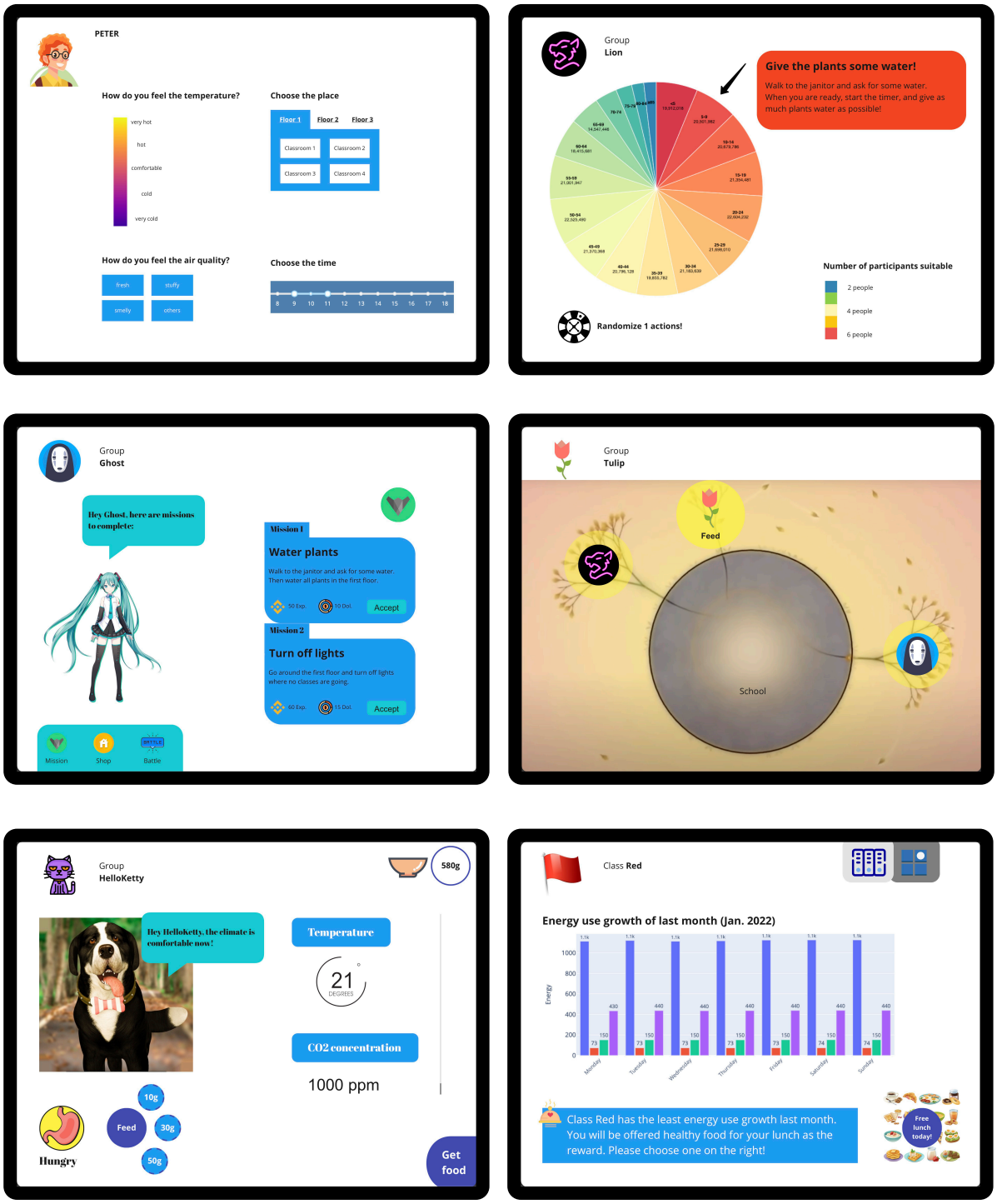


Fig.24 - An overview of concepts presented

Main takeaway

Sustainability in school is a matter of all students, not of individuals. Participants are all in favor of concepts with social interactions either as a group or a class, which can be referred to Sections 2.4 and 2.5 where an informal student group is defined as a ‘clique’ that has intensive social interaction (Kohnstamm, 1997). Feedback on different features from every concept was recorded for Cycle 2 development. Here two main takeaway were discussed, i.e. ‘Game and Reality' and ‘Motivation and confidence’.

> **Game and Reality**
>
> Participants were fascinated and motivated by the games and competitions. Yet it shouldn’t miss the link to sustainability and energy conservation in reality. Otherwise, it loses its meaning and becomes just a game. To make the connection, for instance, the impact of actions on sustainability needs to be indicated.

Motivation and Confidence

Participants were motivated by different stimuli. Competitions and gamification motivate them generally as they want to win the competitions and games. A case study also shows the positive effect of competitions on students' motivation (Pierce et al., 2008). Rewards of games also motivate people and the more real the rewards are, the more motivation people will get. Moreover, motivation can come from social interaction within student groups. People can be motivated by other students in the group who motivate each other to act.

Confidence comes from a concrete and specific action. A participant said 'It gives high confidence as I know what to do'. Confidence can come from a gamified system that works and tells how much impact an action has. So a trustworthy system also gives confidence to participants. Both confidence and motivation can be sustained by using Message tailoring and Message framing as a way that parallels the processes associated with a new pattern of behavior (Pelletier & Sharp, 2008).

The rich and diverse sources of motivation and confidence inspired me. People have their own interpretation of motivation and confidence. Since my intervention is open to every student in school, it's better to have as many students as possible join and make use of the intervention no matter what motivates them and gives them confidence.

Four out of six concepts were kept and iterated to be more complete yet different from each other in terms of features. In the following cycle, they were developed and test further.

5.3 Design cycle 2

Based on the feedback in Cycle 1, I iterated on four concepts by improving their shortcomings and making them more complete while keeping their own unique features. The goal of this cycle is to gather feedback from students on concepts about different features and co-design ideal concepts.

The concepts (Fig.25) vary from basic ideas, social forms and rewards as well as contained information related to indoor climate and energy use.

Three users of the target group participated in the tests online (Fig.26). In the session, several questions were asked first to know about their school and their attitudes to sustainability. Then we went through four concepts and gathered feedback on the interactions. Finally, participants were asked to create their ideal concepts (Fig.27).

The detailed iteration of the concepts, the test guideline and analysis can be found in Appendix 4.

Main questions to answer with the prototypes:

1. How do participants feel about the interaction?

2. How does it affect participants' motivation and confidence?

3. What features and information do participants would like to have in the design?

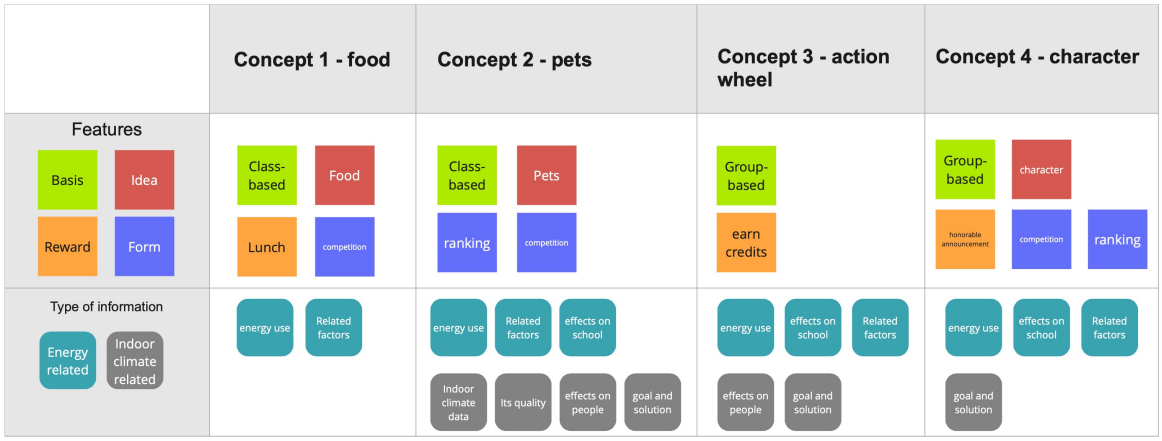


Fig.25 - An overview of different features and information of 4 concepts

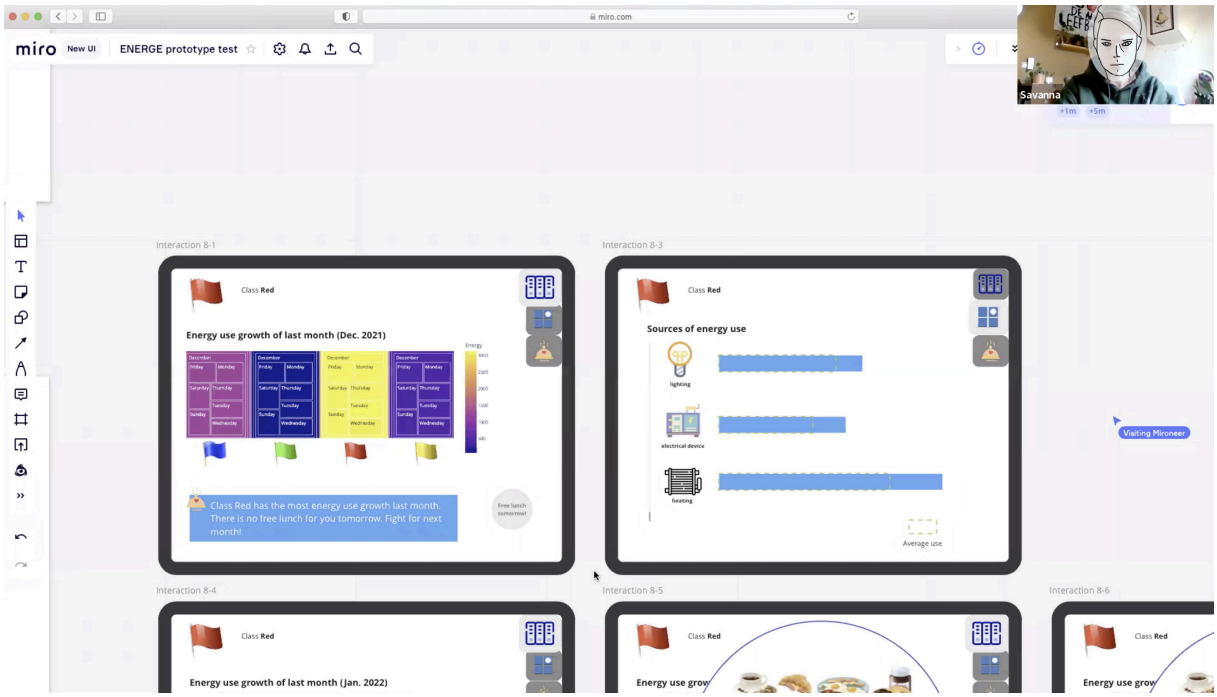


Fig.26 - Testing prototypes with participants on Miro remotely.

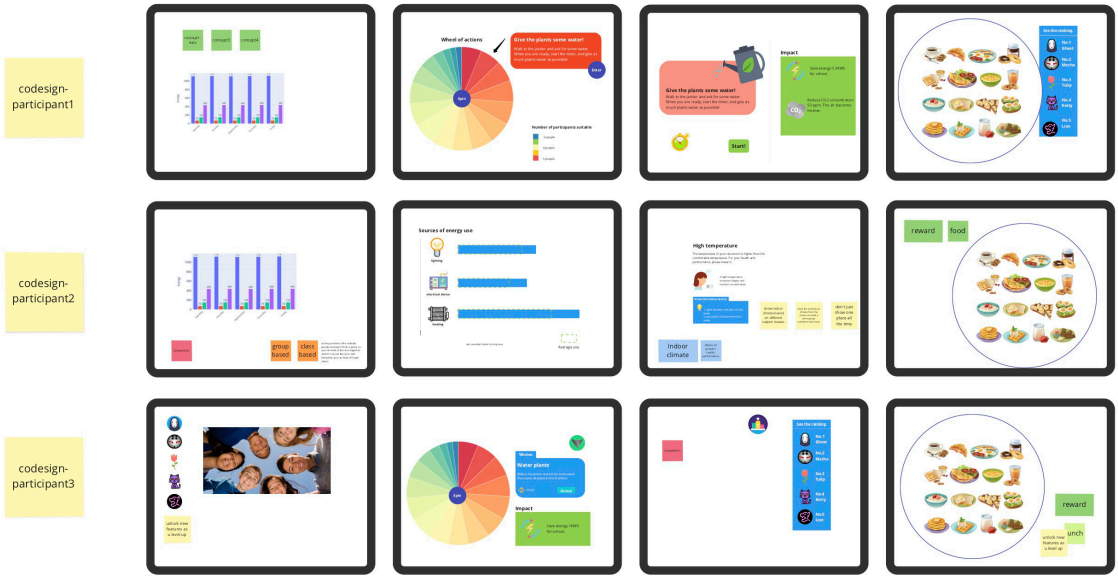


Fig.27 - The ideal interfaces that participants designed

Main takeaway

The sources of motivation and confidence became clearer. Competition and reward create motivation. Students like games and want to play and win. The more students want the reward, the more likely they incline to participate. Group-based activities and competitions between groups motivate most people, which reflects the people's fundamental needs of relatedness and competence (Deci & Ryan, 2008). People care about friends and can hype them up to do activities. This has essential background information that students switch classrooms depending on subjects, so they have much stronger connections with friends than classmates. Confidence comes from different stimuli including winning games or beating others. Everybody can do small actions so confidence won't come from that.

A difference between motivated students and less motivated students was found. Motivated students prefer a more straightforward way to do actions even though it's not a competition like the Action Wheel concept and less reward because they have strong inner motivations. So they experience more autonomy as they act with high willingness and in accordance with their personal goals and values (Peters et al., 2018). But less motivated students need more outside incentives to motivate them like competitions and rewards. In order to attract more students to participate in activities, competitions and rewards are better choices.

5.4 Chapter conclusion

From two cycles of iterating prototypes and testing, valuable insights were generated and inspired me a lot. Here are two main insights that I deem important for the final design:

First, it's valuable to see users' own interpretations of motivation and confidence. The rich meanings of these two feelings and their sources vary from competition to rewards, from believing in what has been done to believing in beating others. Therefore, not only the intervention itself can motivate students and promote sustainable behavior, but the participation of different types of students and positive social interaction between them driven by the intervention also have a positive effect on their mindsets and behaviors towards sustainability. So what can be the role of the intervention? It can be seen as a platform that accelerates the sustainability progress in school with students altogether.

Second, most features and information in the concepts can give people motivation or confidence to a different extent. But it doesn't mean to show everything on the screen at once. The information layer is needed to organize information in an effective way. For example, Indoor climate effects on people's comfort and health can make users aware of their conditions and thus react to them, which results in energy conservation. This feature works but not at any time for anyone, thus it should be hidden as same as some other information. In another word, it's important to build the structure of the information layer that prioritizes the features and information that work for most users and have more effects while hiding the rest for some students to explore.

6 Final Concept PROMOTIVATE

The progress of exploration, definition and iteration results in the final concept design PROMOTIVATE. The concept development is based on what I know to be feasible, desirable and viable.

In this chapter, the final concept is described in detail. Furthermore, the evaluation process of the design and the results are described. The chapter concludes with a reflection on the limitations and recommendations for the final design.

Methods: Observation, Interview, Questionnaire, Prototyping

6.1 Concept description

The final design outcome of my graduation project is PROMOTIVATE, an interactive digital application intended for the secondary school context (Fig.28). The application runs on a digital device with a touch screen and without any physical buttons, which will be a new touchpoint of the system that also detects indoor climate and energy use in schools. See sensors distribution in Section 3.1.

Fig.28 - The landing page of the final concept PROMOTIVATE

The interface of the application is designed for students about promoting sustainable behavior in secondary schools. It incorporates group-based competitions combing with sustainable actions as well as indoor climate and energy use related information. As for the sources of the information, the samples of energy use data are adapted from ENERGE data platform. The impact of actions contributing to energy conservation is my estimation. It's adequate to show users the estimated impact as it worked during prototype testing. And the measurement and accuracy of that are out of the project scope. Other types of information used in the design, e.g. indoor climate quality, its effect on users' health and its related factors, are reliable and can be found in Sections 3.2 and 3.3.

The application enables students to take action and contribute to sustainability at school through teamwork in a competitive manner. And it allows students to be more aware of the indoor climate and energy use around them in their daily school lives. Students can also learn knowledge about the interrelationship between indoor climate, health and sustainability by teamwork and competition.

6.2 Context and usage scenario

The device with the screen is installed on the wall in the building of secondary schools. There is a number of screens in the hallway of every floor (Fig. 29). So around half number of all groups interacting with PROMOTIVATE simultaneously is assured. This is because most actions designated in PROMOTIVATE take around half to a whole 10 minutes break to do. With this number of screens, every group can at least do one action per day.

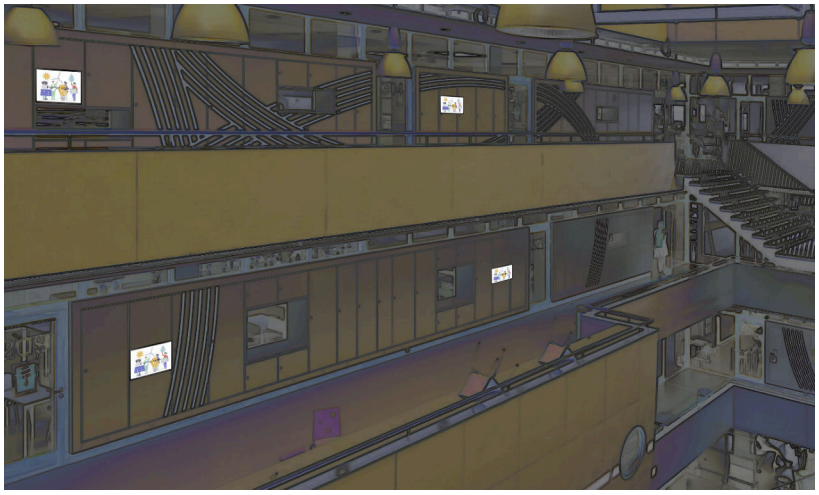


Fig. 29 - The layout of screens in the school building

The screen can be in the classroom and in the hallway or in the canteen. Since the project focus on the scenario of the hallway and canteen, here only the image of the focused scenario is shown accordingly (Fig. 30). I chose the size of the screen to be a tablet since I was influenced by a similar proposal from the ENERGE team at the start of the project. Besides, it's not too small to see for multiple people front and it's not too big to keep students' eyes away from it. The big screen usually makes minors obsessive.

Fig. 30 - The screen on the wall in the hallway where a group is interacting with it

6.3 Interface and content

The image (Fig.31) shows the information of PROMOTIVATE consists of group-based competitions with sustainable actions that provide a basic idea of the concept and are the most important part. Then the energy use related information and the food reward form a gamification system. Last but not least, indoor climate related information is the last piece of the puzzle.

The application has four units, i.e. Group, Action, Ranking and Reward (Fig. 32), which can be related to the important information described above.

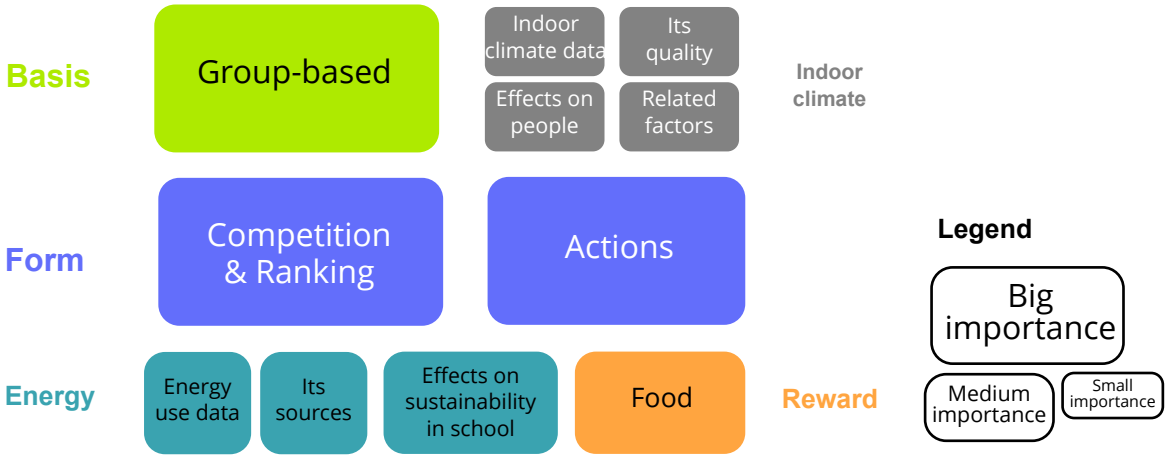


Fig.31 - The composition of information in PROMOTIVATE differentiated by importance

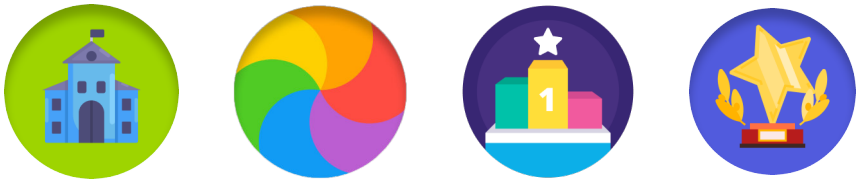


Fig. 32 - The icons of four units, namely Group, Action, Ranking, and Reward

On the interface, visuals such as icons and illustrations were used to make the interface more aesthetic and attractive to students in secondary schools. But they are not originally made. Some visuals used in the prototype are adapted from the Iconfinder in Miro and some are adapted from the work on Freepik (Fig. 33).

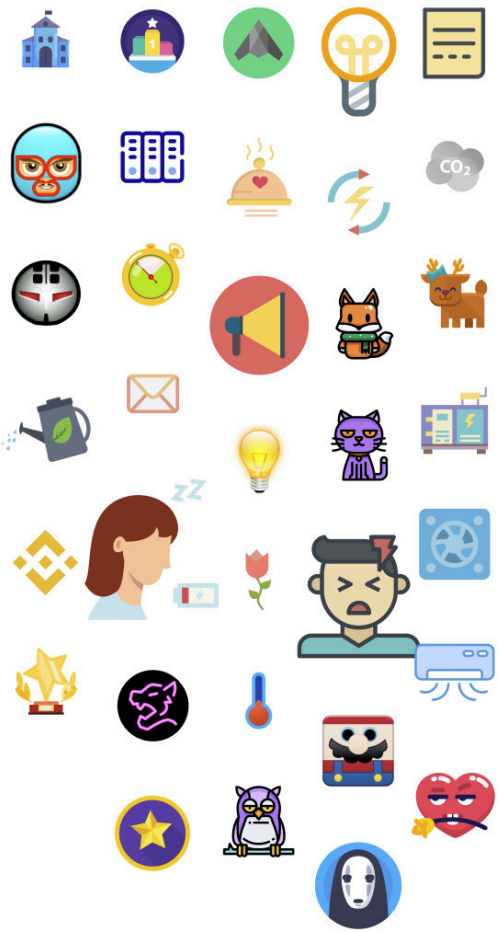


Fig. 33 - Visuals from Iconfinder and Freepik

Here is the link of the prototype: https://www.figma.com/proto/uEuE2hmzK3qJmyRbTOudoR/ENERGE---PROMOTIVATE?page-id=0%3A1&node-id=10%3A403&starting-point-node-id=10%3A403&scaling=scale-down.

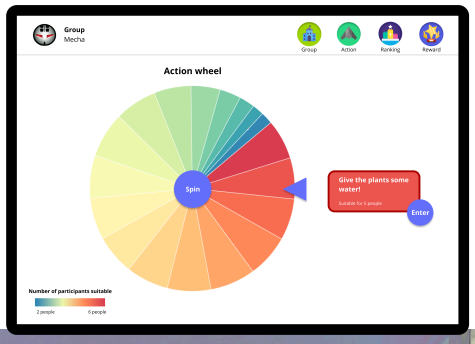
All interfaces developed can be seen in Appendix 5.

6.4 Storyboard

This storyboard introduces the features of the concept by four units with intended scenarios to show how students can interact with it and contribute to energy conservation.

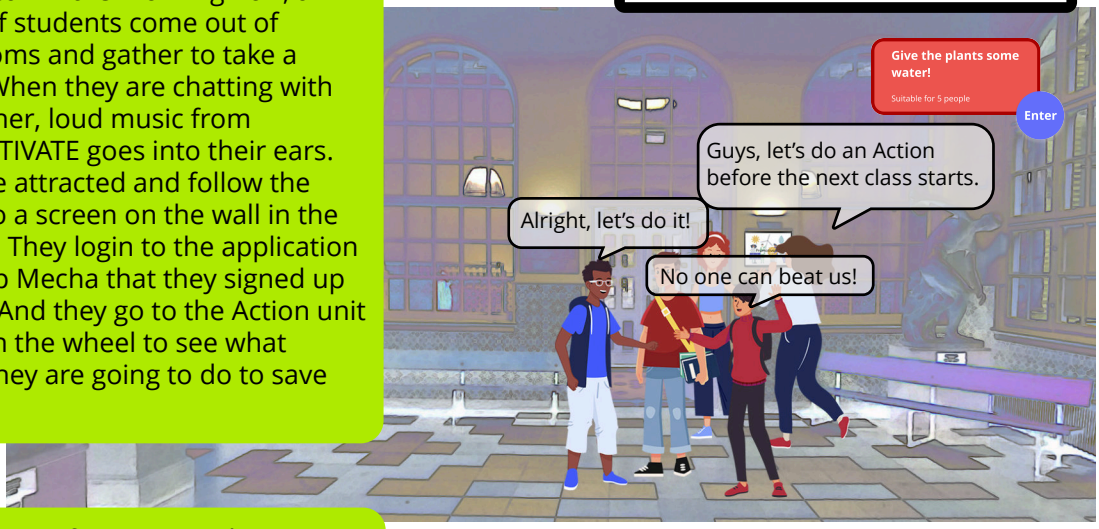
Action

Students take action

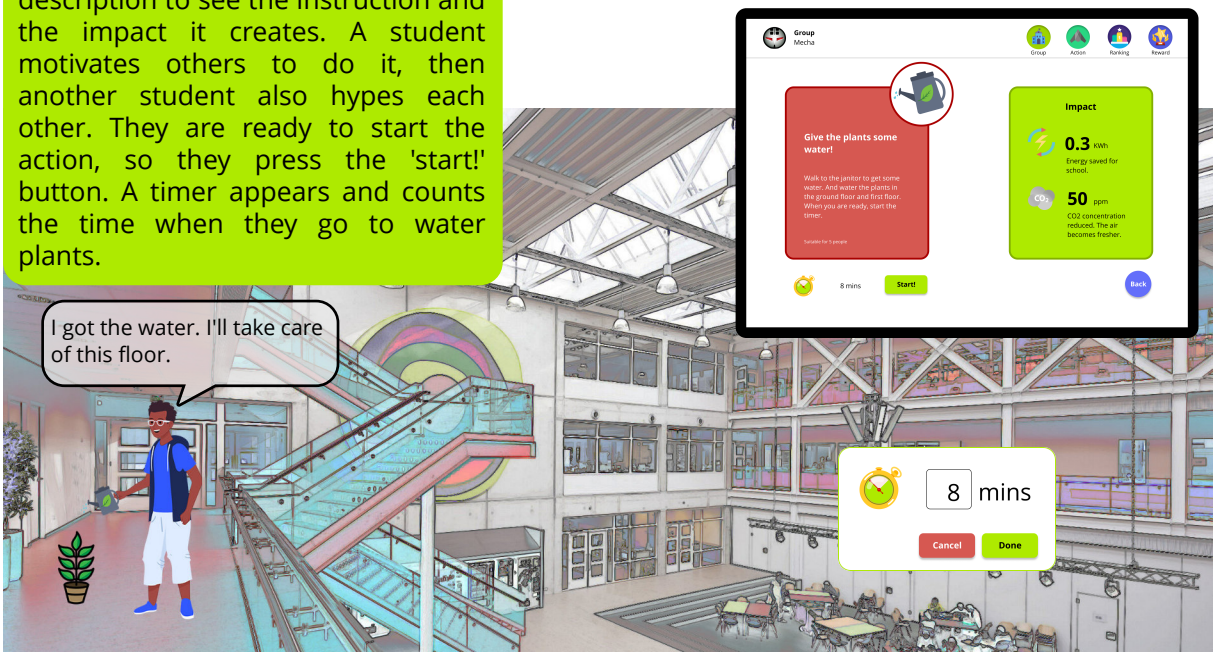


Scenario 1

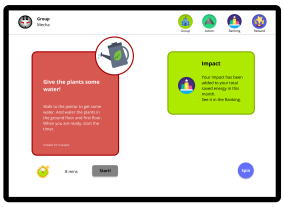
It's a break in the morning now, a group of students come out of classrooms and gather to take a break. When they are chatting with each other, loud music from PROMOTIVATE goes into their ears. They are attracted and follow the music to a screen on the wall in the hallway. They login to the application as group Mecha that they signed up before. And they go to the Action unit and spin the wheel to see what action they are going to do to save energy.



The action of watering plants turns out and they enter the action description to see the instruction and the impact it creates. A student motivates others to do it, then another student also hypes each other. They are ready to start the action, so they press the 'start!' button. A timer appears and counts the time when they go to water plants.



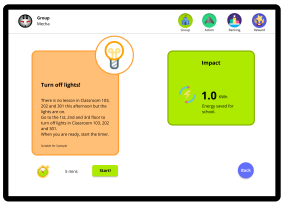
Several minutes passed, they watered all the plants required. After they press 'Done' on the screen, the impact they created has been recorded to the energy they saved in total, which gives them the confidence to win the competition.



Impact

Your impact has been added to your total saved energy in this month.
See it in the Ranking.

PROMOTIVATE offers other actions too, turning off lights or devices etc. They are suitable for different numbers of people and the impacts they create vary.
At any certain time, any two groups won't receive the same action to avoid system confusion.



Turn off lights!

Suitable for 3 people

Enter

Turn off lights!

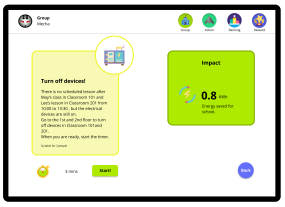
There is no lesson in Classroom 103, 202 and 301 this afternoon but the lights are on.
Go to the 1st, 2nd and 3rd floor to turn off lights in Classroom 103, 202 and 301.
When you are ready, start the timer.

Suitable for 3 people

Impact

1.0 KWh

Energy saved for school.



Turn off devices!

Suitable for 2 people

Enter

Turn off devices!

There is no scheduled lesson after May's class in Classroom 101 and Lee's lesson in Classroom 201 from 10:00 to 13:30 , but the electrical devices are still on.
Go to the 1st and 2nd floor to turn off devices in Classroom 101and 201.
When you are ready, start the timer.

Suitable for 2 people

Impact

0.8 KWh

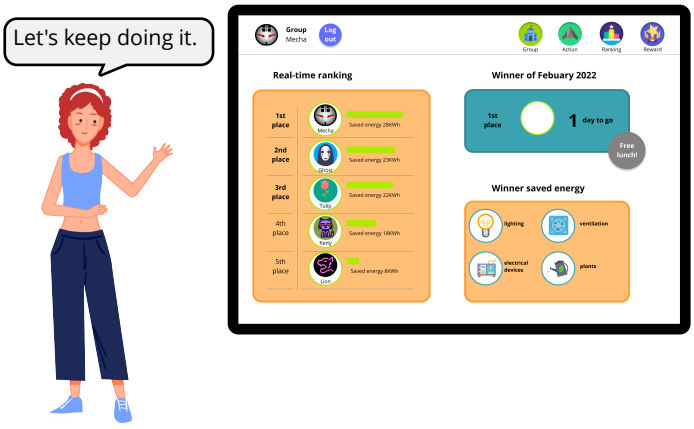
Energy saved for school.

Ranking

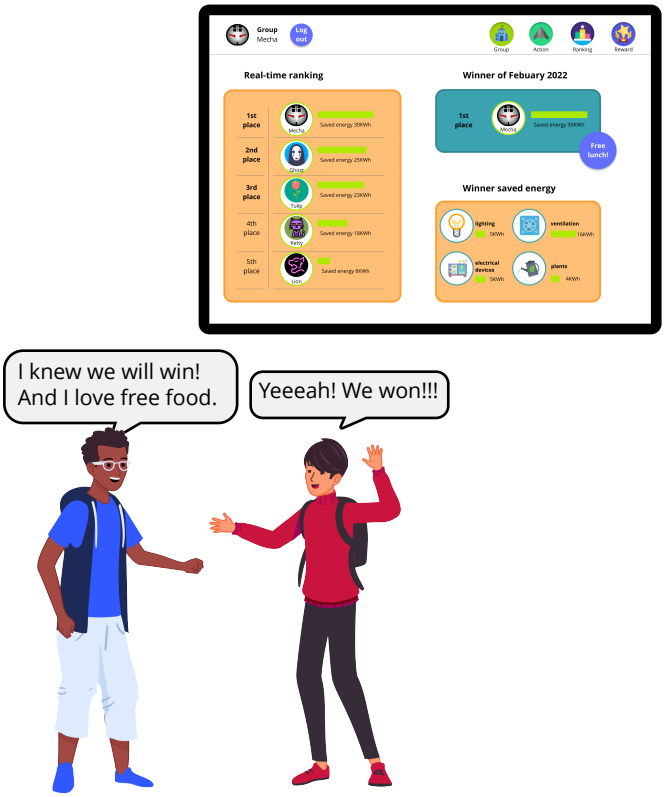
Group ranking

Scenario 2

It's lunchtime now and the group just had lunch. Then they want to check out which group is leading the competition and where they are in the ranking. They go to the Ranking unit and find out their group Mecha is now at 1st place in the real-time ranking. They are happy to see that but also realize the group at the 2nd place is quite close to them. They need to keep taking action to win the competition. And they are motivated and confident to do so. It's the last day of this month and the winner will be revealed tomorrow.



A day passed, it was the day to reveal the winner of the month. It's the group Mecha with no doubt. The group is super happy to see it and their contribution regarding the energy they saved via different sources in the month. Now they can celebrate it and claim their reward, the free lunch.

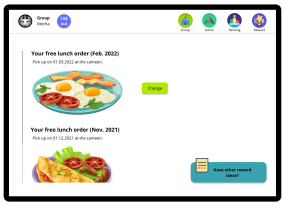


A group of friends in secondary school is usually of the same age. So there will be groups of young students or old students. If competitions happened between those groups, it's very likely that the groups of a certain age would perform better.
To make the competition fair for the groups across the school, groups compete with their own age range, either of low age students or high age students etc.

Reward

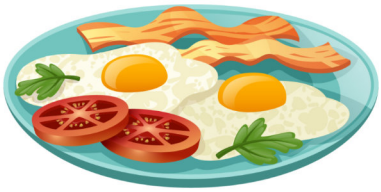
Free food

Currently, the reward for winners is free lunch on the first day of the next month. Every member in the winning group can choose their own free lunch from the list. If anyone changes mind, they can change it on the Reward unit before the next day. Then on the next day, namely the first day of the next month, they can pick up their orders at the canteen.

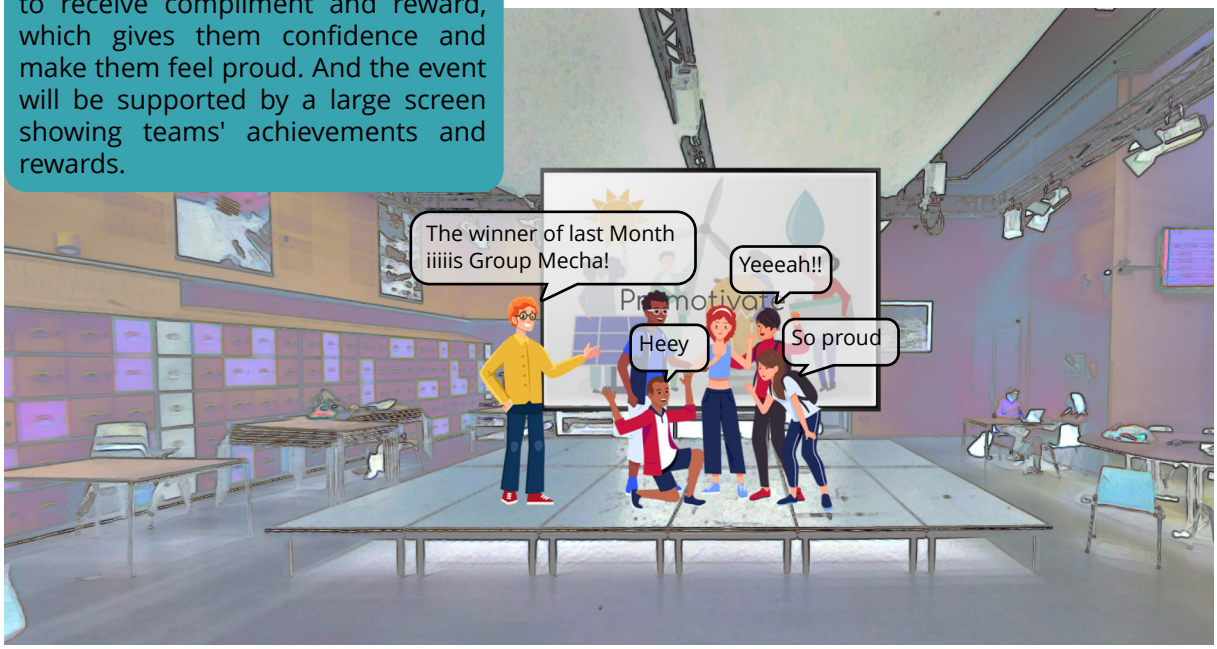


Your free lunch order (Feb. 2022)

Pick up on 01.03.2022 at the canteen.



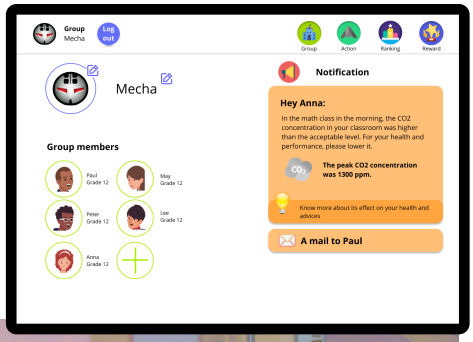
Once every month, a rewarding event will be held during lunchtime in the canteen by the ENERGE student group or the student council to reward the best group who contributes most to energy conservation in the school. The group will be invited to the stage to receive compliment and reward, which gives them confidence and make them feel proud. And the event will be supported by a large screen showing teams' achievements and rewards.

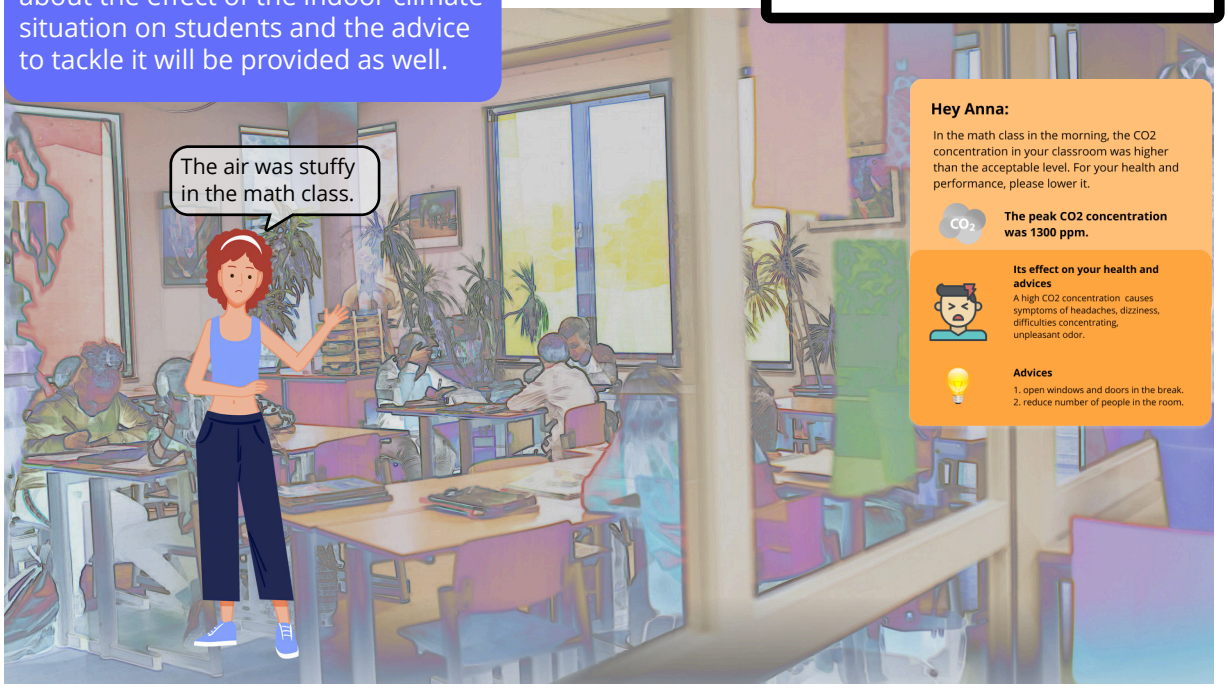


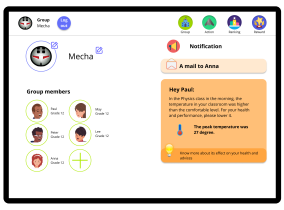
Group

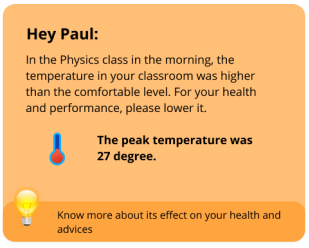
Group information

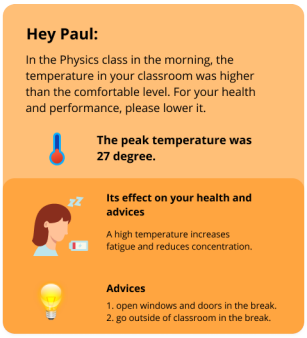
Notifications about indoor climate problems will be distributed to the group if any group members are supposed to be in the situation according to their class schedules. The problem will be explained by showing the data detected by the system. Moreover, the information about the effect of the indoor climate situation on students and the advice to tackle it will be provided as well.





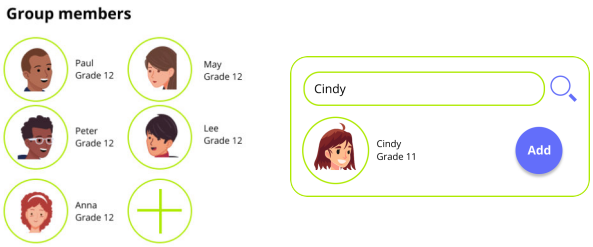


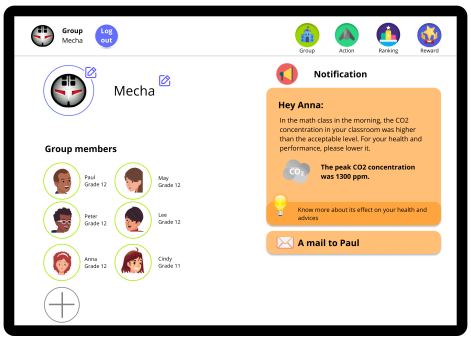


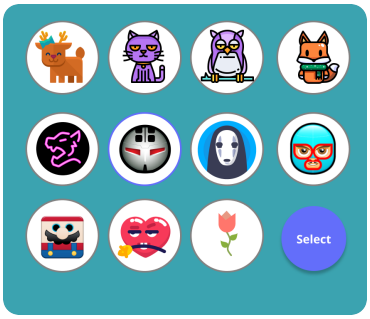


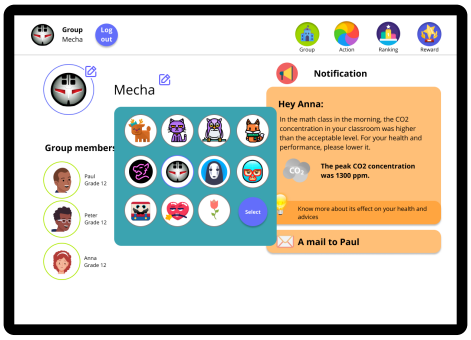
The system has a database of every student's basic information and schedule. Since students are members of the group, it's possible to indicate precise information about who is in what lesson at what time and facing what indoor climate issue.
Same as its effect on people and the advice, this relevant knowledge is inputted into the system in the first place.

If a friend wants to join the group, it's possible to add the friend in the Group unit by searching for the name or student number.
Besides, students can change the group profile photo and group name for customization.

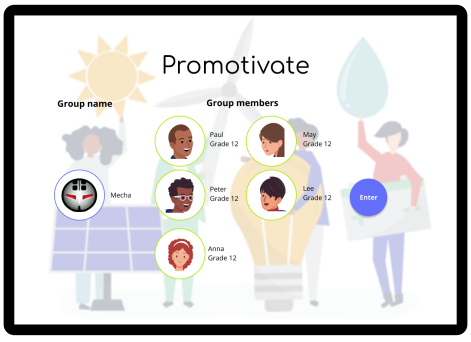








Students can create groups on PROMOTIVATE and the number of members in a group ranges from 2 to 6 students since the 'clique' hardly ever exceeds 7 people mentioned in Section 2.5. Besides, it doesn't need too many people that are up to 7 to do an action.



6.5 Concept validation

The concept was able to be developed on Figma, a digital interface design tool, where animations and transitions were also developed to make it high fidelity. Since PROMOTIVATE is digital, it can be tested both online and offline. And the experience of using it won't differ much as the interaction with the screen is similar i.e. tapping basically. The main goal of the evaluation is to assess if the concept achieves the design goal and interaction qualities. So the questions are:

1. How are participants' motivation and confidence towards sustainable behaviors influenced?

2. How do social dynamics affect participants' experience with the prototype?

3. How do participants experience the prototype in terms of usability?

Furthermore, the validation should indicate the design compliance with the design goal of 'making students feel motivated and confident in sustainable behaviors'.

Test plan

The final concept was tested and evaluated with secondary school students for around 40 minutes. For online tests, participants are asked to share the screen while interacting with the intervention. For offline tests, participants interact with it on a tablet. The plan is to test with both one student and multiple students. Testing with one person can get to know the person's experience in depth. Testing with multiple people is to provoke social interactions to simulate a real situation since the concept is based on that. Moreover, people will talk to each other and build on others' talk. As for the ages of participants, both young and old adolescents will be recruited to avoid age bias in the result.

Participants and procedure

In total, 5 participants attended the tests, of which 3 of them were tested online individually and the other 2 were tested together at their school (They are friends studying in the same secondary school) (Fig.34). Their ages from young to old are 12, 14, 16, 16, 19, which covers almost the whole age range of the target group. Due to the difficulty finding participants within the target group in the exam weeks, one participant, age 19, left secondary school in 2021. But the participant hasn't started higher education and still has a fresh memory of secondary school. Fig.35 shows the actual test setup.

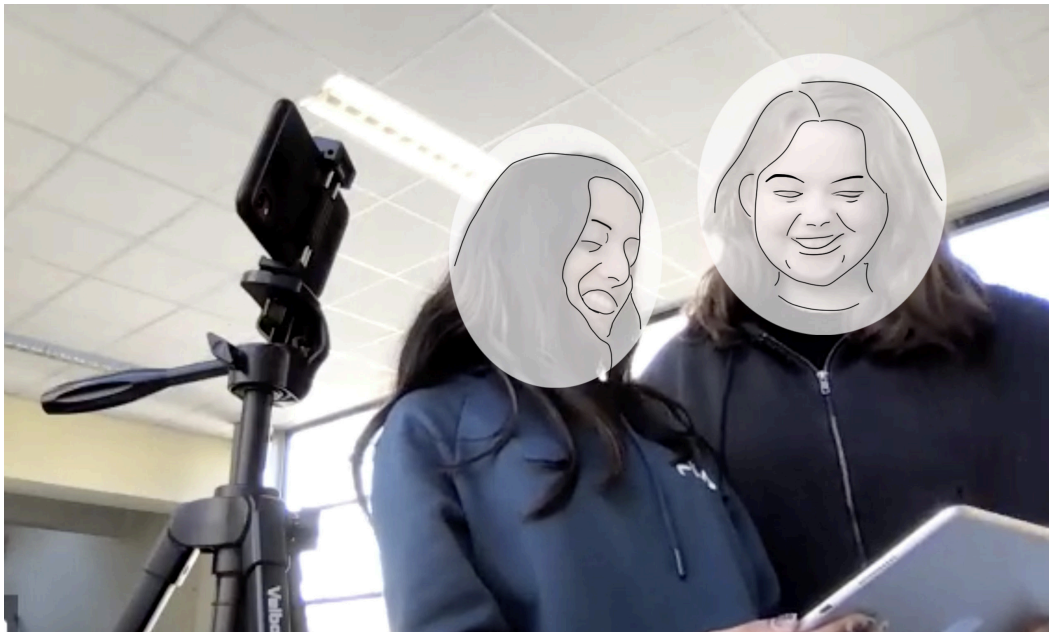


Fig.34 - Tasing with 2 participants at school

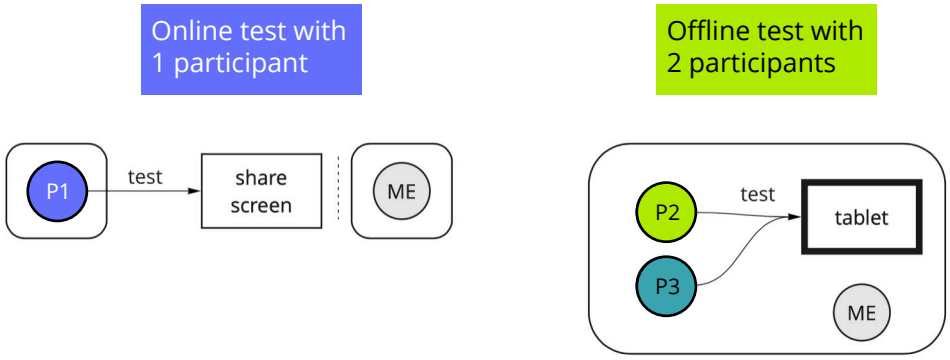


Fig.35 - Two test setups conducted in the concept validation

During the test, the test goal and procedure were explained to participants first. Then before the test started, the context was also shown to participants. The main part of the test was asking participants to interact with the intervention given the designated scenarios. Here are some examples:

1. Actions:

a. It's a break in the morning now, you want to do some actions to save energy. And your group wants to beat others and win the competition. What would you do?

b. It's now lunchtime, you just had lunch with your friends. You want to do actions to keep leading the 1st place in the ranking, what would you do?

2. Rewards:

a. Today is the end of this month, you are excited to check which group wins this month. What would you do?

3. Group:

a. Cindy is also a friend of yours and wants to join the group Mecha. And you are happy to welcome her to the group. What would you do?

After completing the scenario-based tasks, an interview was conducted. At the end of the evaluation, participants were asked to fill numerical ranking sheet to assess the interaction qualities and the User Experience Questionnaire (UEQ) to assess usability.

See the test guideline with detailed scenario-based tasks and interview questions, the numerical ranking sheet in Appendix 6.

Analysis

The feedback from participants was combined and clustered into groups of overarching themes to assess the intervention qualitatively. The surveys were analyzed to assess the interaction qualities and usability quantitatively.

Results

The feedback from participants was categorized into the themes of ‘Content’, ‘Usability’, ‘Emotions’ and ‘Group dynamics’. Some categories consist of multiple sub-clusters, ‘Motivation’, ‘Confidence’ etc. The full overview of the clustering shown in Fig.36 can be found in Appendix 7. The detailed insights from every category follow.

The results of the two surveys, numerical ranking sheet for interaction qualities and UEQ, will be added into ‘Emotions’ and ‘Usability’ respectively. The data and its analysis can be seen in Appendix 7.

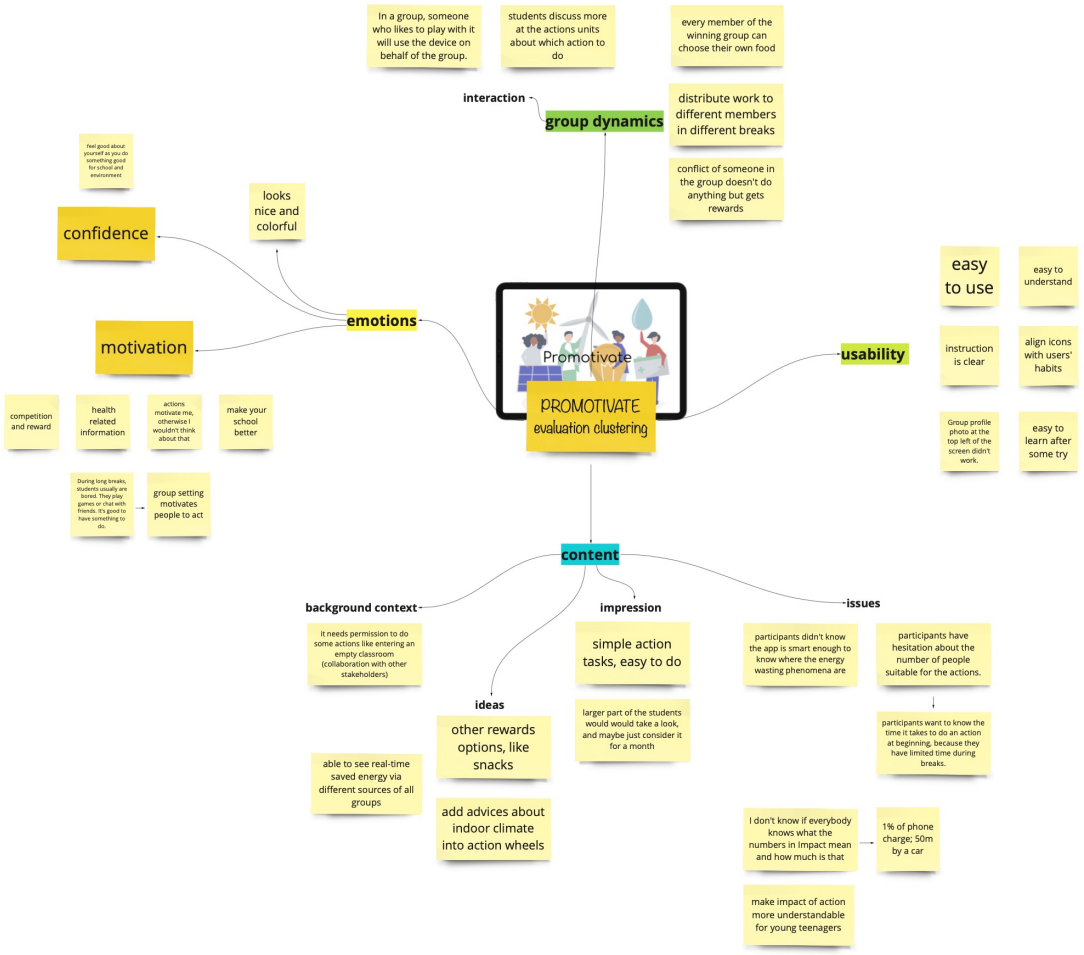


Fig.36 - Clustering the participants’ feedback in Miro revealed four overarching themes

Cluster 1: Emotions

From the numerical rankings of interaction qualities (Fig.37), it shows that participants have very positive feedback on all four qualities of Involved, Motivated, Purposeful and Confident.

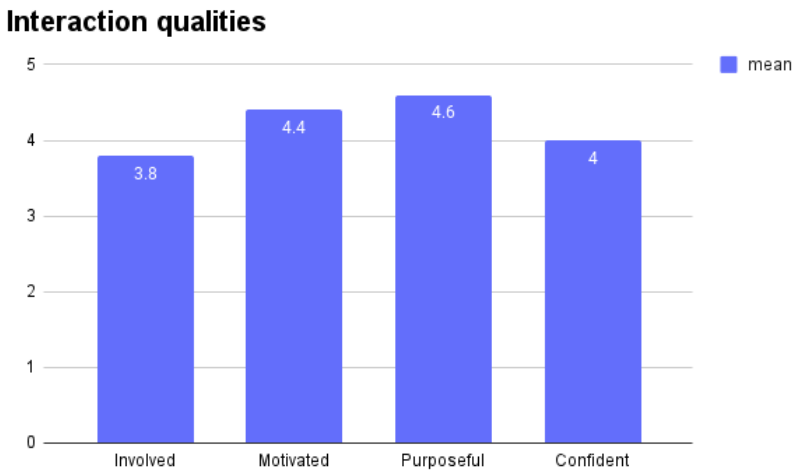


Fig.37 - The means of numerical ranking of interaction qualities

As for the motivation, all participants felt motivated by the intervention to act on sustainability. The most common stimuli are competition and reward. ‘Large part of the students would take a look, and maybe just consider it for a month.’ A quote from a participant. It’s also said that during breaks, students usually are bored and they play games or chat with friends. It's good to have something to do and it can make schools better. Moreover, the group setting boosts participation. Students can do it together.

Confidence is rather a tacit feeling as participants felt hard to express where the feeling comes from, but they did feel it. And often it mixes with other emotions, like satisfaction. As one participant mentioned when talking about confidence, ‘feel good about yourself as you do something good for school and environment’.

Cluster 2: Content

The general feedback for actions designated in the intervention is that they are simple action tasks and easy to do. It's good to see that everybody can do it, which can increase participation. However, the contents of actions need to be adapted to different contexts of schools. Some actions like turning off lights in classrooms may require permission from other stakeholders.

Some issues were identified. I would mention one here that is in the Action wheel screen, the information of 'number of students suitable for the action wasn't the most wanted but rather the time provided for the action. It's because they have limited time during breaks and they need to think first if they have enough time for the action.

Some ideas were generated as well. One idea is participants want to know more information about other groups they are competing with, like saved energy from different sources etc., which I think is feasible and stimulates competition.

Cluster 3: Group dynamics

The results related to group dynamics are most impressive for me, which gave me a picture of how it will happen in reality, especially from analyzing the test conducted with two students at their school. It's found that in a group, someone who likes to play with the tablet more will use the device more on behalf of the group. And the rest of the group stays passive even the participant is closer to the tablet. And they discuss more at the Action units about which action to do.

Further visions about group dynamics were provided from the interview. Students may distribute work to different members in different breaks. And someone in the group not doing anything might happen as well.

Cluster 4: Usability

In terms of the usability of the intervention, the general feedback from the participants was ‘easy to use’, ‘easy to understand’ and ‘clear’ etc. Some problems happened that the participant clicked the group profile photo on the top left of the screen when asked to add new members into the group, but the group photo didn’t work as I only activated another button for ‘group’ with an icon. However, the participant said it’s easy to learn how to use it.

The UEQ data analysis shows the concept performs positively generally in all six scales (Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, Novelty) (Fig.38). And the relative usability quality of the concept compared to other products in the data set of UEQ is excellent in the scales of Attractiveness, Perspicuity and Novelty (Fig.39). It shows that users like the concept - it’s easy to get familiar with and it’s innovative and creative. But the mean quality of Dependability is below average, which means users don’t feel in control of the interaction much. In the detailed results of 26 items, only the mean of predictable/unpredictable, an item of Dependability, is negative. It shows that users experienced something unexpected sometimes. It may be due to the first time trying it.

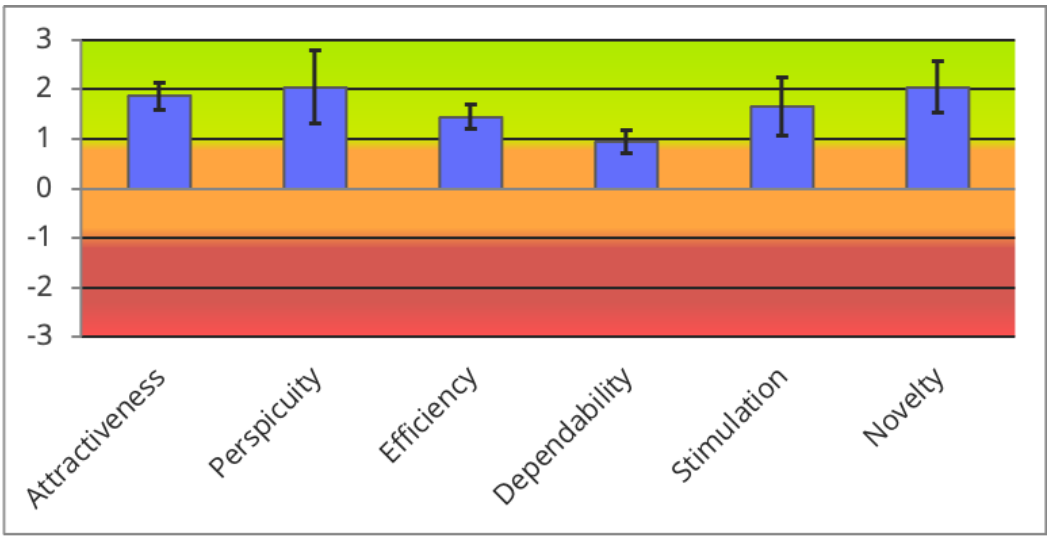


Fig.38 - The chart of UEQ results in different scales

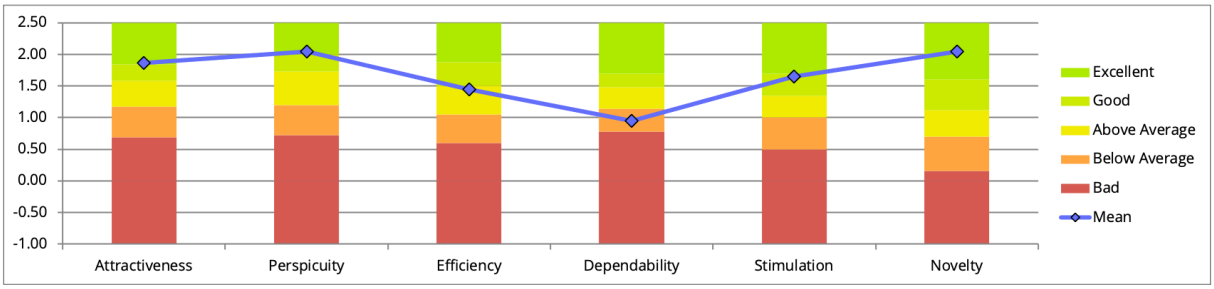


Fig.39 - The chart of UEQ results comparing to the benchmark in different scales

Test limitation

The evaluation of the final concept was limited by place, time and participants.

1. Three out of four tests were conducted online. Compared to seeing participants interacting with the intervention in person, I got fewer insights from the online tests.

2. During the tests, it was not possible to do the actions described in the intervention even in the offline test at the school. We just pretended the participants managed to do the actions but actually skipped doing them. It would be better if I could observe the participants do actions and got insights from that.

3. Due to the difficulty of finding the right participants within the requirements, there were only 5 participants recruited and of which one participant is 19 years old and left secondary school last year.

6.6 Insights and recommendations

The validation of the final prototype indicated that the design has the potential to motivate and encourage participants to act on sustainable behaviors and that participants were also positively influenced by the social dynamics within the group. The concept, with the application as the main design, was described as motivating and satisfying. And it's overall easy to use and attractive.

It was interesting to see every participant's own stimuli of motivation and confidence and how they influence each other in a group. It cannot promise that everyone will keep using the intervention but at least students will give it a try.

Along the process of iterating the prototypes, I have been focusing on the content of the concept mostly and less on the interaction with the prototype. What I did on the final prototype was using the simplest interaction but I designed it in an intuitive and clear way. Surprisingly, the feedback on the usability from the participants was very positive. They considered it as easy to use and it's attractive from the results of the survey.

To enrich the experience using PROMOTIVATE, working on the interaction with the prototype can engage students more as they enjoy a playful experience. One necessary work is to add music and sound effect onto the prototype, which definitely will enrich the user experience. Due to the restricted time and resources, I couldn't add sound effects to the prototype.

7 Project Conclusion

In the conclusive parts of the previous chapter, the insights and recommendations for the final concept PROMOTIVATE were discussed. This chapter will wrap up the project and its outcomes followed by an answer to the design goal. Then directions for future work are given. A personal reflection during this project will complete this report.

7.1 Project summary

This graduation project explored how to communicate information related to indoor climate and energy to motivate students to save energy through social dynamics.

extensive user research including co-design sessions with users and literature review into the topic of social dynamics between students and their attitudes towards sustainability helped to understand users comprehensively. It revealed most students don't have the motivation to contribute to energy conservation for the school. Yet, there is intensive social interaction within student cliques which is a potential means to motivate students to engage with sustainability. Based on the exploration, the design goal was defined and followed by the iteration phase. A series of design prototypes with information related to indoor climate and energy, based on the information communication method, was created and tested with the participants to inform the final design.

The final design of the project is an interactive application that motivates secondary school students to act on sustainable actions in the school context. The evaluation of the application showed that it is experienced as motivating and encouraging for participants with an easy-to-use interaction. Participants were motivated and encouraged by diverse features of the final concept. The practical information provided in the application related to detailed descriptions of the energy-saving actions was clear for participants. They also motivated each other in the group.

The design research and practice conducted in this project prove that social dynamics can play a big role in engaging users with the topic of energy conservation. Furthermore, it showed that the information on indoor climate and energy can be used to evoke motivation and confidence, which offers interesting directions for future work.

7.2 Answering the design goal

The iteration phase and final design were guided by the defined design goal to ‘make students feel motivated and confident in sustainable behavior’. Through the process of identifying the features that create motivation and confidence, the final design builds upon the composition of different features in an effective way. The design validation showed that it is possible to create an experience that evokes motivation and confidence among students in sustainable behavior by activating social dynamics between users.

7.3 Future work

The project started from the background of the ENERGE project and generated its own outcomes. Yet the graduation project has restrictions of time and resources, only the focus of the project could be done thoroughly. And the rest parts in the scope became the directions for future work, which can be the references for the ENERGE team.

Direction 1: Building upon PROMOTIVATE

In the prototype of the final concept, only a number of actions were provided. However, the situation differs in schools. So the next step is to build a complete set of actions that can be done in the schools and adapt it according to different schools. It applies to the indoor climate related information as well, which includes its effect on people and advice that needs to be put into the system. Technically if the concept wants to be functioning, the energy use data and the indoor climate data in PROMOTIVATE need to be inputted from ENERGE data dashboard by using API technology for instance.

Direction 2: Developing specified interventions suitable for the segmented target groups.

The current PROMOTIVATE is facing all students in secondary school aging from 12 to 18. Through the design process, it was acknowledged how big students change their mindsets and behaviors as they grow up during adolescence. If we want the concept fits more with students from 12 to 18, it's better to develop specified interventions for different age groups in secondary schools, like one for younger students (12-15) and another one for older students (15-18).

Direction 3: Developing for the in class scenario

The project focuses on the scenarios of the hallway during breaks and canteen at lunch which leads to the outcome inclines to energy conservation and sustainability but pays less attention to the scenario of in class. indoor climate and students' comfort. It wasn't validated that it applies to the scenario of the classroom during class. Since students care more about the comfort thus the indoor climate during class, the final concept probably won't work. So for the scenario in class, it's a direction to develop another concept.

7.4 Personal reflection

In the initial project brief of my graduation, I mentioned my motivation to create an impact on sustainability, as well as my personal ambitions on what to learn. I wanted to improve my digital prototyping skills and try to use data to build interaction with humans as a training practice for a professional designer.

Looking back on the process of my graduation project, and all the things that I did not mention in the report, plenty of things and activities happened in the past several months. I am surprised by the diversity of various activities that have been done including research and design across many disciplines, and how comprehensive they are. But the journey was not as smooth as I expected - lots of unexpected challenges paved the way for this tough project. The most impressive difficulty was recruiting the right participants for Co-design sessions and tests even though I had plan B and considered the influence of COVID-19.

It was a pity that I could not achieve my ambitions related to technology and data completely. I couldn’t dive deeper into designing with data within the limited amount of time. In the final design, the data that has been used was either gathered from the research activities or generated manually by myself. It would be better if the data could come from the ENERGE data dashboard so that it would make the design more complete. However, it requires more time and effort that I don't have more, unfortunately. But still, I am glad to see the impact I created by my design on the students to motivate and engage them in sustainable actions, which I could tell absolutely from the feedback they gave in the tests.

As the final project for the master of Design for Interaction, it’s a wonderful practice to design from experience to interaction to interface. Or I should say it the other way around - interface to interaction to experience. But the core of that, as I summarized, is information communication, which is big learning I had from the project.

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