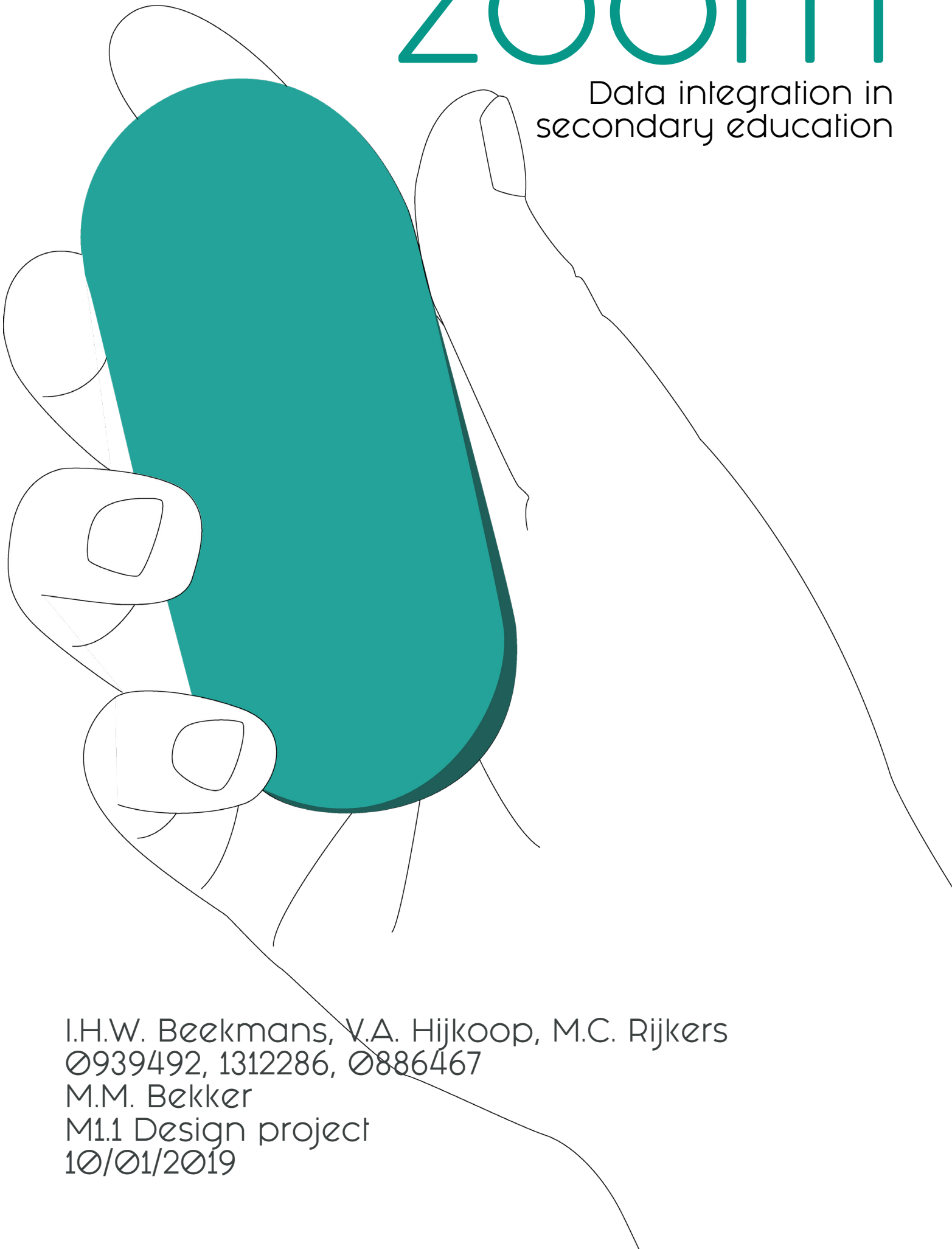
zoom

Data integration in secondary education



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Executive summary

The National Institute of Public Health and the Environment published the fact that fourteen percent of children within the age category of 12 till 17 years old are overweight[42]. On average, students sit for 11 hours a day! From this 11 hour, 67% of that time is spent at schools[1]. This results in a sedentary lifestyle which will keep developing as they grow older[17]. Schools can play a significant role promoting a more healthy physical lifestyle.

The Dr.-Knippenbergcollege - a secondary school which identifies itself with an advanced sports education[30] - came to us with a design challenge. The goal of the project was to design a curriculum that integrates playful physical exercise with learning, to stimulate 21st century learning goals, as well as make students more motivated to become physically active The design process is characterized by an user-centered approach, involving the stakeholders from the beginning till the end, resulting in zoom. zoom provokes physical activity by experiential learning by both gathering and exploring with personal data. zoom consists of a data-station, four different data-collectors and a platform for the students to work with the data. The four different data-collectors can measure different kind of data, and the data-station ensures the connection and charging of the collectors. The students can work with the data by dragging and dropping different blocks of functions within a digital environment. The user study shows that students value the hands on experience and the physical exploring aspects of zoom. During visualising an assignment and real-time experiencing it, the users were convinced that they will learn more quickly and remember the theory better than they do with the current system. Most of them were thrilled about the idea to combine movement with education. Yet, they were not sure if they will be motivated to move more in generally.

Table of contents

1

Welcome

Introduction

The National Institute of Public Health and the Environment published the fact that fourteen percent of children within the age category of 12 till 17 years old are overweight[42]. This is exactly the age category which is being secondary educated. On average, students sit for 11 hours a day! 67% of the time sitting is done at school[1]. Schools can play a major role in breaking these habits by provoking physical activity throughout the day. Nowadays, educational system is outdated and needs to be revised[33].

The well-known traditional school approach origins from the Industrial Revolution. In that time, the thought was that learning was a linear approach. Starting with the basics and when time passes expertise increases, or at least that is what they hoped. In reality learning is a more dynamic complex process of both falling, struggling and trying out before one can really understand the theorem. Without saying there is a significant difference between remembering facts and understanding the underlying connections[7]. Traditional schools still focus on memorising facts, originates from the requirements for working in a factory. With the introduction of the computer the industry grew expansional. A recent study from Redwood Software and Sapio Research shows that IT leaders believe that nearly sixty percent of businesses can be automated within the next five years[44] [26]. With other words artificial intelligence (AI) and robotics will slowly take over labour intensive jobs. Robotics and AI are really good at precision and repeatedly movement. However, we as humans have our own strengths compared with robots namely, adaption; creativity; planning; decision-making.

It would be illogical to train humans to do the labour intensive jobs which will be automated. It would be logical to emphasize the excelling characteristics of the human. If one wants to survive in the society of the future, one needs more than those skills. A group of entrepreneurs, teachers and researchers created a framework which involves all skills needed in order to participate successfully within the 21st century, the so called 21st century skills[29].

One of the schools which took the first steps to dislodge is the Dr.-Knippenbergcollege. The Dr.-Knippenbergcollege - a secondary school which identifies itself with an advanced sports education[30] - came to us with a challenge. The goal of the project was to design *a curriculum that integrates playful physical exercises with learning, to stimulate 21st century learning goals , as well as make the students more motivated to become physically active*. This report will take one through the whole journey, starting with understanding the design target and context, followed by the different design iterations, final design, userstudies, and the business plan.

Design target

zoom is envisioned to be an interactive data integration tool for educational purposes with a platform for both teachers and students of secondary schools. Besides the regular educational topics, the students will learn about sensors and their function, gathering, visualising, and working with their own data. zoom supports the students to work proactively with the topics and delve into them. zoom introduces student as well as teacher to the world of (big) data. Many say that the world's most valuable resource is no longer oil, but data[43][38]. We (humans) can not deny it anymore, we tend to be 24/7 online and leave our digital footprints everywhere. Companies try to find the golden rule in order to use the data in their advantage. One better prepares the next generation on how to deal with data, because, like it or not, data will become more and more important in the coming next years[44]. As for the user studies, the user group exists of secondary school students. The average age of a student in secondary school differs from 11 years old to 18 years old. As the opportunities of data integration were explored, the focus was on the users who have to work with zoom.

2

Design space

The client

Dr.-Knippenbergcollege is the client of this project which offers three levels of education; preparatory secondary vocational education (vmbo), school of higher general secondary education (havo), pre-university education (vwo). The total student count of the school is 1650 students. The school identifies itself with an advanced betá - and sports education[30].

The Dr.-Knippenbergcollege will soon - September 2021 - move to a new location "de Braak", Helmond. At "de Braak", the "Sport- en (be)leefcampus" will be ready in 2023[12]. Almost 2000 students will develop themselves at the Campus by a broader and richer educational, sportive, and cultural learning offer[14]. Along with the new location, the Dr.-Knippenbergcollege introduced 'domain education' in September 2018. This new education form is all about creating cross-curricular education. Cross-curricular education is more closely related to the modern society. The main focus of domain education is personal development of the students, they have the responsibility to plan their own learning plan and work independently and at their own pace on projects[11].

Instead of the traditional subjects, domain education is using learning labs as cross-curricular learning domains and ateliers in which experiences are the main point of focus. Students work on relevant society based themes and explorative projects within a two years program. The three learning labs are Spanish, Man and Nature, and Man and Society. The two ateliers are Sports and Design. The core subjects, Mathematics, Dutch, and English, are educated separately but are intertwined in their projects [11].

Context

Understanding the context is a core-value in order to create a service which is both innovating and meaningful for the user. That is why the design process starts with an in-depth research of the context. For many of us, the internet is integrated so thoroughly into our daily routine that we often fail to realize how a day without would look like. With the introduction of the internet one has the possibility to access all knowledge created by humans within just a few clicks. Changing the whole information transfer between cultures, experts and institutes. But if the information is just one click away, why would we bother to learn mostly facts?

In order to answer that question, we should make a leap back to the late 1700s. The Industrial Revolution ensured a radically change in the education system. The economic boost made it possible that children could attend schools and create a better future for themselves. These schools are characterized by acquiring objective knowledge, prior to application based on a fixed education offer[40]. The used methods are for passive learners, in other words for students who can sit still, keep quiet and learn on their own. Moreover, learning is been seen as a linear mechanical process. But research shows that in reality the process is dynamic and chaotic process. The education models did not change since then. But, the world did. The 21st century skills are brought to life, in order to bridge the gap between the things we teach and the things one needs[7].

21st century skills

The 21st century skills are constructed by a group of researchers, entrepreneurs and teachers in order to to prepare students for the quick changing world we now live in. With skills such as information skills, computational skills, media wisdom, ICT-basic skills, problem solving, communication, creative thinking, critical thinking, problem solving, collaborating and self regulation, students will be more prepared for the modern society[39]. Digital literacy is an important cluster of the 21st century skills, it combines ICT-basic skills, media wisdom, computational thinking and information skills. Computational thinking is about (re)-formulating problems in such a way that it can be solved with computer technology. It focuses on solving problems that need a lot of information, variables and computing power. ICT-basic skills contains the knowledge and skills that are needed to understand the operation of computers and networks and to be able to use different kinds of technologies and understand their possibilities and weaknesses. Information skills focuses on the ability to formulate and analyse information from (often digital) sources. Formulating the information problem and finding out what information is needed. Media wisdom stands for handling online and offline media in a smart and responsible way. You have to understand how media influences the daily life and how to use it in your advantage [39][35].

The importance of 21st century skills in the development of students are widely recognised, however the knowledge about how to implement these skills in the current education programs is limited. It appeared that the curriculum provide some possibilities to implement the skills, however the guidance and incentives are limited. Teachers report core goals, reference levels and educational tools lacking to implement 21st century skills[39].

The stakeholders

Within the context there are quite some stakeholders - beside the most obvious ones - which need to be considered. Figure 1 shows the stakeholders within the context of education. Fontys stands for the education of teachers. The government ensures that every school performs well by introducing an inspection team. The umbrella organizations are schools which work together with the same vision of education on the future. The publishers are without saying the school book publishers (e.g. Malmberg, Noordhoff, Blink, thiememeulenhoff). The most important stakeholder are the students who will interact with the system. The interaction needs to be meaningful as well as insightful. Learning can be characterized by a curve with a slow start, meaning one has to put quite some time and effort in order to understand the basic parameters. The curve continues ramping up more quickly over time in order to reach a performance plateau with slow progress. The curve suggests a linear process, however one can only create understanding by *trial and error*[45].

Experiential learning theory

zoom relies on the experiential learning theory. The experiential learning theory defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience"[24]. By collecting and working with data zoom enables the possibility to grasp and transform experience. Experiential learning is a set of tools and techniques to provide learners with experiences as if often thought[23]. Experiential learning is a process of constructing knowledge that involves a creative tension among the four learning modes that are responsive to contextual demands[24].

The experiential learning theory portrays four learning modes, two modes of grasping experience - Concrete Experience and Abstract Conceptualization and two modes of transforming experience - Reflective observation and Active Experimentation. The learning process is experienced as ideal when the learner "touches all the bases" - experiencing, reflecting, thinking, and acting. James Zull, Professor of Biology and of Biochemistry, suggests that the process of experiential learning is related to the process of brain functions[24].

The experiential learning theory posits that learning is the major determinant of human development and how individuals learn shapes the course of their personal development[23]. The learning styles can be assessed with the Learning Style Inventory (LSI). An individual with diverging style has 'concrete experience' and 'reflective observation' as dominant learning abilities. It is labeled "diverging" because they perform better in situation that call for generation of ideas, such as a "brainstorming" session. They are best at viewing concrete situations from many different points of view[24]. An individual with an assimilating style has 'abstract conceptualization' and 'reflective observation' as dominant learning abilities. They are best at understanding a wide range of information and putting it into logical form. They are less focused on people and more interested in ideas and abstract concepts[24]. An individual with a converging style has 'abstract conceptualization' and 'active experimentation' as dominant learning abilities. They are best at finding practical uses for ideas and theories. They prefer to deal with technical tasks and problems rather than with social and interpersonal issues[24]. An individual with a accommodating style has 'concrete experience' and 'active experimentation' as dominant learning abilities. They have the ability to learn from primarily "hands-on" experience. They enjoy carrying out plans and involving themselves in new and challenging experiences[24]. Students with an accommodating learning style benefit most with using zoom. By visualising and real-time experiencing complicated matters and abstract topics they can understand it quicker and have a more valuable and meaningful learning experience.

Self-regulation

As research shows, physical activity will not only exercise the body but the mind as well. It helps sharpen the focus and memory. Therefore it helps during attending the lessons and recalling what has been taught[30]. Research shows that moving and learning at the same time stimulates the brain, acquiring knowledge will go easier and the information received will be easier memorised[8][16]. Zoom relies on this principle by stimulating physical activity by letting the students gather their own data. Furthermore, Jonker[22] found that the percentage of talented athletes who attend pre-university education is higher than the Dutch national average. Figure 2, shows that (talented) athletes have a higher percentage of never having to repeat a class and of being not satisfied with a 5.5[21], in contrast to most students in the Netherlands[2][21]. On top of that talented athletes spend less hours on homework than their peers[21]. This can be led back to self-regulation.

In the context of learning and development, self-regulation reflects an individual's capacity to control it learning behavior. Zimmerman defined self-regulation as "the degree to which learners are metacognitively, motivationally and behaviorally proactive participants in their own learning process"[20]. The metacognitive component relates to awareness of, and knowledge about, one's personal thoughts and feeling. The use of self-regulatory skills is associated with success in a range of domains, including sports and academics. More successful students outscore their less successful counterparts on self-regulatory skills[20].

Studies suggest that metacognitive skills arise as early as four to six years of age and grow in the years. From the age of eleven to twelve, the metacognitive skills develop and transform from a set of domain-specific skills to a more general repertoire that can be used across performance domains. The age of twelve seems critical for the use of motivational skills, as children after twelve years of age are better able to balance their efforts to succeed and the interpret their capabilities. Evidence suggests that self-regulatory skills do not occur naturally[20].
Perry (1998) subdivided four contextual aspects fostering the development of self-regulation[32]. A context has to:
1. Have complex tasks[32].
2. Allow students to have a choice in task and level of challenge[32].
3. Provide opportunities for evaluation[32].
4. Offer opportunities for collaboration[32].

When using ZOOM the children are responsible for their own approach, development and learning process. However, the teacher will coach the children to make sure they follow the desired path. The students will be triggered to think about how and what kind of data they want to gather, with a required outcome.

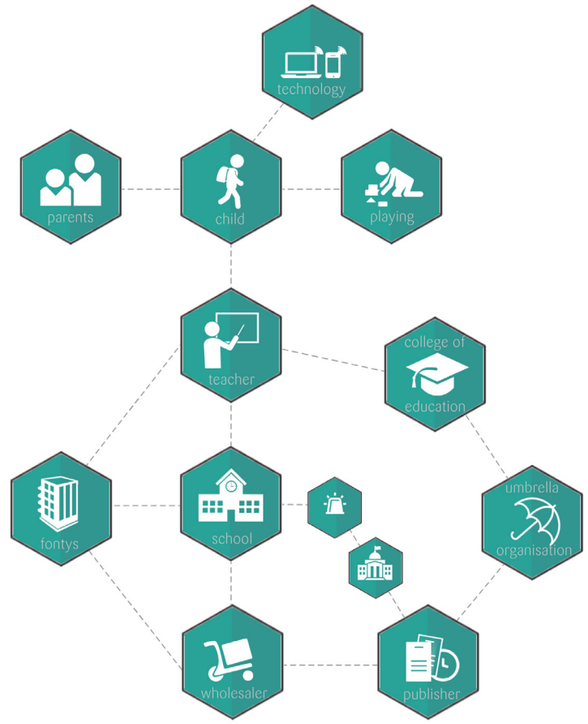


Figure 1: Visualisation of the involved stakeholders

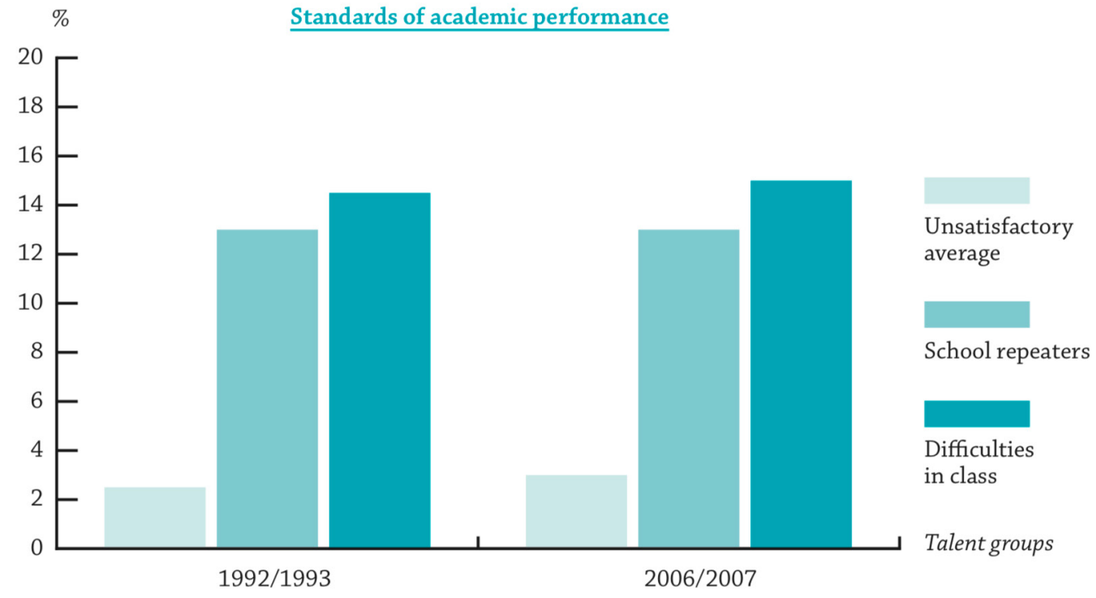


Figure 2: Visualisation of school efforts divided into talented athletes, athletes and non-athletes[19]

3

Ideation and Prototyping

First iteration | Pressure cooker

The first iteration emerged parallel with the research of creating empathy and grip on the context. As the design process initializes, it is particularly critical to identify who all the key constituents are that might have a stake in design outcomes[26]. Stakeholder maps serve this purpose, the visualisation can be found above in figure 1. To start the wave of endless ideas several techniques as rapid ideation, round-robin brainstorming, brainstorming and bodystorming are been used[6].

The goal was to generate as many ideas as possible. After all, it is all about possibilities, vision and diverging.One tends to think that designers only care about solving, about solutions that end a task, about closure. Nothing could be less true, finding opportunities, opening new doors is were it's all about[34]. At a certain point it a critical mass of ideas has been reached and it will become unproductive to attempt to keep pushing for more. The second phase initiated. The ideas got evaluated, compared, ranked, clustered and even thrown away in an attempt to pull together a few great ideas. One can distinguish between five domains, namely: learning with the aid of augmented reality or virtual reality, working with data, gamification to stimulate exercising, stimulating interdisciplinary in the broadest sense, and an online personalized tailor-made learning platform.

The best ideas from the five domains are selected and feet into a weighting matrix, figure 3. The matrix consists of requirements, preferences (personal goals) and constraints. The different parameters are been weighted and created by our gut feelings based on literature and expert meetings.

	Weight (0-5)	AR/VR	Data	Gamification	Interdisciplinary	Online platform
Requirement						
21st century skills	2	1	5	1	4	3
Playful interaction	3	4	5	5	2	3
Physical activity	5	3	4	5	2	1
Potential market size	3	3	4	3	3	4
Preferences						
Low cost	2	3	3	2	4	4
Low threshold	1	2	1	3	2	3
Original	2	3	3	3	4	2
Learning	3	2	4	2	5	3
Reliability	2	3	4	4	5	4
Technology (goal)	3	2	4	3	1	3
User (goal)	2	4	3	3	2	3
Constraints						
School context	4	3	4	2	5	4
Feasibility	3	3	3	3	2	4
Total	185	93	143	110	110	102

Figure 3: RPC matrix

In particular, one idea excelled: Learning by working with your own data. This idea revolves around the use of one's personal data in order to create understanding. Nowadays, educational systems focuses on the lower levels of bloom's taxonomy. The bloom's taxonomy is a framework used to define an distinguish between different levels of human cognition[13]. By aiming at the higher levels of this framework one can motivate and created a better understanding. Moreover, it introduces the (basic) principles of data. One thing is certain, data will become the main focus point of companies[43]. Good customer experience can be reached with the feedback (data) from the users. Recommended systems like Netflix, and Youtube function with the aid of ones data. There is a reason that data oriented companies will grow faster than normal companies[28]. It is no surprise that data is integrated as a goal within the 21st century skills.

The concept consists of a measurement tool, figure 4 and 5, which can measure different data like speed, time, light intensity, humidity, acceleration, etc. The student needs to decide which data-collector he/she needs in order to perform the exercise. The student can do this by turning several parts within the design. In total two different sensors can be selected at the same time.

To communicate the idea with experts, teachers, students and designers a low-fidelity prototype has been brought to life. The prototype made it even possible to test the interaction of turning. In order to help the audience a visionary design is been created within the Solidworks environment.

Validation

An expert meeting was organized in order to boost the design cycle. Below one can find some citations of feedback got from this presentation.
"I like the look and feel of the data block . . Withal, I prefer the idea of one sensor over modular ones." ~ Expert in gamification

"Think about the manufacturing costs, are the schools going to pay for it? Or the students?" ~ Entrepreneur in education design

"What does it support? Is it built as a wearable or as static sensor?"
~ Expert in playful interaction

"I admire the open-ended part of the project. Providing the teacher just enough support to work with it but giving them all the space to explore."
~ Entrepreneur in education design

Figure 4: 3D-printed model of the pressure cooker

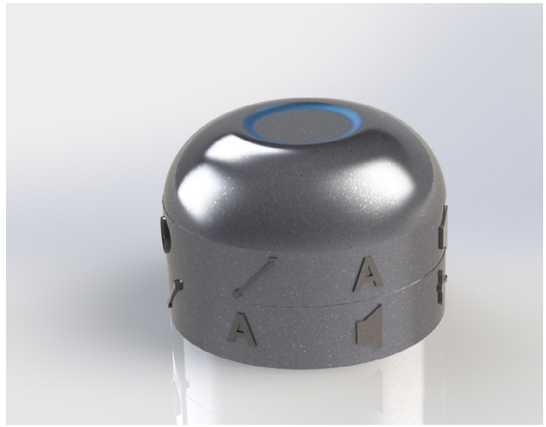


Figure 5a: 3D-model of the pressure cooker

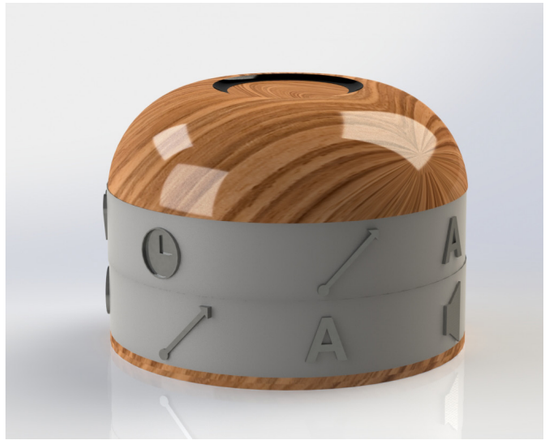


Figure 5b: 3D-model of the pressure cooker

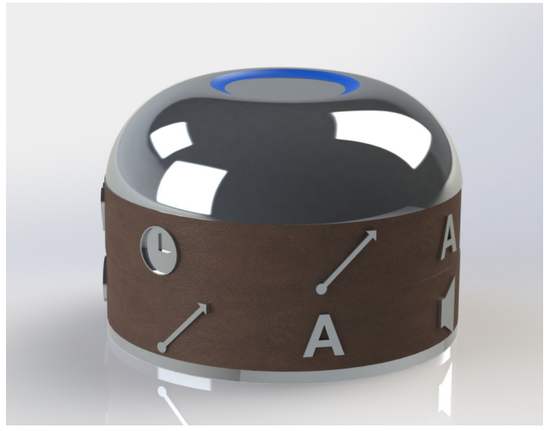


Figure 5c: 3D-model of the pressure cooker

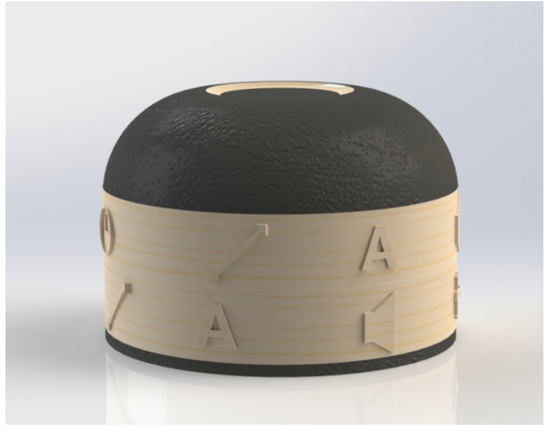


Figure 5d: 3D-model of the pressure cooker

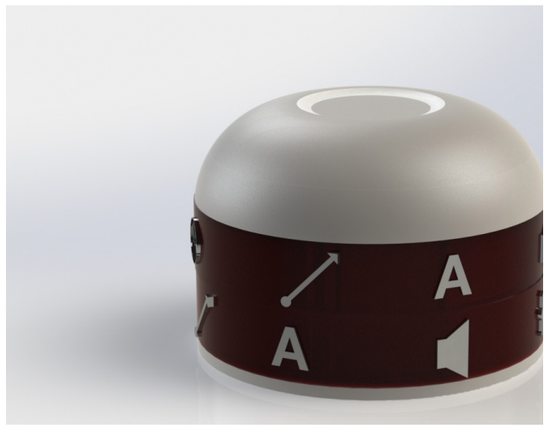


Figure 5a: 3D-model of the pressure cookee

Second iteration | Back to the roots

Showing the concept to experts, students, and teachers ensured that the design cycle became iterative. The overall feedback from both experts and students was positive, however one always needs to take positive feedback with care. It did not felt good to put the other concepts completely aside. Therefore, a new research initialized towards educational products, education models, and at the same time visiting and talking with the client. The next step was going through the design process all over again. However, to keep an open mind the idea of data was set aside.

The team participated in a value workshop, this resulted in a reminder of the importance of the values of all of our stakeholders. We used the method Behavioural Lenses of U CREATE, to achieve a better insight in the behaviour patterns of our user. These insights were used to map the values of all stakeholders including ourselves considering the concept[40]. Moreover, it helped to find and enhance the desired values.

To speed up the process the emphasis was put on the individual strengths of the team and every individual had one week to go through the whole process from ideation to prototyping on their own. The goal was to come with a stand-alone product or service instead of an addition to the existing schoolbooks.The main reason to do so, is that , most publishers are already working on an online platform to replace the textbooks[15]. They make small additions instead of a real game changer.

Expectation management

A way to create both meaningful and innovative ideas one can decide to keep the stakeholders really close within the design process, resulting in an user-centered-design approach. To prevent incomprehension, a meeting with the client has been organized. During this meeting general information, views, and preferences for the project were discussed. The take-home messages from the meeting read as follows: the iPad should not just become a 'book behind glass'. When the school will transfer to their new location, the Flex Schedule will be introduced. With this schedule the students will have 'ordinary' lessons and 'flexible' lessons. Students have the time and opportunity to choose which subjects they want to work on. The lessons will be more diverse as classes will be mixed. It should be possible for the concept to be 'flexible' integrated in a few years. At the end, all parties were on the same page.

Analysis of the observations

Not much later, several observations were conducted at the Dr.-Knippenbergcollege. The results of the observations are written down in an AEIOU. AEIOU is an organizational framework which helps the designers to attend to, document, and code information under a guiding taxonomy of Activities, Environments, Interactions, Objects and users[26]. The observations were conducted within several classes and were mainly passive. At the end of the observations, short conversations with the students took place. The core findings are written below within their specific category.

1. Activities

Some students made notes, but the main part was looking at their iPad. Secondly, some students started their journey right away and went for the path of trial and error, while others started reading the information in the book. It was noticed that especially during the domain education, students had a lot of freedom during classes and worked independently on projects and assignments, Students explained us that they liked the fact that they could work on their own and in their own pace. Some students were busy with the first assignments, while others were already at the next assignments.

2. Environment:

Research and Design There were two different classrooms, one is the more authentic one. Quite boring and leaves something to be desired. Secondly, are the working spaces which were chaotic, and noisy. This environment was more about trying out, communicating and doing projects.

Media Design The classroom has a really nice and open ambiance, which the teachers take at heart. The classroom has a rental desk for equipment. The classroom consists of three areas - excluding the studios (two sound studios, a photo-video studio, lightboxes)- an instruction area, a working area, and an individual area. The ambiance of the classroom matches the assignments the students receive. The assignments are very open to invite the students to be creative.
Domain Education The classroom consists of three smaller classrooms. The first classroom is the place where the teacher explains the theory to the students and helps them with questions they have. The second classroom is the place where students can work individually or quietly in groups. The last classroom is a classroom where students are not allowed without supervision, as there are heavy machines to work on projects

3.Interactions

One of the most interesting interactions was between student and their iPad. However, the iPad is a source of information it leaves something to be desired when looking at the interactions. It is not designed for school work and several applications didn't function as wished. The interaction between student and teacher changed a lot from our own experiences. The teacher is takes more and more the role of a coach instead of source of knowledge. Mutual respect between the teacher and the students is key for this situation. The last interaction was between students. Most of the time it a personal conversation between students instead of discussing the knowledge.

4. Objects

Of course the iPad which changes the interaction with school books. Of the downsides of the iPad is that it need to be charged in order to function properly. Secondly, the setup of the chairs and tables. Lastly, the desk of the teacher.

5. Users

Design and Research First years students with a preparatory secondary vocational education and their teacher.
Media design First years with a preparatory secondary vocational education , first and third years with a pre-university education and second and fourth years with a higher general secondary education and their teacher.
Domain education First years students with a preparatory secondary vocational education and a pre-university education.

Persona's

The observations together with the expectation management ensured a new and fresh look on the whole design challenge. The insights of the observation and interview resulted in several personas to empathise and understand our users. The persona's can be found in figures 6-8.

1. Students

The importance of 21st century skills in the development of students are widely recognised. Project based working and personal development are two important elements which is increasing important to prepare the students for modern society[39]. The team focuses on individuals with an accommodating learning style which has concrete experience and active experimentation as dominant learning abilities. People with this learning style have the ability to learn from primarily "hands-on" experience. By visualising and real-time experiencing complicated matters and abstract topics they can understand it quicker and have a more valuable and meaningful learning experience.

2. Teachers

An element that emerged was that the teachers had little to no guidelines nor tools to implement cross-curricular teaching. The domain teachers are expected to be creative, this freedom is important for them, but also quite difficult. The teachers have to stick to the learning objectives of their students and in the same time teach them the 21st century skills without tools to do so.

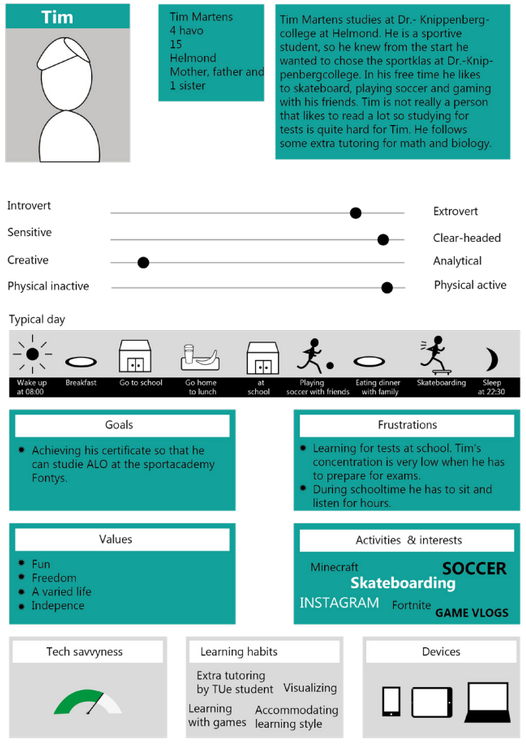


Figure 6: Persona of Tim

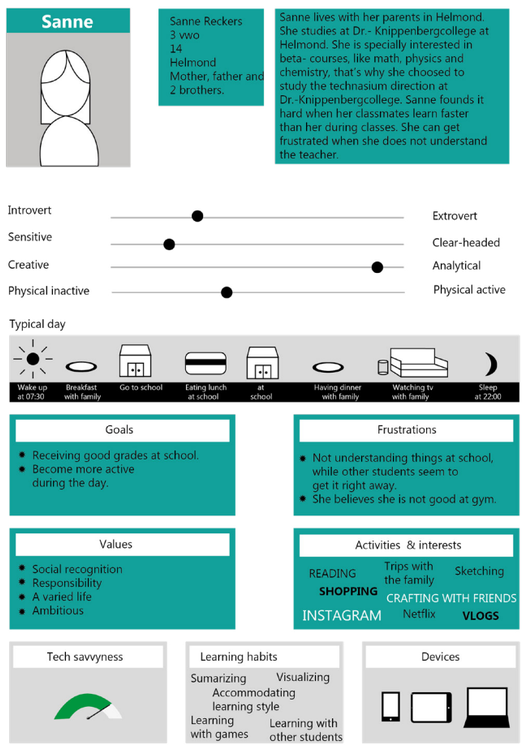


Figure 6: Persona of Sanne

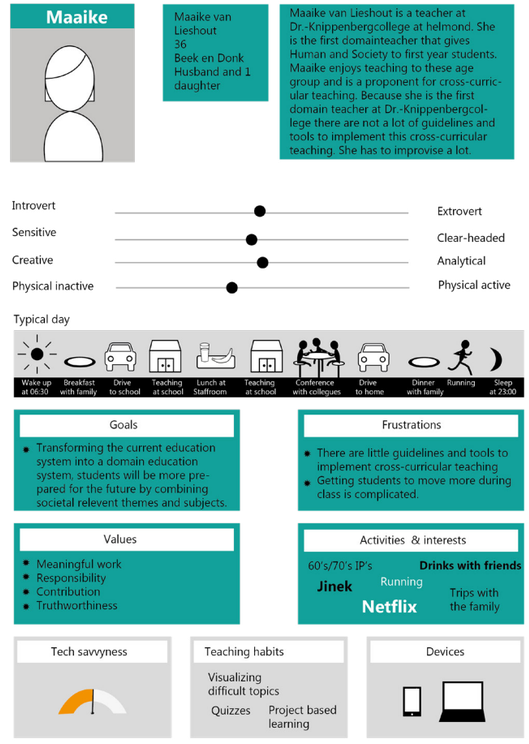


Figure 8: Persona of Maaike

Idea 1 | Online portfolio

This idea revolves around an online portfolio which keeps track of one's goals, weight, height, top speed, condition and other factors. The students will carry the sensors during the physical education class in order to register the desired data. After the class the students can take a glance at their portfolio and see their top speed (m/s), how many calories they burned or their acceleration over time. It can motivate the students by showing their progress over time, and setting new goals. The pitfall here is that the students will focus on becoming perfect, however it was designed for creating an understanding of data and their body. For some it can work preposterous due to the fact that it is too confronting, resulting in a grudge towards the system. The portfolio can be too confrontational for some people.

Idea 2 | Hybrid game-buillding platform

Secondly, the idea emerged of a service hybrid system which support students in building their own interactive game. The system consists of both a physical and software part which communicates seamlessly with each other. The students can work on different levels of programming. For the sake of simplicity, the most code are blocks which can be dragged and dropped, in addition one can create lines in order to create connections between the blocks. So for example, a switch case can be dropped and the students will make the connection between the determinant and as it corresponds with a certain value or sign do this. For the more experienced students it is possible to create the algorithm all on their own. The pitfall here are the costs and the usability within a classroom context.

Idea 3 | Collaboration tool

This idea is all about stimulating teachers to work together with teachers from other subjects. This planning application should empower the teacher to work interdisciplinary. By having an overview of the subjects within the different subjects the threshold got lowered. Creating an easier and less time-consuming interaction in order to work cross-curricular. Moreover, the system will alert teachers when subjects can be merged or connected in the broadest sense. One could think of learning about muscles during physical education classes, breathing and oxygen (biology and chemistry) or even the different forms of movement from art to physics.

The online portfolio showed some ethically problems for secondary school students. It is a great way for keeping track of one's condition for professionals, but it can be quite confronting for some people to constantly track their physical state. Besides, it did not seem to fit the individual goals, the squads nor the goals from the client. Therefore, this idea is put aside for now. The "drag and drop" and connecting part of the product-service hybrid system was something to investigate more into. The same goes for the plan-app, the interdisciplinarity has a great potential, especially when looking at the 21st century skills.

Third iteration | converging

It was time to close some doors and open new ones. Immediately, it seemed obvious, why not take all the strengths of each concept in order to generate a better one. This resulted in a service hybrid system for both the teacher as student, whereby the teacher can use the system to create cross-curricular classes with other teachers. It will aid the teachers to lower the threshold and make it less time-consuming to create these interactions. This is all done by having an online overview of the topics within the different subjects over time. The student can gather data with a physical product and work within a platform with its own data. This can be explained due to the fact that those countries focus on reproducing from existing knowledge. Blooms taxonomy is a framework which visualizes how to go from knowledge to wisdom. Most subjects only touch the lower levels of the pyramid while the goal is to create new value of knowledge. A teacher gave the following example which illustrates the problem: when the students need to make a physic exercise about speed they all know that the unit of speed is meter per second. However, they do not understand that 3 m/s means that one travels 3 meters every second.

DEMI

DEMI is an educational data measurement instrument consisting of an online platform for both teachers and students, figure 9. With DEMI students will be introduced to data, their bodies and exercising. They will receive assignment relevant to their lessons. Within these assignments they will be motivated to do exercises and gather certain data. They will learn more about sensors and their functions, gathering and transporting data and visualizing and presenting data. DEMI consist of different sensors, a data-station, an online platform for teachers and one for the students.
The sensors are divided into four different ones. Starting with one to measure heart rate, acceleration, and steps also known as the body sensor. Secondly, there is a sensor to measure temperature, humidity, wavelength, light intensity and air pressure better known as Environment. Thirdly, the vibration, magnetic fields, sound can be measured with the physic sensor. The last sensor is able to communicate with RFID, Bluetooth stickers which can be equipped with force sensors. All sensors are equipped with a timer and have a local storage. In order to get the data from the local storage into the online platform one needs to push the sensor back in data-station. The data got saved as a JSON file including the sensor id and timestamp, it will collect every 50 ms a datapoint.

The data-station will be used to both dock and charge the sensors. There will be attributes around the station which can help during the data gathering phase, like wristbands, chest straps, foot attachment tools, etc. When the data-collector is put back on in the data-station, it starts to send the data. Both the data-collector as the datastation are been equipped with pins for data transfer. These are connected when the data-collector is placed within the data-station. The data-station will function as gate for the data. It will take the json file from the data-collector and send all values with a http request to php-script which put the data in a database (mysql) with the use of the HTTP POST-method. The platform of the student can obtain the specific information by using the HTTP GET-method.

Within the platform teachers share their lesson topics with each other, figure 10 and 11. It enables teachers to give cross-curricular education. The teachers can help each other by adjusting some themes and activities to provide each other data, knowledge and skills.

The online platform has the possibilities to show the schedule and the homework of the students. But the core page is where the users interact with the data. This can be done with the use of certain code blocks which can dragged and dropped. For example, the body sensor will provide a json dataset including time, heart rate, acceleration and steps taken every 50 ms.. The student can select and drag the time dataset and put it on the x-axis of a graph. The same goes for the acceleration but now on the y-axis. Moreover, the student can choose between several graphs like a line graph, bar chart, pie chart or scatterplot. The students can work with their data and calculate the mean, the highest number, the lowest, normal distribution, etc. The building blocks are designed in such way that it is plug and play. However, for the ones who seek more of a challenge can code their own block. The teacher can make a distinguishing between students and ask for example code to create ones own block to calculate, for example,how often ones heartbeat got over 140 bpm.

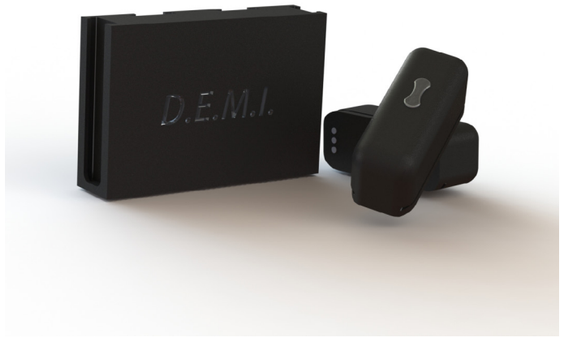


Figure 9: 3D-model of DEMI

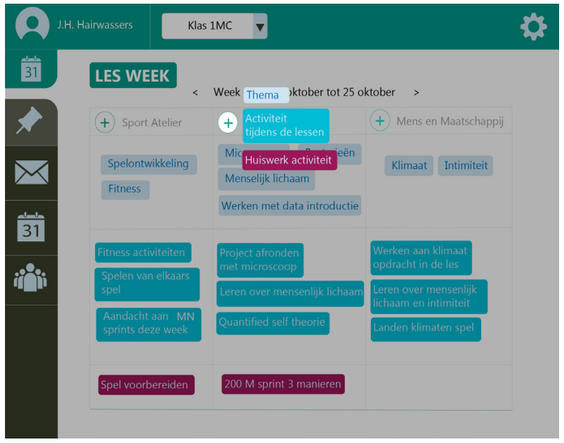


Figure 10: Platform of the teachers

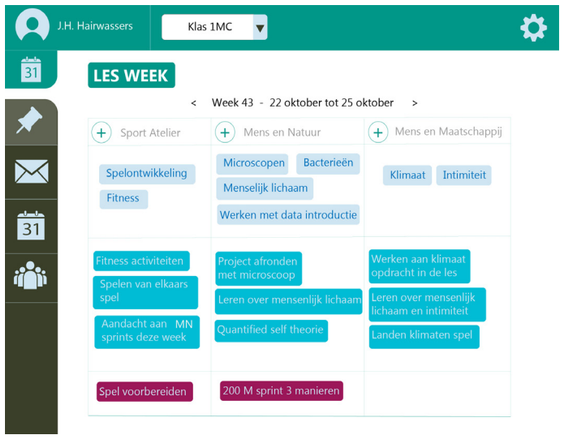


Figure 11: Platform of the teachers

Self-determination theory

> Humans have a deeply curious nature, and more often than not it is about the minor things in our lives. We tend to read about people we surely will never meet, go to places we never go back to, and learn about topics we will never have to use in our daily lives ever again. But due to our intrinsic motivation we keep doing so. Intrinsic motivation refers to behaviours done in the absence of external input that are found inherently interesting and/or enjoyable[27]. When humans are intrinsically motivated they explore, play, and engage in activities for fun and excitement of doing so. Such behaviours are accompanied by feelings of curiosity and interest. Self-determination theory (SDT) points out that intrinsic motivation is sustained by satisfaction of the basic psychological needs for autonomy, competence, and relatedness[27].
>
> The drag and drop system will enhance autonomy, giving the students the opportunity to work with the data on their own. One can build quite a complex system of calculations in order to transform the data into a more meaningful matter. Making the students able to solve problems of their own level. The students will have total control over their own process, creating a space for trying out and working on their personal issues. Moreover, the students will be introduced with the system creating the competence and the feeling that they are able to work with it. By making the exercises more personal - personal data - one can create relatedness.

Midterm demoday | Feedback

At the midterm demoday DEMI got evaluated by different experts. Below one can find the most relevant feedback received from the midterm demoday.

"The concept seems promising, however think of every concept… See the SLO – website for more insights". ~ Expert playful interaction

"How to visualise the data, in such way that it becomes easier for Students to understand?" ~ Student

"Data integrations seems still a bit underdeveloped. The strength now is more the planning system." ~ Expert gamification

"Open system, however a lot of structure and clearness" ~ Student

"Try to focus on one aspect instead of trying to do all at once"
~ Expert play and learn

"Try to think of scenarios in order to find early bottlenecks!"
~ Expert playful interaction

"Try to get into contact with teachers in order to add the pedagogics part." ~ Student

All the other received feedback have the common ground as stated above. The midterm demoday functioned as an eye opener. It seemed that the project was about tackling too many things, which resulted in not tackling anything at all.

Fourth iteration | Going forward

The project is starting to become a victim of creeping featurism. Overtime more and more features are been added resulting in a swiss army knife which loses its core value. One of the well-known examples is the phone, which also became a flashlight, calendar, calculator, camera, mp3 player, navigator, dating device and microcomputer. Resulting in a device which becomes an inefficient product. Moreover, the interactions become too complex to use for the most users[18]. DEMI was going to end up the same way. This iteration starts by taking out the additional features the idea becomes simple and plain forward, which is not a bad thing at all. All attributes are evaluated with the help of the Kano Analysis to determine which attributes has the greatest impact on customer satisfaction[26].

Kano analysis

The more is better approach is an ineffective strategy when creating additional customer satisfaction[26]. The Kano model is a theory for product development and customer satisfaction, which makes a distinguish between five different product attributes, namely: Required, desired, delighter, Neutral, anti-feature[26]. Figure 12 shows a visualisation of the placements of the different attributes. Without saying the product will focus on the required and desired attributes and get rid of the neutral, anti-features.

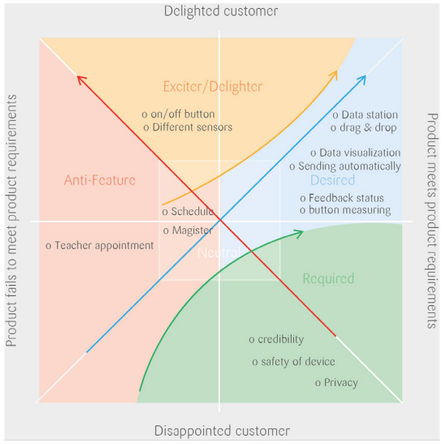
zoom

The core principles from the kano analysis ensured a new concept, namely zoom. zoom is a data measurement instrument for educational purposes with a platform for students. The students will got introduced to data and how to gather, visualise and work with it. The students can work with the data-collectors separately and together. The data-collectors can be used for different subjects; e.g. biology, physics, physical education, science, geography, history and sociology. zoom enables project-based learning. It supports the students to work proactively with the topics and delve into it. Focusing on the 21st century skill; digital literacy.

Prototype | Drag-and-drop

At this point in time, a prototype has been made to test the interaction with the data. The algorithm has been created within the processing environment, figure 13. On the right side one can see the interface with different parts which are been used in order to work with the data. In other words, one can distinguish different actions. Firstly, adding the data within the environment. This can be done by dragging the different ellipses with the corresponding names to the axis. Secondly one could aggregate the data with the use of different code blocks. Code blocks are pre-written blocks which will do the magic for one. Meaning that the student can select different actions and see immediately the result of it. The prototype got created and tested within the team. The results were promising but the drag and drop action was not as smooth as hoped. The first problem that emerged is that the software needs to run on a laptop or tablet, which can be tricky with the use of processing. Secondly, processing is not designed for user interaction. In addition the user is restricted to the given functions, a way to get rid of this is by providing the opportunity to the user to create their own code block. Another feedback point is that the aggregation is hard to follow due to the fact that one does not got any feedback on this.

A good alternative is creating an interactive HTML site, which is actually designed for user interaction. The environment is divided in three different parts namely, the navigation bar, workspace and inventory, figure 14. On the top one has a navigation bar, which for now only holds the logo of the project. On the right side of the site, one can see an inventory with different buttons representing different action blocks. The remaining space is claimed for work space. This is the area where the magic happens, every block has the possibility to connect to another one in order to visualize the aggregation of the data. The graphs can have two inputs namely for both the x- and y-axis, the sensors can have multiple outputs but no inputs and for the mathematically modifications it depends on the action. The standard principles like multiplication, dividing, plus, minus, integration and filtering the data will be added. In order to make sure that none will be forgotten, one has the power to program their own block. Moreover, this enables that students can challenge themselves.



Question 1: If product attribute is present, the customer feels...

Question 2: If product attribute is absent, the customer feels...	Satisfied	Neutral	Dissatisified
Satisfied	Questionable	Anti-Feature	Anti-Feature
Neutral	Exciter/Delighter	Neutral	Anti-Feature
Dissatisfied	Desired	Required	Questionable

Figure 12: Visualisation of the Kano analysis

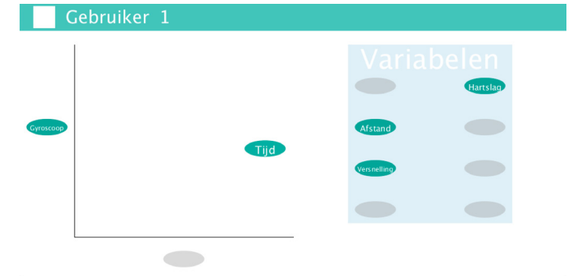


Figure 13: Processing environment

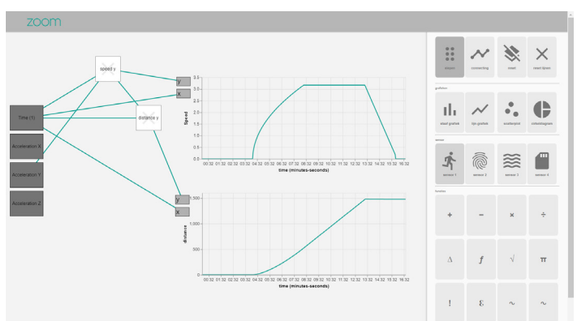


Figure 14: Data-visualisation environment (HTML)

To lower the threshold the adding feature is kept simple and straightforward. Below one can find an example code which will take the summation of all inputs. One starts with the name of the action, in this example it will be Summation. Within the square brackets one states the amount of inputs and the name, followed by another pair of square brackets with the output. If one wants let's say three different outputs, it can just add these parameters in these brackets divided by a comma. Between the curly brackets one creates the algorithm to perform the action. You may have noticed but the code is based on javaScript.

```
Summation[infinity][summationValue]{ for (int i = 0; i < infinity.length() ; i++){
        summationValue += infinity[i];
    }
        return summationValue;
    }
```

The data visualisation part has been handled with the aid of Vega. Vega is a plugin for HTML pages in order to create interactive visualisations. In order to make a distinguish between drag and connecting one has switch the button on top of the inventory.

Prototype | Data-collector

zoom consists of four different data-collectors which all are equipped with multiple sensors. Several scenarios are been created in order to find the desired sensors within the data-collectors. The following group of sensors are been used multiple times together, On the first place the heart rate, body temperature, and acceleration got grouped. Secondly, infrared, ultrasonic, sound, vibration, magnetic fields and linear rotary got put together. The third one is all about environmental conditions like light intensity, color, humidity, substances, temperature and barometric pressure. The last one is about a force sensor, gyroscope and gps.

The sensors were decided. However, the look and the size of the data-collector not. To explore as many possible looks, the shapes were explored. First, by sketching to determine a direction and setting different requirements. When it was determined, the 3D-model exploration started. The size and requirements were set and the look was about to. As you can better decide when you have a hands-on feeling on how it feels, it was decided to print the 3D-models, figure 15. The shape explorations can be found in appendix B. The following conclusion could be made from the 3d models. The data-collector needs to be small, so it will not influence the user. Moreover, the data-collector needs to be wearable, ensuring that the user can run, jump or put it on something.

The data-collector got designed with these insights kept into mind. This chapter will be divided this process into two parts namely, the look and feel of the data-collector and the electronics. Although both influence each other to a certain degree they both got treated separate. The decision to separate these is simple, trying to find the most optimal for both. The cycle starts with an exploration of several different forms (figure x sketches). The different forms got brought to life with the use of rapid prototyping. Every form got considered and graded with the help of a weighting matrix. Including parameters like: look, feel, size, material and color scheme. In the end, the form shown in figure 16was prefered over the other ones.
The user need to be able to work with the data-collectors. Without saying they are in need of any form of feedback to make sure they understand its working. It can be possible without but this will result in confusion and eventually into frustration for the user. To counter this the user needs to get a clue when the data-collector is on, collecting data or when an internally error occurs. All different possibilities are put into a weighting matrix. The best way to inform the user that the data-collector is on, or collecting data is by making use of visual feedback. Haptic feedback will be to unobtrusive to notice and the main problem with sound is that it only notifies the user once. In order to (de)activate the data-collector the user has to push both buttons at the same time. This ensures that the user cannot (de)activate the data-collector accidentally. The data-collector activates automatically when taken from the data-station. The functionality is described with the use of a finite state machine which can be found in the appendix E.

In order to create a fully functional data-collector the electronics need to be designed. To make sure that the data-collector got as small as possible, working properly and is the most efficient considering battery consumption a personalized printed circuit board is been preferred over existing modules. For prototyping purposes the data-collector got created with existing modules, resulting in an inefficient, big prototype. For the brain of the sensor a Wemos-d1 mini pro has been selected due to its efficiency, size, and it can connect over Wifi. For the memory a SD-shield has been used. Below one can find the different setups of the data-collectors used for the project and the corresponding equipment. The circuitry can be found within the appendix D. One drawback of the Wemos-d1 mini pro is that it has only one analog pin, and some need several analog pins. This has been solved with the use of a 16-channel multiplexer (CD74HC4067) which enables the prototype to have 15 inputs on the analog pin. On the bottom of the data-collector one can see two small metal plates, these are been used for charging the data-collector via the data-station. The positive side is also connected to a digital pin of the Wemos (microcontroller) to inform that it can start sending the data.Like stated above, every data-collector will have their own custom printed circuit board. The main reason to do so is to create a prototype which works properly, is efficient and modified so it can fit in the case.

Prototype | Data-station

In order to tackle all possible bottlenecks like charging, sending data, who borrowed the data-collector, and storing of the data-collectors, a data-station has been created. This data-station will tackle all problems in an unobtrusive way. The data-station is able to hold 75 sensors and is equipped with an RFID reader on top of it. The students need to scan their school card and the data-station will light up the data-collector which is charged and ready to be used. The LED ring on top (figure 17) provides visual feedback to the user. In addition the data-station links the taken data-collector with this school card, and saves it for administration purposes. The different holders of the data-station are powered, so that it informs the data-collector it can send its data and in the meantime it can recharge the battery. The data transfer is been handled with the use of a TCP server which has been set up by the data-station itself.

The data-collector will first send it's unique id, the data-station waits till it receives the id, creates a socket and sends that it's ready to receive the values. The data-collector will in return send its data. The data-station will save the data and makes it accessible for this certain user only. A TCP server has the preference over an UTD due to the fact that an UTD drops all information at once without knowing if the system is ready to receive any information. If one does so, it is possible that data got lost. Therefore, the slower one (TCP) has the preference. When all data has been send and the data-station confirmed that it has been saved the data-collector empty it's local storage and waits to be used again. The finite state machine explaining the different stages can be found in the appendix E.

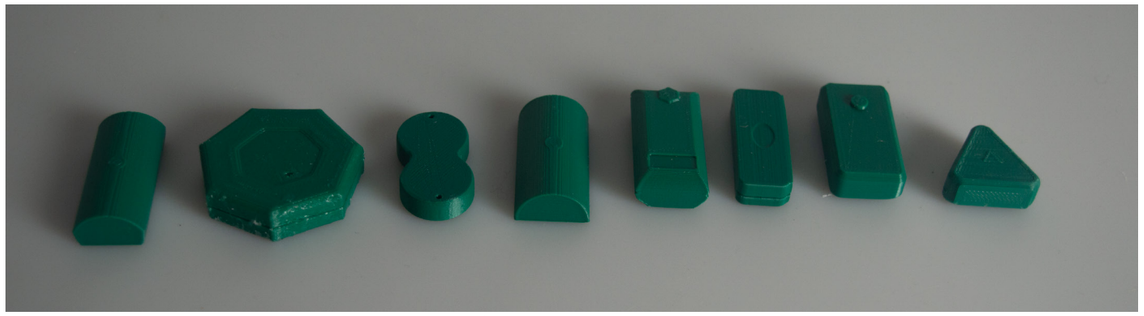


Figure 15: Results of the shape exploration

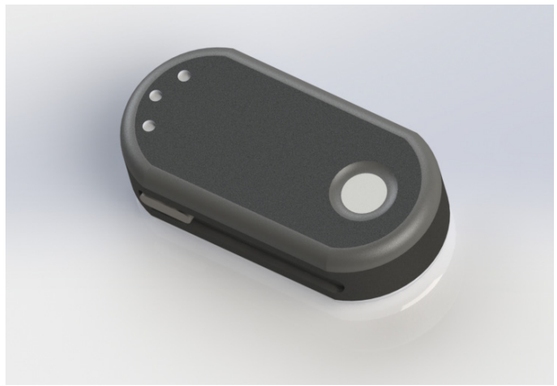


Figure 16: 3D-model of the preffered shape

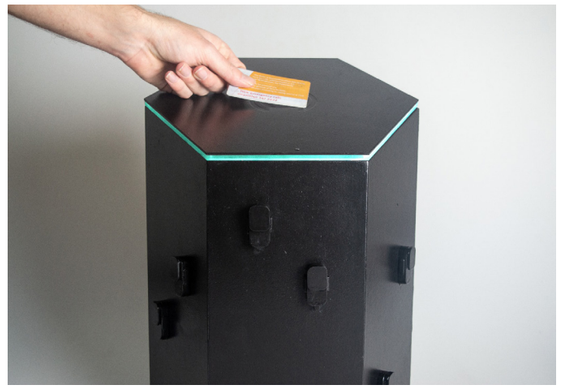


Figure 17.a: Interaction with data-station

Figure 17.b: Interaction with data-station

Figure 17.c: Interaction with data-station

Prototype | Material

In order to tackle all possible bottlenecks like charging, sending data, who borrowed the data-collector, and storing of the data-collectors, a data-station has been created. This data-station will tackle all problems in an unobtrusive way. The data-station is able to hold 75 sensors and is equipped with an RFID reader on top of it. The students need to scan their school card and the data-station will light up the data-collector which is charged and ready to be used. The LED ring on top (figure 17) provides visual feedback to the user. In addition the data-station links the taken data-collector with this school card, and saves it for administration purposes. The different holders of the data-station are powered, so that it informs the data-collector it can send its data and in the meantime it can recharge the battery. The data transfer is been handled with the use of a TCP server which has been set up by the data-station itself.

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Students are not famous due to their caution towards products. The sensors will fall, be scratched and put under certain amount of loads. To make sure that the product survives these typical actions a material analysis has been conducted. The following preferences and requirements are been used to make a choice between different materials and manufacturing techniques. First of all, the material needs to withstand temperatures from, in most extreme cases, minus 5 till 40 degree Celsius. Secondly, the senor will definitely fall and therefore the outer case needs to withstand these forces. To make an estimation of the magnitude one can make use of the basic formula for potential energy which is represented as followed: $E = m{\cdot}g{\cdot}h$. The mass depends on the chosen material, thickness and electrical parts. The gravitational force is equal to 9,80665 [m/s^2] and the height can be determined. For the sake of simplicity we say that the max mass will be 300 gram and the height will be max 10 meters (two floors). This means that the impact energy will be around 30 newton. This is just an estimation and guideline. 30 newton is not that much but one has to remind that it is a point force and that these calculations keep momentum out of scope. Not to forget, the outer case needs to protect the electronics from tearing apart. The sensor needs to be both lightweight and safe to work with. Moreover, the visual appearance of the device, which needs to emanate the vision.

To make the leap from the requirements to the optimal material one can make use of Ashby diagrams, which shows two different attributes opposite to each other. The first one is the Young's modulus strength vs relative cost per unit volume, revealing the cheapest and most stiff material. Secondly, the strength vs the density, finding the lightest and strongest (with respect to forces) material. Both most optimal materials can be found by moving the red line (figure 18 and 19) parallel to the left, the latest found material is the most optimum[3]. The most optimum one would be foams, followed by polymers. Foams will not do the job, therefore the preference goes to polymers and especially to ABS (PC) due to its rigid, weight and price.

All manufacturing processes have their own strengths, weaknesses, and aesthetically outcome. Depending on the material (ABS) and wanted result one can go for a certain manufacturing and finishing process. The case of the sensor will be made with the use of injection molding, appendix J. This process is relative cheap compared to others. Moreover, the mold can be reused meaning that the variable cost of each sensor will reduce when the quantity increases.

With the use of infinite element analysis within the Solidworks environment, the most optimum thickness has been calculated. The sensors case need to have a thickness of at least 1,2 mm, appendix E. The creation of the custom made PCB will also be outsourced. However the soldering and programming will be done internally.

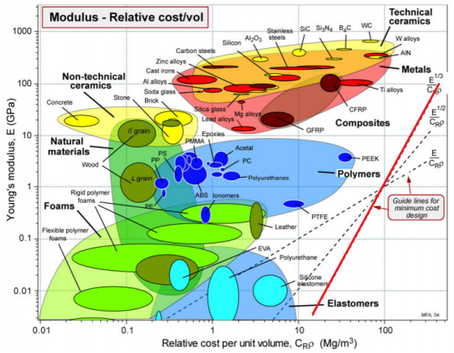

Figure 18: Interaction with data-station

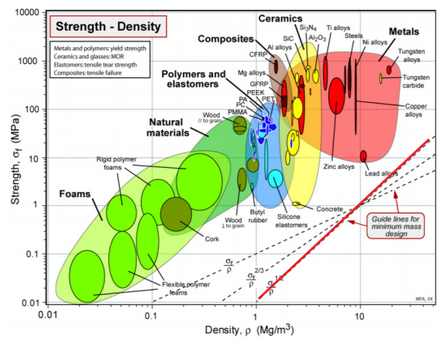

Figure 19: Interaction with data-station

Validation | Speaking with teachers

Below one can find the most important feedback received from our conversations with experts about zoom.

"*It is nice that* zoom *supports the independence of the students. With open assignments you support this as well and you give the student the freedom to choice to to more in-depth on the offered topics*"
~ Teacher Man and Nature, Dr.-Knippenbergcollege

"*Do not underestimate the students, some are capable of doing things we even did not think of*"
~ Teacher Man and Nature, Dr.-Knippenbergcollege

"*I do see the added value* zoom *gives, but I am skeptical about the efficiency. As the amount of lessons we have declined from 3 till 2, we already have a hard time to implement all the topics we need to cover. Can this be integrated outside of the lessons?*".
~ Physics teacher, Dr.-Knippenbergcollege

"*When students are working with/on something, you need to make sure it is fool-proof. It is important that an assignment is well-structured. And that all assignments are structured the same way*".
~ Industrial design student and Physics teacher in training

4

Final design

zoom

zoom is a data measurement instrument for educational purposes with a platform for students from the age of 11 till 18. zoom gives students the opportunity to work with the 21st century skills while being physically active. Relying on the experiential learning together with self-regulation theory. Zimmerman defined self-regulation as "the degree to which learners are meta-cognitively, motivationally and behaviorally proactive participants in their own learning process"[20]. When using zoom the children are responsible for their own approach, development and learning process. However, the teacher will coach the children to make sure they follow the desired path. The students will be triggered to think about how and what kind of data they want to gather, with a required outcome. The experiential learning theory defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience"[24]. Research shows that moving and learning at the same time stimulates the brain, acquiring knowledge will go easier and the information received will be easier memorised[8][16]. zoom relies on these principles by stimulating physical activity by letting the students gather their own data.

Besides the regular educational topics, they will learn about sensors and their functions by gathering, visualising, and working with - their own - data. zoom enables project-based learning. It supports the students to work - proactively - with the topics and delve into it. The students platform consists of a data visualisation environment in which they will explore with their own data. The platform enables students to work on the 21st century skill; digital literacy.

zoom especially focuses on individuals with an accommodating learning style which has concrete experience and active experimentation as dominant learning abilities. People with this learning style have the ability to learn from primarily "hands-on" experience [24]. By visualising and real-time experiencing complicated matters and abstract topics they can understand it quicker and have a more valuable and meaningful learning experience.

zoom has four different data-collectors, a data-station and a platform for students. The data-station holds in total 75 data-collectors, which consists of 4 different data-collectors: Body, environment 1, environment 2 and physics. All of the data-collectors measure time, on top of this the sensors will the following.

The data-collectors can be used for different subjects; e.g. biology, physics, physical education, science, geography, history and sociology. The subjects can work together on several topics as well, example given in appendix G. One can think of going to physical education class and using the acceleration meter and calculate the traveled distance, the burned energy, how much mol water it would take to burn the calories, and the average speed of that class. zoom enables project-based learning. It supports the students to work proactively with the topics and delve into it. The students platform consists of a drag-and-drop interface in which the students will work with their own data. The platform enables students to work on the 21st century skill; digital literacy.

The data-visualisation environment consists of several functions which can be used to aggregate and visualize the data. The students have a workspace where they can drag, drop and connect all kind of function with each other in order to create the desired outcome. The students can make use of the pre-written blocks of code, or they can decide to create their own block which can modify the data.

Scenario

One can find the scenario on page 18 (figure 20), in which the use of zoom is explained with an example assignment. The teacher chooses the assignment based on the current educational themes and objectives. The students will receive a short introduction of the assignment from the teacher, after this they can work on their assignments in groups and/or independently. On their iPads the students can read the assignment and place a reservations for the data-collectors which they think they will need. The students can pick up their data-collector at the data-station which is placed in a lab or classroom of choice. The ideal place for zoom is a multifunctional lab where students work on different subjects and where different tools are available. Ofcourse zoom can also be placed in traditional classrooms. By holding their student card above the data-station, the data-station will indicate the appropriate data-collector by shining a light. The student can now grab the data-collector. The data-collector is turned on automatically when it is not connected to the sensor holder. By pressing both buttons on the side of the data-collector, it will start measuring. This is indicated by a light that will shine on the data-collector.

Depending on the assignment and the approach the students chose, the students can execute their experiment with the data-collector. Afterwards the students lock the data-collector back to the data-station by holding their students card again above the data-station. The data-station will indicate the appropriate place for the data-collector by shining a light at the correct data-collector holder. The data-collector can only be placed at the data-collector holder when the data-collector stops measuring. When the data-collector is placed back on the data-station, the data will be sent to the account of the student.

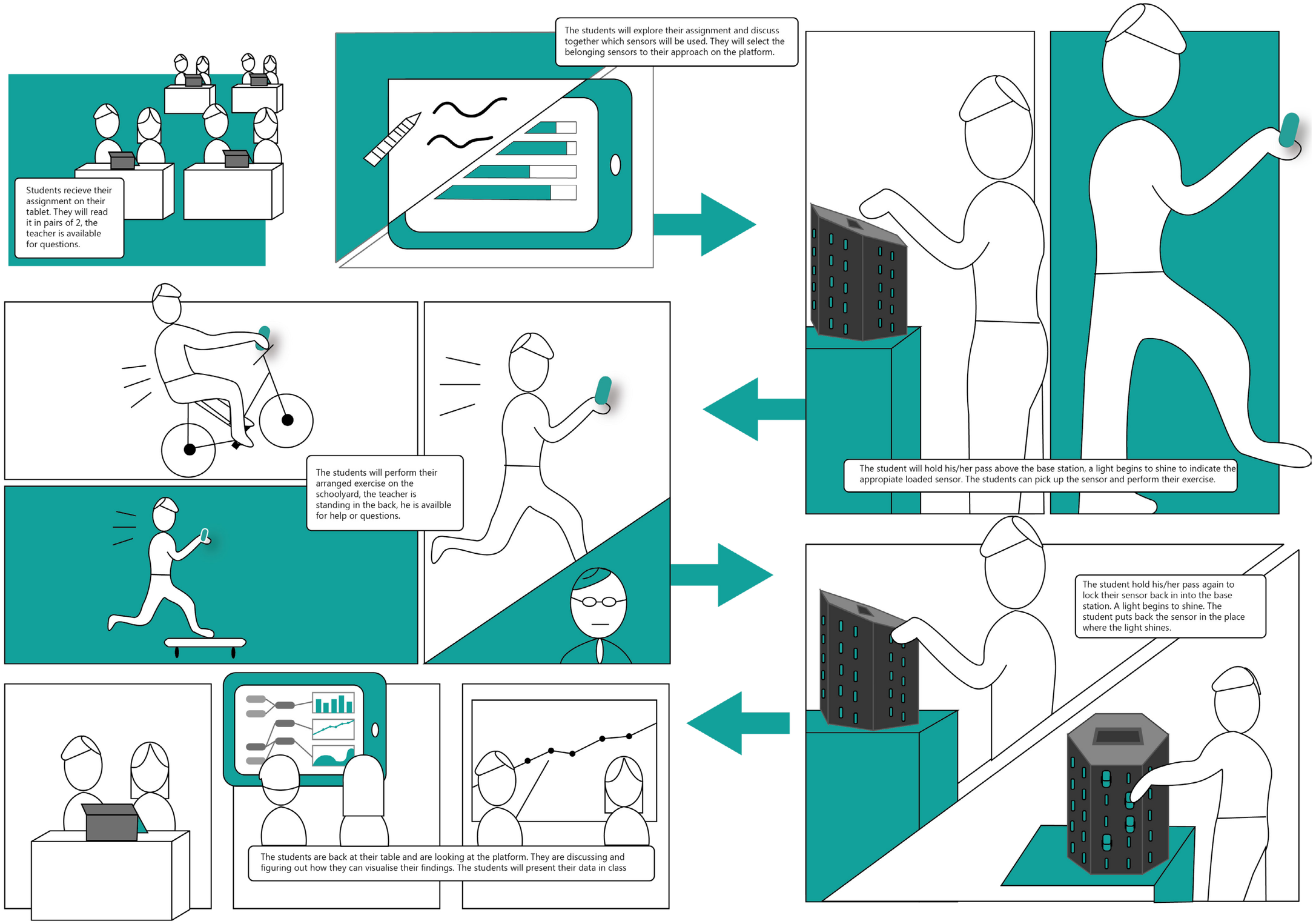

Figure 20: An example scenario of using zoom

When the students get back to their table, they can work with the data with the data visualisation system, the drag and drop platform of zoom. The students can calculate, analyse, and visual their measured data. They can play with it and make different sort of calculations and graphs. Afterwards they can discuss their different findings with other students and the teacher. During class, they can compare their results.

Values for stakeholders

To visualise the added benefits and values of the product ZOOM, a Value Ladder is created. Below one can find the functional benefits of the product divided by the different elements of the product, meaning the assignments of ZOOM, the data-station with the data-collectors and the drag and drop system. As well as the emotional benefits of ZOOM. At last the most important values of ZOOM are visualised.

All values are based on individual experience, no scientific tests are conducted in order to come to these results. However, it helps to emphasize the opportunities within this market. The parameters are been chosen based on the skills needed to function successfully in the society of the future. The value for schools and teachers lays especially in the immense deployability.The possibilities with ZOOM are extensive, teachers can be creative with assignments that fit their educational purposes, subjects and methods. Furthermore the demand of teaching material that is tailor made for achieving 21st century skills is increasing, however the knowledge and tools of implementing these skills in the current education program is limited. With ZOOM schools can offer a meaningful tool to approach the learning of 21st century skills and captivate students. For students the experiential learning is an important value of our product, students are stimulated to experience complex matters themselves by real-time experimenting and visualising. The students are intellectually, physically, and socially engaged with the topic instead of just reading it in their books.

Application in education

ZOOM has a wide range of possibilities to be integrated in the secondary education system. In this description, the implication will focus on domain education. On the new campus the possibilities for the integration of cross-curricular education is promoted. zoom can be used for different subjects on different levels: Man and Nature, Man and Society, and Sports. The assignments possible with zoom are adjustable to the current education themes, topics, learning objectives and levels of the students. The themes that are conducted at the moment can be strengthen by assignments with zoom to have practical exercises and meaningful learning experiences.

Man and Nature teachers are interested in experiments regarding the environment, the human body, acceleration/speed, etc. Man and Society is interested in the environment and climate as well. In the appendix G, an example assignment is shown where different fields are explored of the greenhouse effect. The assignments for accelaration or the human body can be combined with the atelier Sports. For these assignments, one can using the acceleration meter during atelier Sports and do the calculations during Man and Nature. The students can calculate the traveled distance, the burned energy, how much mol water it would take to burn the calories, and the average speed of that class.

Figure 21: 3D-model of final design

5

Validation

User study

To evaluate our concept with our target group, a limited user study was executed. The objective of this usertest was to evaluate the concept of using a data measurement tool to stimulate 21st century skills as well as motivate students to move more during class. The two main aspect we focussed on during this user study contained, firstly the evaluation whether the approach of zoom fits the students learning goals, secondly the evaluation of the motivational factor of zoom to exercise more. We wanted to look at it in their perspectives and observe the concept in a classroom context. This user study especially focuses on the opinion of students and teachers about the concept.

Set-up

The user study consist out of 3 parts, in the first part the students will gather data by a simple running exercise, secondly the students work with their data with the drag and drop system of zoom by completing an assignment, at last the concept will be evaluated in an interactive setting. During this part negative questions are avoided because they tend to cause problems for children. The same is true for complex questions, that's why the questions used in the last section of the user study are framed positively. (Bell 2017) The complete set up can be found in the appendix F of this report. First a pilot study was executed to evaluate the set up of the user study With this pilot study we learned important lessons, at first, before the final user study we asked the teacher to remind the students and the parents of the consent form to ensure we could test more students with the final user study. Furthermore we changed the assignment the students had to do within the data visualisation section, so that the test would take no longer than 15 minutes. Not to mention the pilot study was a bit chaotic, we believed that was because we as a group did not discuss a clear division of tasks, which resulted in confusion by the students. Also the usability of the drag and drop platform was not that intuitive, students did not understand how to use the platform and how to make graphs.

Ethics

The students and their parents are asked before hand to fill in a consent form in which they consent to this research and/or recording audio/visual material, appendix H. Although the sensor is working, the data of the students won't be recorded, the students work with default data during the user study. Only the students of whom they and their parents consent to the consent form will be asked to participate in the user study.

Results

Evaluate how the approach of zoom fits the student's learning goals

The students mentioned a lot of interesting added values of executing exercises themselves instead of reading an assignment in their books. Most of them mention the fact that it is more fun than the traditional way. A student mentioned that he thinks he will learn quicker and remember the matter better when he executes the exercise himself. Another student says that you will remember interesting things quicker and longer. Another student mentioned that if you execute an assignment yourself, you are more motivated to perform calculations in it. The visualising aspect is also mentioned often, a lot of students learn better when they visualise complicated matters. A few students are uncertain about the added value to their learning process, they think it's more fun but not per se better. On the statement: I think I learn more with this approach than with the traditional approach, they all react with the fact that they won't learn more, but they will learn quicker, because you will remember it better by experiencing it yourself. Not to mention the students like to work with their own data. A few students mentioned that they like to work in groups so that they can compare their data, then it also will be more accurate.

Evaluate opinions about the motivational factor of zoom to exercise more.

The majority of the participants thinks it's good that moving will be better combined with school with this concept. Currently they won't move a lot during subjects like physics, with zoom they are stimulated to move more at that moment. They don't know if it will motivate them in general to move more. One student mentioned that he likes moving more in a gym than at school.

While observing the students during the user study it was noticed that the students had some trouble with the interaction of the drag and drop system. The use of the platform had to be explained quite well. This is an important finding, the teacher can't be bothered by questions about how to work with the data and with the platform, therefore the platform needs to work more intuitive and user-friendly.

To summarise, during the user study of zoom students mentioned the value of experiencing it themselves quite often. During visualising an assignment and real-time experiencing it, they thought they will learn quicker and remember the matter better. Most of them like the fact that moving and education will be combined at school, they did not know if they will be motivated to move more in generally. With these results the focus of the concept of zoom is changed, the value for students lays more in the experiencing and visualising aspect, than in exercising during classes. More research about this effect is done and the concept is improved to fit this value better. Furthermore the usability of the drag and drop system is improved to make it more Intuitive in his use.

6

Business

Business plan

The next chapter will describe the business model of the service hybrid system zoom. Currently there is a lot of changes going on within the educational systems, more and more companies tend to join the innovating trend. Namely, creating teaching material that stimulate the 21st century skills. However not so much is created on teaching how to gather, and work with data. Therefore, the market in which zoom operated is a relative new one. In order to get an understanding of our position within the educational field a competitor analysis has been made, figure 22. The five biggest Dutch education Publishers are compared with regard to specific parameters to excel the created value from zoom.

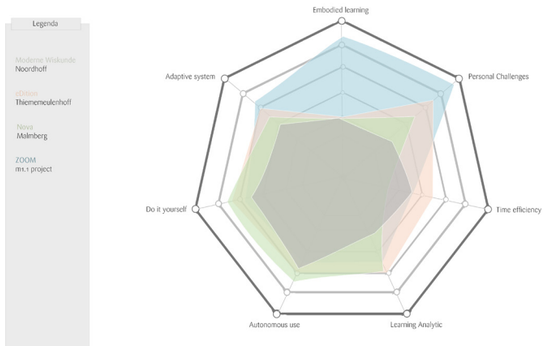

Figure 22: Competitor analysis

The business model is created with the aid of the board of Innovation, figure 23. The board of innovation provides a new way to communicate ones business model to other stakeholders. This method is based on simplicity while communicating the idea clearly.

At the top, one can find our own company. The company will mainly develop the environment, the sensors, the base station and provide the service. The manufacturing of the sensors will be outsourced due to the high initial costs of the machines. In order to access the market seamlessly the company will anticipate on the demand of the 21st century skills. By offering an platform which can be used together with the textbook they already familiar with. All book publishers try to come up with teaching material that covers the 21st century skills. They want to distinguish themselves from the others, however they all follow the same path, namely creating an online platform which focus on learning analytics. zoom is differently and focuses on the data part of the 21st century skills. In order to convince schools zoom needs to focus on modules which can be used together with zoom. Providing some guidelines which can be followed but also can be ignored. This gives the teachers enough space to get familiar with zoom and start to explore their own exercises. One of the most important aspects is word-of-mouth within this context. Therefore the schools can count on free service when the product gets corrupt and will get free updates of the software. Besides, the company try to cooperate with academics to improve, test, and evaluate the product. One can think of the PABO, Industrial Design, psychology and behavioral sciences.

The company will also sell their product via wholesalers - like Iddink or van Dijk - as a standalone product. Without saying the wholesalers want a part of the profit but in return they will do the advertisement, shipping and selling. It is not completely impossible to do this on our own but they already have a reputation and the customers are familiar with these services. These wholesalers are a good starting point, in the future the company might do it by themselves depending on the gained reputation, profit and vision. Once the 21st century skills are proven and accepted within the education, the umbrella organizations will put these in action. The umbrella organizations are defined as schools which work together in order to create a vision on education. The umbrella organizations will search for existing methods, our product will by then already gained some ground.

Lastly, the company will keep in contact with the users. This can be done with feedback sessions, surveys and observations. This feedback will be used to constantly improve the product and teaching material, ensuring an iterative process of development over the years. Reputation is key within the field of education. Most schools are terrified to lose students when making any mistakes. Therefore, a good reputation is needed before schools will invest in zoom. The Dutch education system is on the edge of a revolution, going towards individual development and learning the skills that are needed to participate successfully within the society of the future. zoom, will leave most competitors behind due to our expertise within this field.

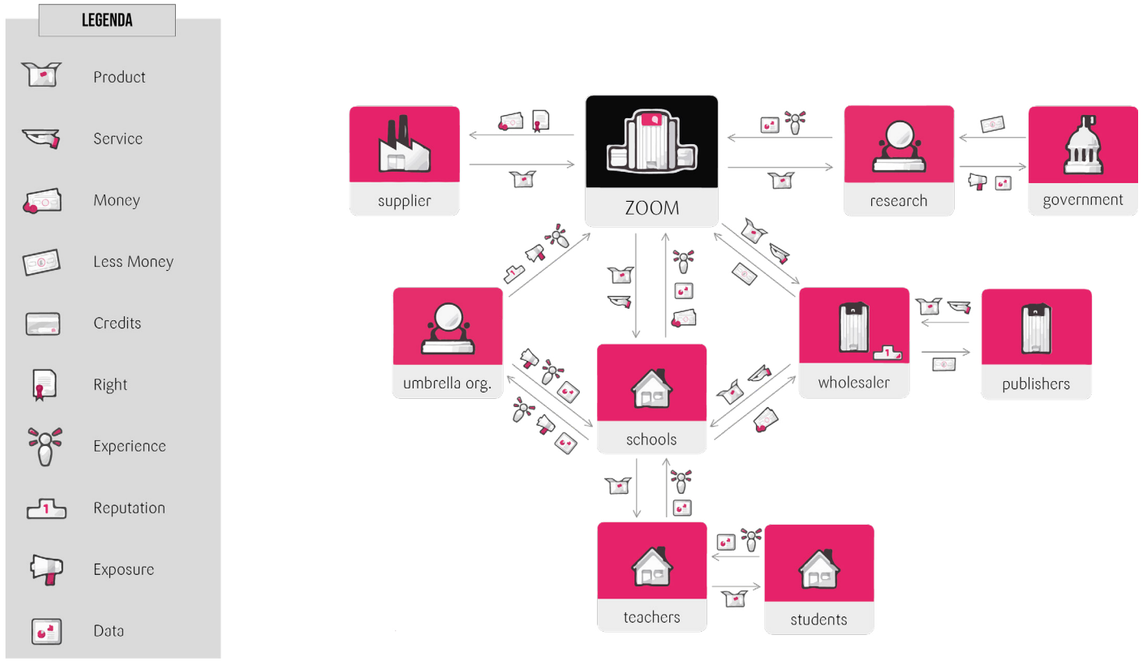

Figure 23: Board of Innovation

Estimation | Costs

In this stage of the design process it is impossible to calculate the exact costs of zoom. However, one can make an estimation. The custom printed circuit board will cost up to 3 euro each, the different chips of the sensors will go up to a few euros in total. There is a negative correlation between the average unit cost and the production amount. One can calculate the cost of manufacturing with the following equation:

$$C = \left[\frac{m\,C_m}{1-f}\right] + \left[\frac{\sum(C_t)}{n}\right] + \frac{1}{\dot{n}}\left[\sum\left(\frac{C_c}{L.t_{wo}}\right) + \dot{C}_{oh}\right]$$

Materials · Tooling · Capital, Labor, Information, Energy... · Batch size · Rate of production

Figure 24: Formula used for the costs analysis

Material costs C_m per kg, and a mass m is used per unit; f is the scrap fraction (the fraction thrown away). Tooling C_t is "dedicated" -- it is written off against the number of parts to be made, n. Capital cost C_c of equipment is "non-dedicated" It is written off against time, giving an hourly rate. The write-off time is two . The rate of production is units/hour. The load factor (fraction of time the equipment is used) is L. The gross overhead rate contributes a cost per unit of time that, like capital, depends on production rate $\dot{n}$[10]. When taking the different parameters into account and aiming for a batch size of 1000, one could stated that each data-collector will be around the 10 euros to produce. The data-station needs a different microcontroller, and production/finishing method. The total cost of this will be around 500 euros. Everything needs to be put together. Estimating the total cost can go from 1500 to over 3000 euros.

Branding

To distinguish ourselves on the educational market we created the brand zoom. As the book ten types of innovation states "Brand innovations help to ensure that customers and users recognize, remember, and prefer your offerings to those competitors of substitutes". A corporate identity was created. All the visuals of zoom have a coherent look. For the data collectors the team experimented with packaging as if zoom would be sold in a store. The book "Structural Package Design" by Pepin van Roojen was consulted in this process. As we wanted to create a professional and clean look for zoom, there was experimented with several color schemes. The branding visualisations can be found in appendix I.

7

Closing

Discussion

The students who participated in the user test, only participated once. As a result the novelty effect cannot be excluded. As it is stated in the book 'Practical Research: Planning and Design'; "The novelty effect, in the context of human performance, is the tendency for performance to initially improve when new technology is institated, not because of any actual improvement in learning or achievement, but in response to increased interest in the new technology"[9]. Likewise, it should be noted that students were not working with their own data. The data which would be collected would be too unreliable and chaotic to use for the user test. The acceleration sensor used should be held in a specific way during the run, which can be seen as mission impossible. Even though 'fake' data was used, the students did not notice this matter. In the future, one can solve this by vector calculations to correct the tilting of the device.

The prototype of ZOOM was bigger than the envisioned size. As the user study was mainly focussing on the interaction, this could have been an influence. The user test was designed to have a small discussion session to gather important intell, due to time the discussion session was not optimal. Furthermore the problems with the interaction of the drag & drop platform could have influenced the results.

Furthermore, after the midterm demoday we decided to focus on the product service hybrid system. The topic tool for teachers got left behind. It was impossible to do everything. However, within the future concept the topic tool will be included. The topic tools will be designed for teachers to pick themes, topics, tasks and activities. To illustrate, a Man and Nature teacher who is currently teaching about temperature, heat transfer, could find meaningful assignments with ZOOM to enhance the learning experience. With the topic tool the teacher could select themes like climate and environment and the topic temperature and as task field research. With this filter ZOOM displays all the appropriate assignments that fits the educational objectives of the teacher and the students[36][37].

Secondly, we suggest that a schedule tool got developed. During observations and interviews we noticed that the teachers faced some trouble with cross-curricular teaching. The main reason was that they had to sit together and try to find common grounds. This is a quite time-consuming activity, which can be reduced with a the help of a tool.

Lastly, the composition of the data-collectors needs to be reconsidered. The sensors within the data-collector are selected based on our own experiment with acceleration. The others are based on example exercises however, it leaves something to be desired. One needs to determine the different desired sensors from both teacher as students its point of view. This can be accomplished by doing a co-creation with teachers and other stakeholders, trying to create several exercises in which the sensor can be used. These can lead to grouping several sensors in a more practical way.

Conclusion

On average, students sit for 11 hours a day! From this 11 hour, 67% of that time is spent at schools[1]. This results in a sedentary lifestyle which will keep developing as they grow older[17]. Schools can play a major role in breaking these habits by provoking physical activity throughout the day. ZOOM can support schools, teachers and student to approach these 21st century skills in a meaningful manner as well as stimulating students to be physically active.

The value for schools and teachers lays especially in the immense deployability. The concept of ZOOM is tested with behalf of a user study within the subject physics, however the team indicates that ZOOM could be used for different subjects e.g. biology, physics, physical education, chemistry, and geography as well as cross-curricular teaching. Students are stimulated to experience complex matters themselves by real-time experimenting and visualising. The students are intellectually, physically, and socially engaged with the topic. During visualising an assignment and real-time experiencing it, the users were convinced that they will learn more quickly and remember the theory better than they do with the current system. Most of them were thrilled about the idea to combine movement with education. Yet, they were not sure if they will be motivated to move more in generally.

All things considered, ZOOM conforms quite well to the new educational system with an educational, sportive and cultural learning focus our client will be offering. While visualising an assignment and real-time experiencing it, the users were convinced that they will learn more quickly and remember the theory better than they do with the current system. Most of them were thrilled about the idea to combine movement with education. Yet, they were not sure if they will be motivated to move more in generally.

8

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