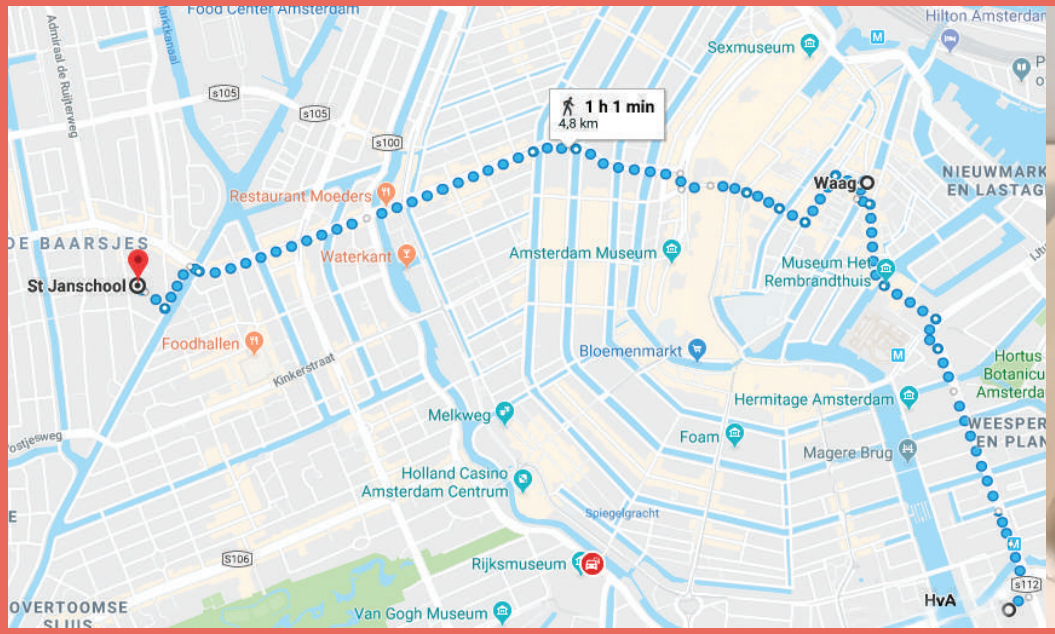
REVEALING DESIGN

Data physicalization for the 21st-century



AMSTERDAM UNIVERSITY OF APPLIED SCIENCES
Marije Kanis, Monique Pijls & Shavonda Kewaldar

ST. JAN SCHOOL

WAAG

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and all others, namely Eva Hilhorst and the participants of the dataphysicalization workshops.

ABOUT REVEALING DESIGN

Can you touch and experience data? The Amsterdam University of Applied Sciences, Waag and the teachers and students from the St. Jan school collaboratively investigated and created fun and interesting data physicalizations: physical representations of (big) data, that you can actively see and touch.

Data is all around us. Yet, we increasingly live in an invisible world of data. Societal and technological developments, such as the rise of pervasive and digital techniques and small intelligent devices have contributed to a world that can be characterized by virtual products and invisible, complex data transactions in which data and its usage is increasingly invisible. With the advent of 'Big data' and computing intelligence, information is and can be increasingly produced, collected, analyzed, shared and used. However, (big) data and its implications are not always clearly seen, accessible, understood, communicated or discussed with the lay, general public. Moreover, the growing collection of 'big' data and other technological means does not necessarily and directly lead to more knowledge, insights and skills.

The goal of the project 'Revealing Design' (Zichtbaar slimmer) is to do practice-based research into the potential of data physicalization –making data tangible– as a vehicle to support data literacy and the 21st- century skills creativity, collaboration and critical thinking. Data physicalization goes one step further than data visualization, in that it deals with designing and creating tangible representations of data, for sharing and discussing knowledge.

The aim is to uncover and demonstrate the potential of data physicalization in educational settings as a way to support such 21st-century skills for a wide group of people.

On the 26th of April, we celebrated the kick-off of the project Revealing design: Data physicalisation for 21st century skills -with critical making and pie! Please see here for the detailed report: (http://www.digitallifecentre.nl/nieuws/kick-off-zichtbaar-slimmer)

On the 14th of June, there was a Data Physicalization workshop @ Waag=Open that was open to everyone! Please see this site (http://www.digitallifecentre.nl/agenda/open-workshop-data-fysicalisatie) for details, and here (http://www.digitallifecentre.nl/nieuws/openbaar-publiek-maakt-data-tastbaar-tijdens-uitverkochte-workshop) for the workshop findings.

On September 19, we held a design session with the primary St Janschool teachers. This was an important part of the co-creation process in which the project partners collaboratively worked towards a successful teaching format for data physicalization & 21st century skills.

In the following weeks, nearly 100 children and teachers from primary school St Jan actively worked on data physicalizations, within the school project theme of Friendship. The pupils from group 7 and 8 made their own collected data tangible for experiencing data in a different way. On October 19, 2018, the children proudly presented their data physicalizations to their parents, teachers, and younger classes. Please also see this news item: http://www.digitallifecentre.nl/nieuws/datafysicalisatie-met-st-janschool-een-succes.

After that, we continued with the data physicalization workshops, such as for HvA Master students in Teaching economics, primary school teachers in Maker education and library professionals.

Project lead: dr Marije Kanis, Amsterdam University of Applied Sciences
Contact: m.kanis@hva.nl | **Duration:** April 15, 2018 - April 14, 2019

CREATIVITY

CRITICAL THINKING

COLLABORATION

The project

"Revealing Design"

aims to do practice-based research into the potential of

- **data physicalization –making tangible representations of data and abstract information–**

as a vehicle to support data literacy & 21st Century skills:

- Creativity
- Critical thinking
- Collaboration

WORKSHOPS

(SEMI) EXPERTS KICK - OFF

(*n*=6)

GENERAL PUBLIC WAAG=OPEN

(*n*>30)

PRIMARY SCHOOL TEACHERS SINT JAN

(*n*=6)

PUPILS SINT JAN

(*n*=90)

MASTER STUDENTS TEACHING ECONOMICS

(*n*=11)

Total: (*N*>130)
>50 Physicalizations

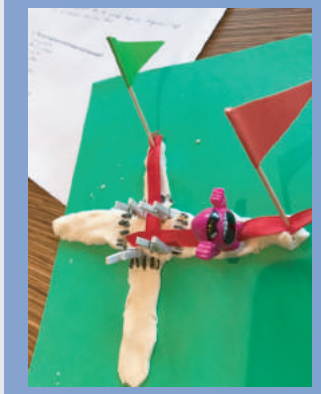
WORKSHOP FORMAT

KICK-OFF WITH (SEMI) EXPERTS (*N*>30)

INTRODUCTION

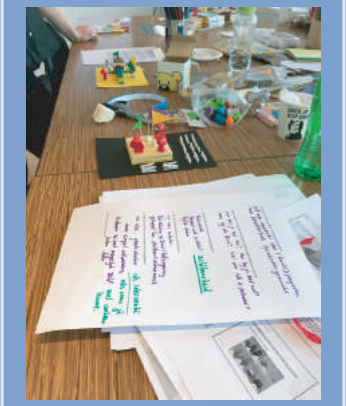
Exploring the potential of data physicalization.

CHOICE OF DATA/ COLLECTING DATA



(Semi) professionals answered questions about data physicalization (their experience, interests, and what kind of data, materials and tools to use).

MATERIALS & TOOLS



All kinds of stock
- Wooden blocks
- Lego (characters and tape)
- Wool
- Tooth-picks
- Rubber bands
- Plastic cups
- Colored tokens
- Balloons
- 3Doodler
- Pegs

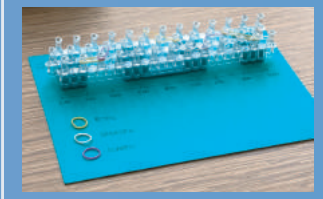
CREATING

"Making the invisible visible." Imagining a toolbox for data physicalization, that also thinks "outside the box".

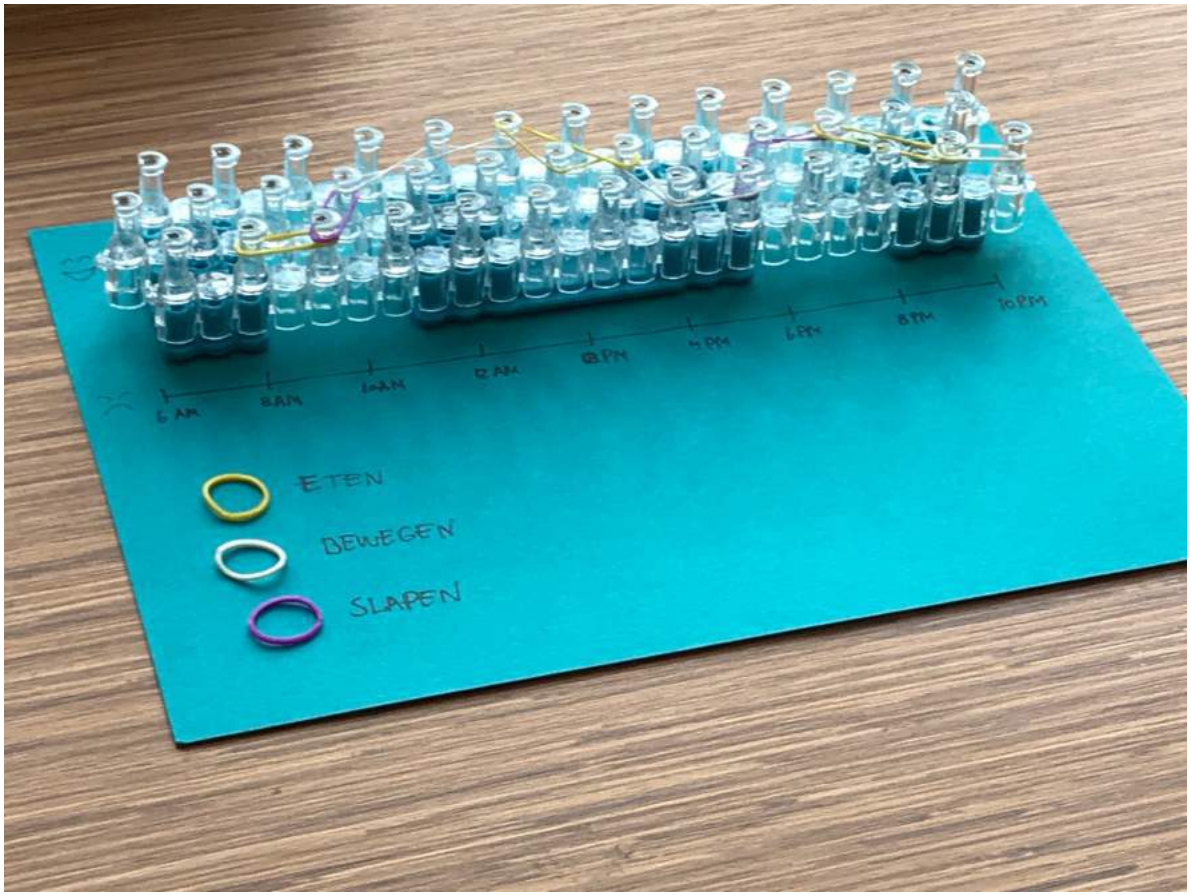
PRESENTING

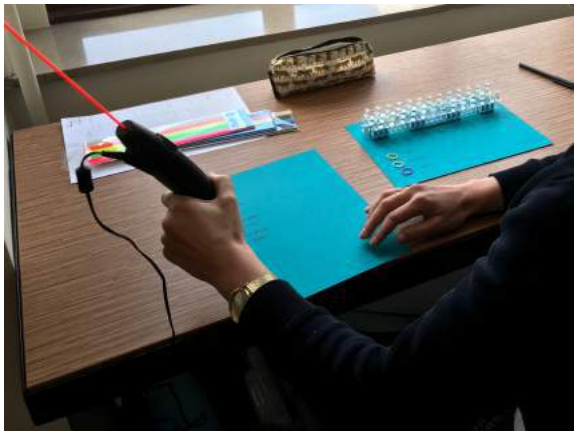
Physicalization helps with translating goals and ideas to others.

REFLECTION & RESULTS



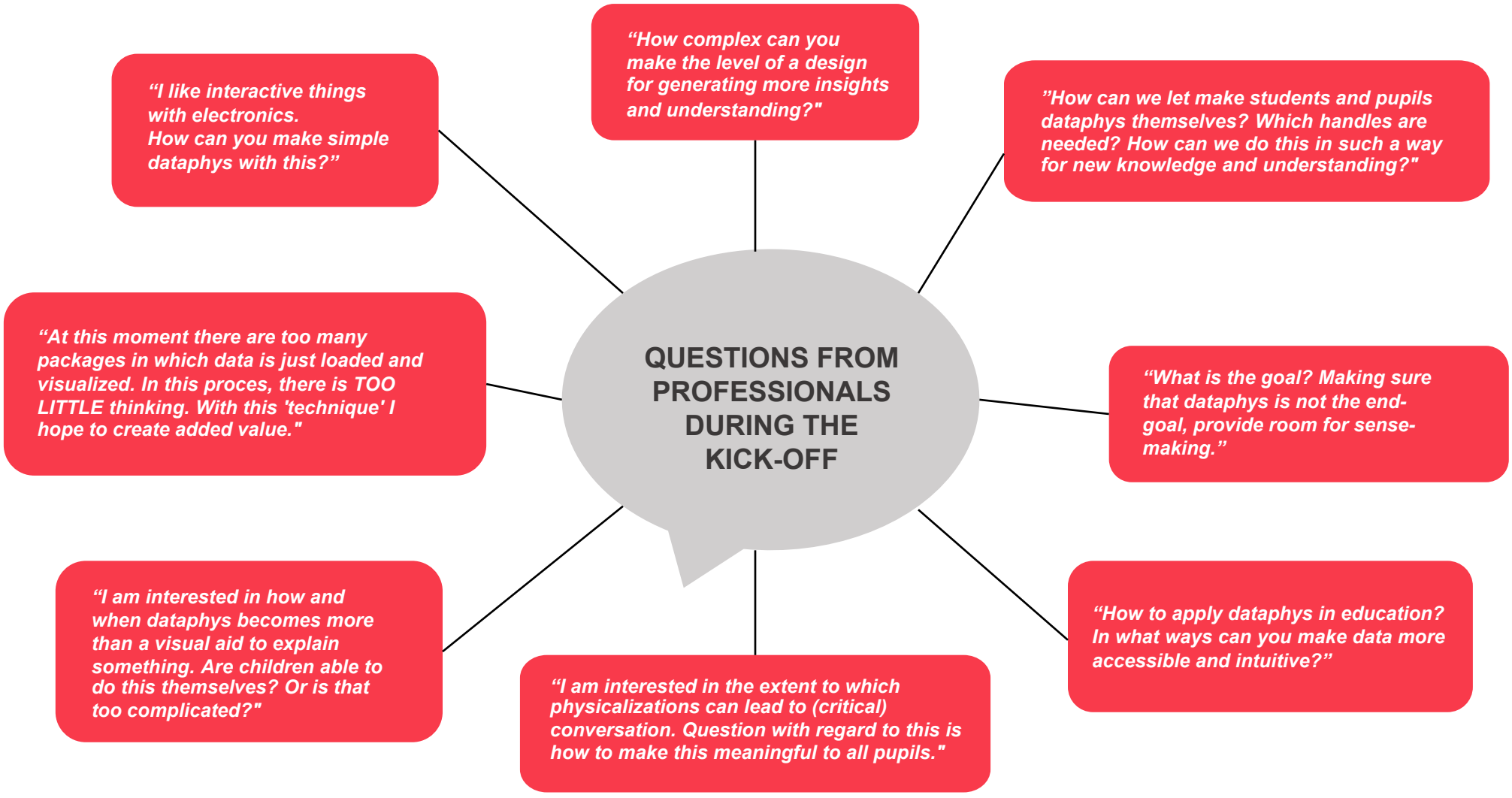
Data physicalization is not the end, but the beginning of new discussion and understanding.





Rapid physicalizations by (semi) experts, including the use of 3Doodler pen for live interactive data collection.

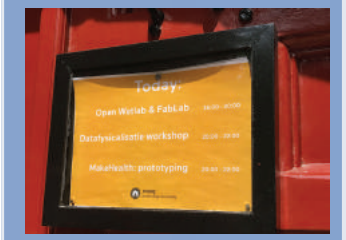
EXPLORING DATA PHYSICALIZATION


QUESTIONS FROM PROFESSIONALS DURING THE KICK-OFF
"I like interactive things with electronics. How can you make simple dataphys with this?"
"How complex can you make the level of a design for generating more insights and understanding?"
"How can we let make students and pupils dataphys themselves? Which handles are needed? How can we do this in such a way for new knowledge and understanding?"
"At this moment there are too many packages in which data is just loaded and visualized. In this proces, there is TOO LITTLE thinking. With this 'technique' I hope to create added value."
"What is the goal? Making sure that dataphys is not the end-goal, provide room for sense-making."
"I am interested in how and when dataphys becomes more than a visual aid to explain something. Are children able to do this themselves? Or is that too complicated?"
"I am interested in the extent to which physicalizations can lead to (critical) conversation. Question with regard to this is how to make this meaningful to all pupils."
"How to apply dataphys in education? In what ways can you make data more accessible and intuitive?"

WORKSHOP FORMAT

GENERAL PUBLIC, WAAG=OPEN WORKSHOP (*N*>30)

INTRODUCTION



A lot of explanation and examples.

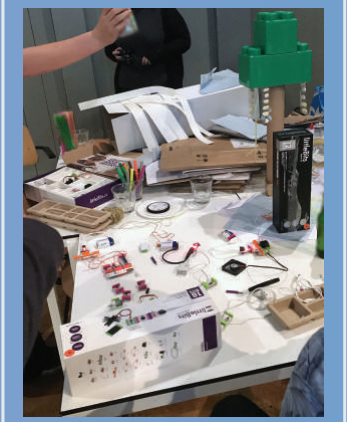
CHOICE OF DATA/ COLLECTING DATA

The data was prepared in data cards.

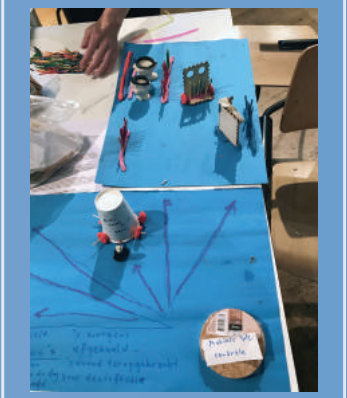
http://www.digitallifecentre.nl/redactie/resources/data-kaart-jesvoordatafysicalisatiezichtbaarslimmer.pdf

MATERIALS & TOOLS

CREATING



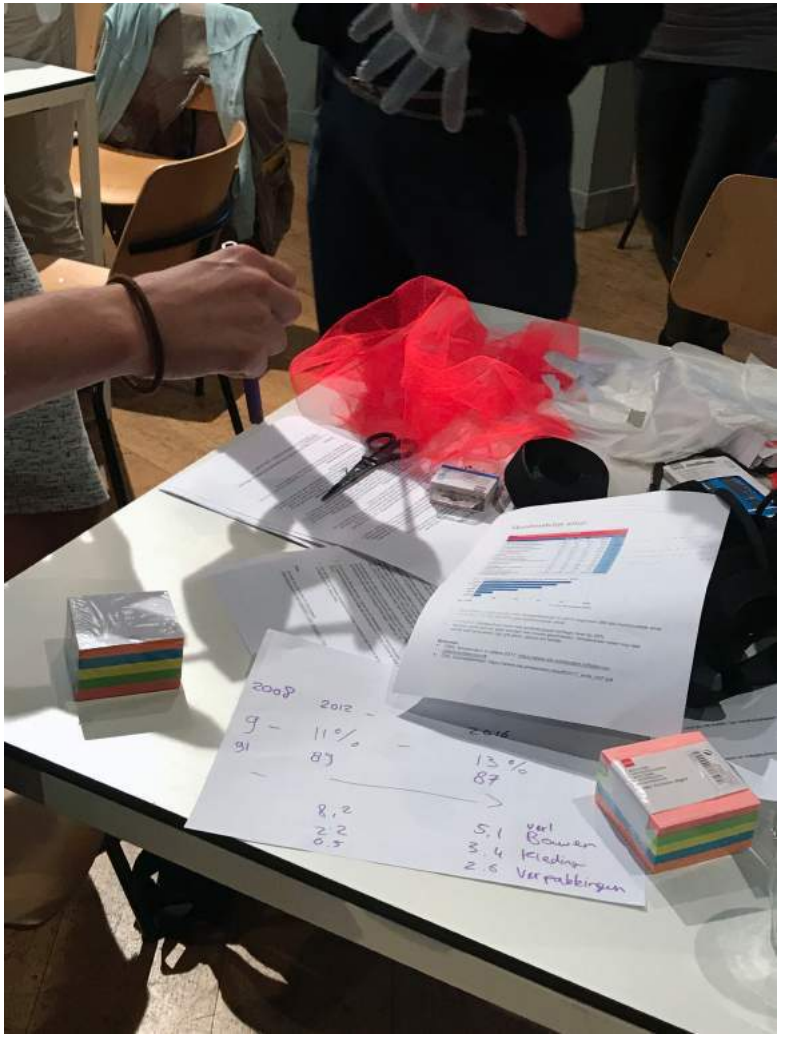
PRESENTING



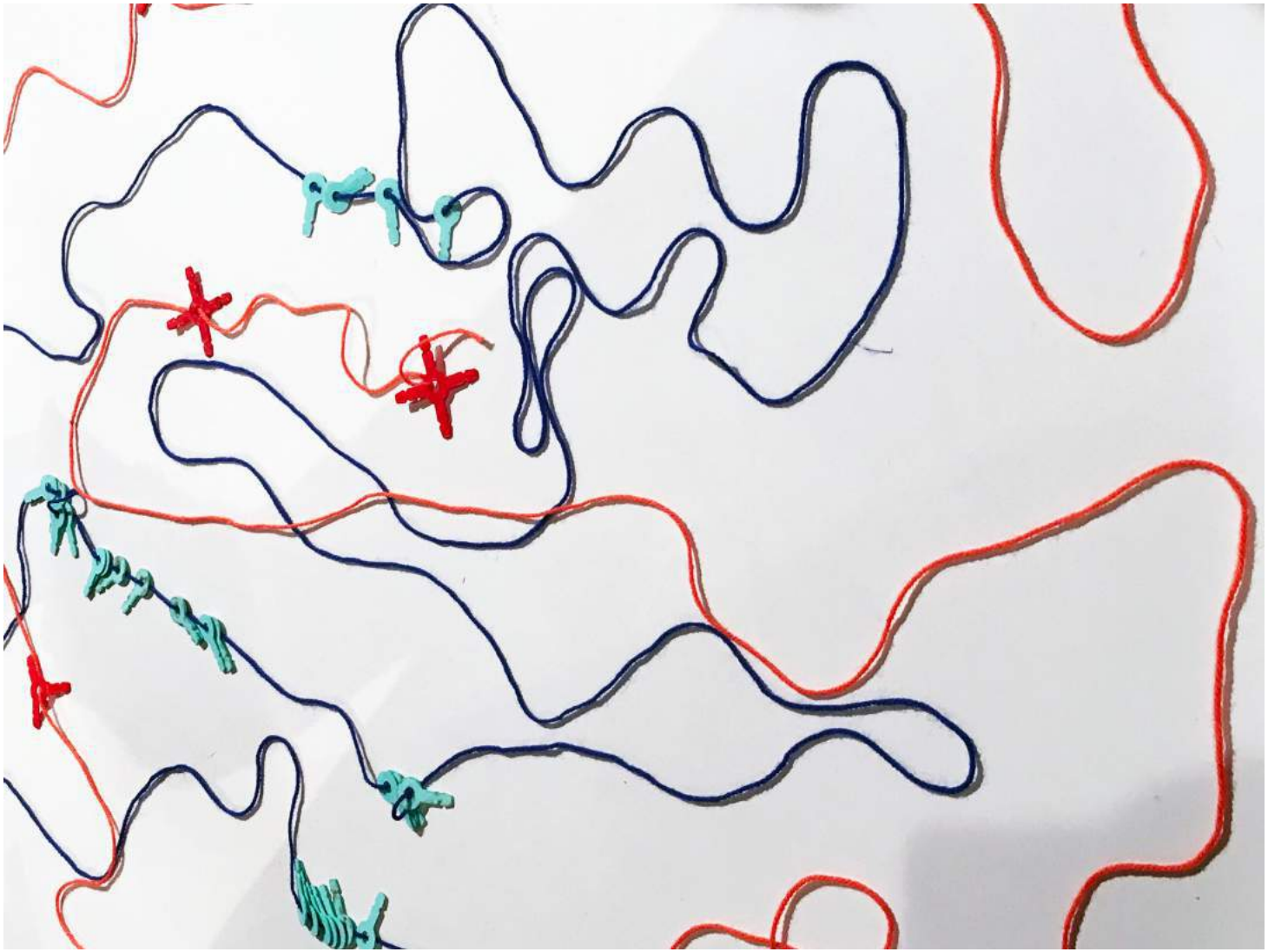
Presenting and discussing solutions.

REFLECTION & RESULTS

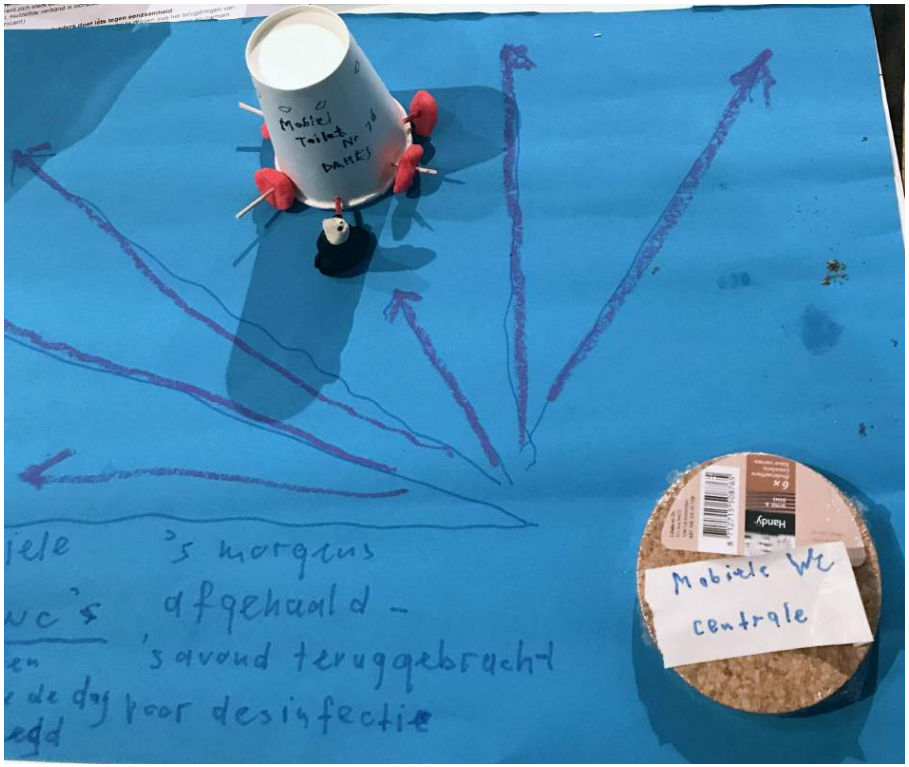
Many different participants (ranging from young to old, from graphic designer and data analyst, to pensioner) enthusiastically participated in making data physical in groups of six.



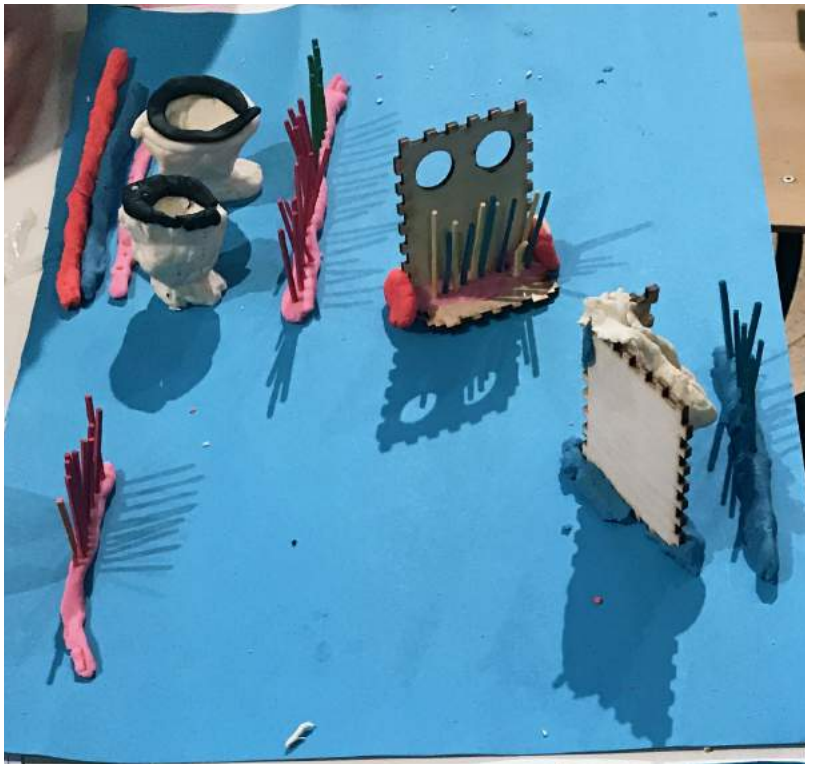
GENERAL PUBLIC



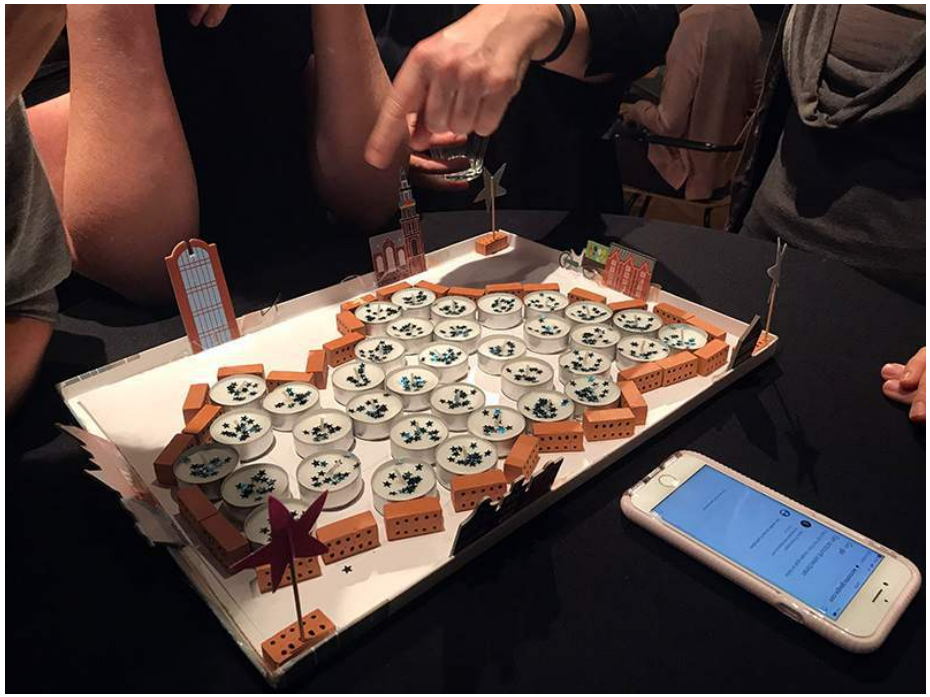
Pyhicalization of data on toilets for men and women in Amsterdam.



Physical prototype for a mobile toilet on demand, made by an older adult during the open physicalization workshop.

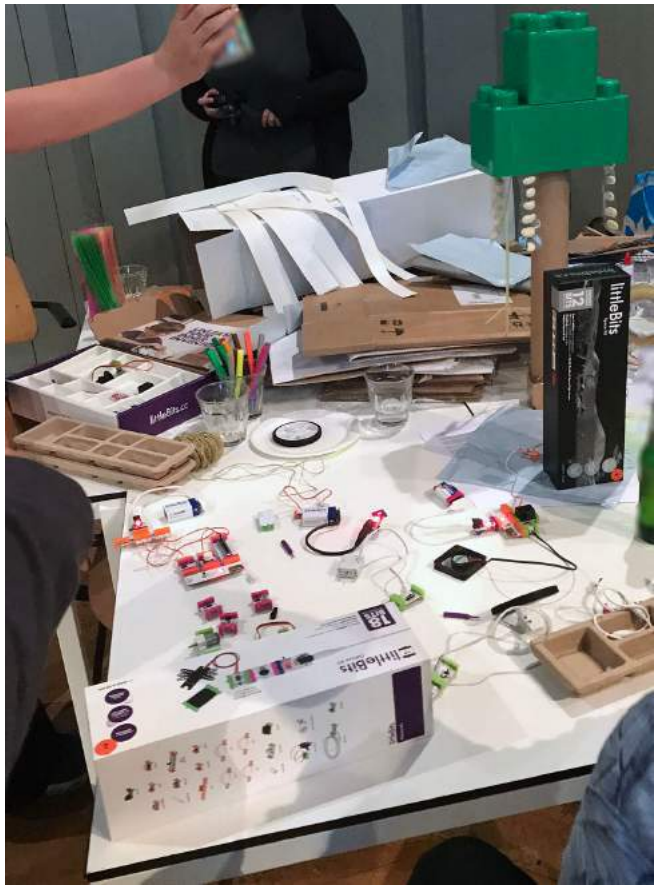


Some participants used recycled material from the laser cutter.



Data physicalizations of Loneliness in Amsterdam by adults during the open workshop.

PHYSICALIZATION OF LONELINESS IN AMSTERDAM



Data physicalization during the Open workshop, concerning hayfever medicine intake (with interactive lighting enabled by LittleBits).

Data physicalization performance during the Open workshop, creatively combining data on Loneliness with Domestic waste.

WORKSHOP FORMAT

TEACHERS SINT JAN | PRIMARY SCHOOL (*N*=6)

INTRODUCTION

Explaining with (Lego) examples.

https://nl.pinterest.com/mekanis/information-physicalization/

CHOICE OF DATA/ COLLECTING DATA

The data was prepared in data cards.

http://www.digitallifecentre.nl/redactie/resources/datakaart-jesvoordatafysicalisatiezichtbaarslimmer.pdf

MATERIALS & TOOLS

Conscious with materials.

CREATING

In groups of two, in an afternoon.

"I quickly had an idea what we could make."

PRESENTING

Small groups, making it easy to present to each other.

REFLECTION & RESULTS

- Creativity
- Critical thinking
- Collaboration

"I enjoyed working with a colleague."

Goal: Designing an educational format for data physicalization with primary school teachers in Amsterdam.

WORKSHOP PRIMARY SCHOOL TEACHERS - ST JAN SCHOOL

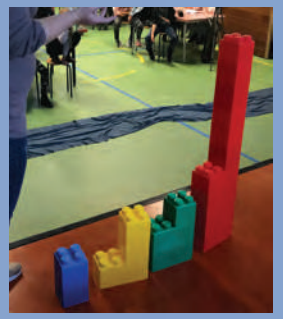
The primary school teachers discussing their data physicalizations, such as data on Loneliness.

WORKSHOP PRIMARY SCHOOL TEACHERS - ST JAN SCHOOL

WORKSHOP FORMAT

PUPILS SINT JAN | PRIMARY SCHOOL GROUP 7 AND 8 (*N*=90)

INTRODUCTION



Explaining with examples and lego XL.

https://nl.pinterest.com/mekanis/information-physicalization

CHOICE OF DATA/ COLLECTING DATA

Pupils collected data around the theme of friendship.

MATERIALS AND TOOLS

All out with materials (recycled material).

CREATING

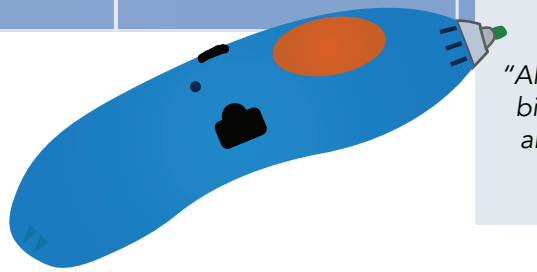
Many pupils (in groups of three), freely working on their project.

PRESENTING

Presenting for the camera, for another project group.

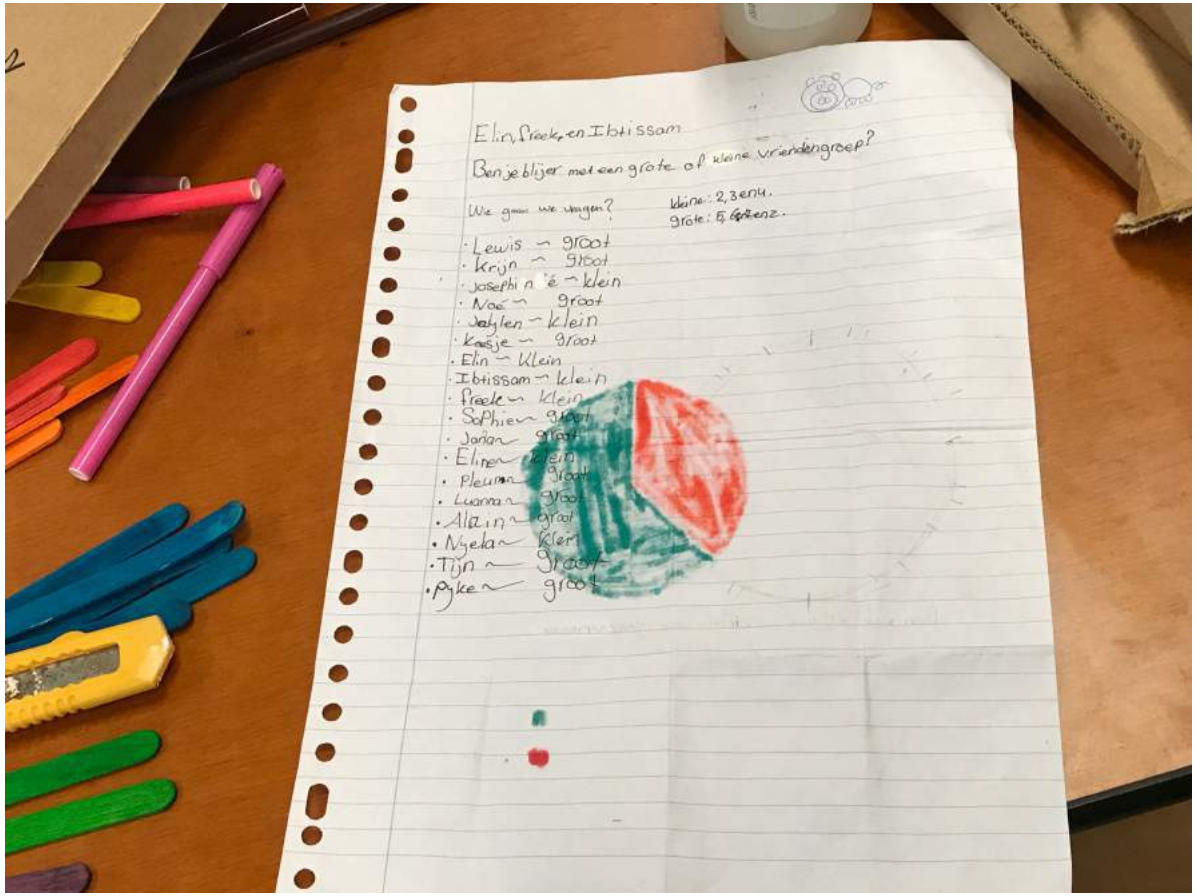
REFLECTION AND RESULTS

The results were presented in one big final presentation to the parents, teachers, researchers and younger pupils from the other classes.



"Also 3Doodler, little bits, MaKeyMaKey and vinyl printer."

DATA PHYSICALIZATION CLASS FOR PUPILS - ST JAN SCHOOL



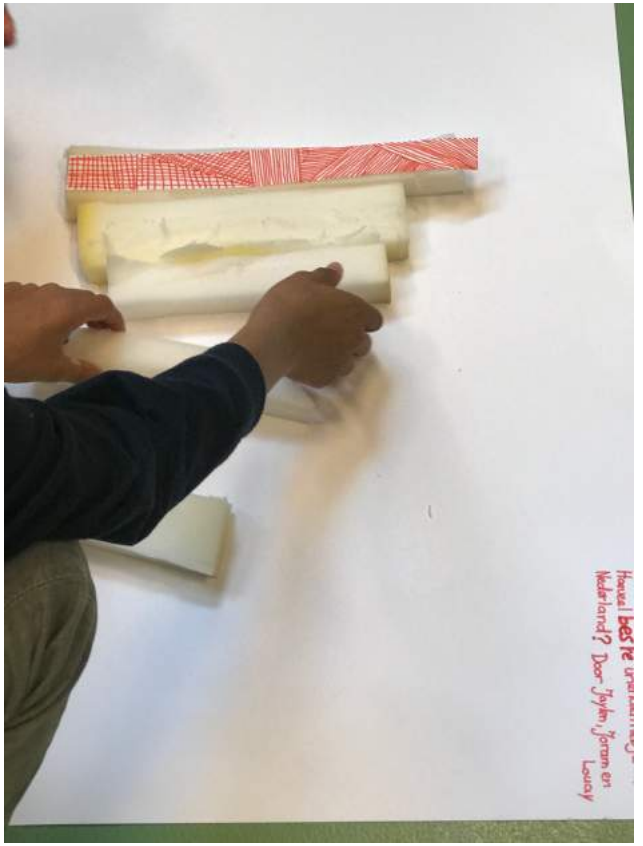
"Are you happier with a large or small group of friends?"

The children had one week to formulate questions themselves and to collect data, under the supervision of teachers. The theme within these sessions was friendship.

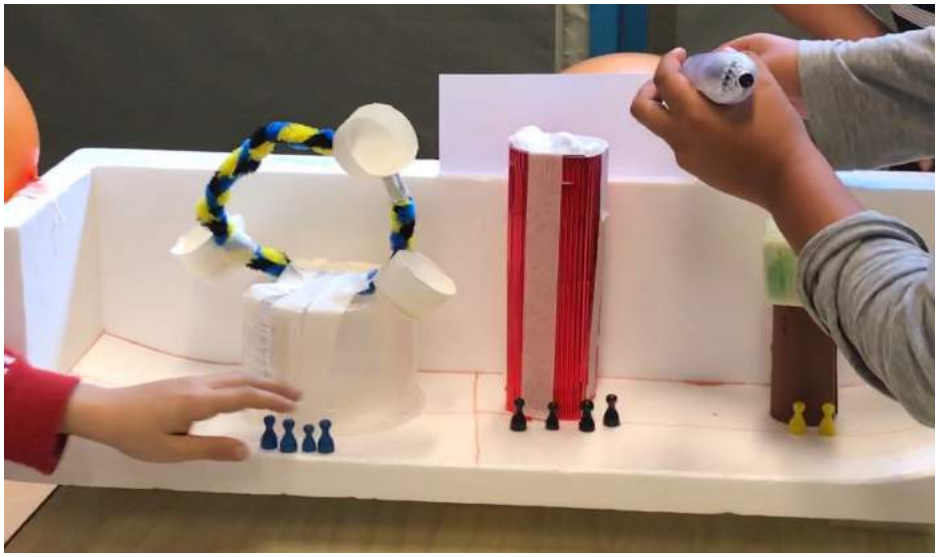
Then, they started to physicalize the data.

BAD
GIRL
CLUB

HOEVEEL



Children discussing their data and how to physicalize it, also with recycled material from the laser cutter.



The pupils used the 3Doodler pen for decorating and annotating their data physicalizations.

The ninety children (in groups of three) made 30 data physicalizations in total.

3Dimensional data physicalizations of the children moving away from the 2Dimensional screen and creatively thinking outside the box.

GIRLS

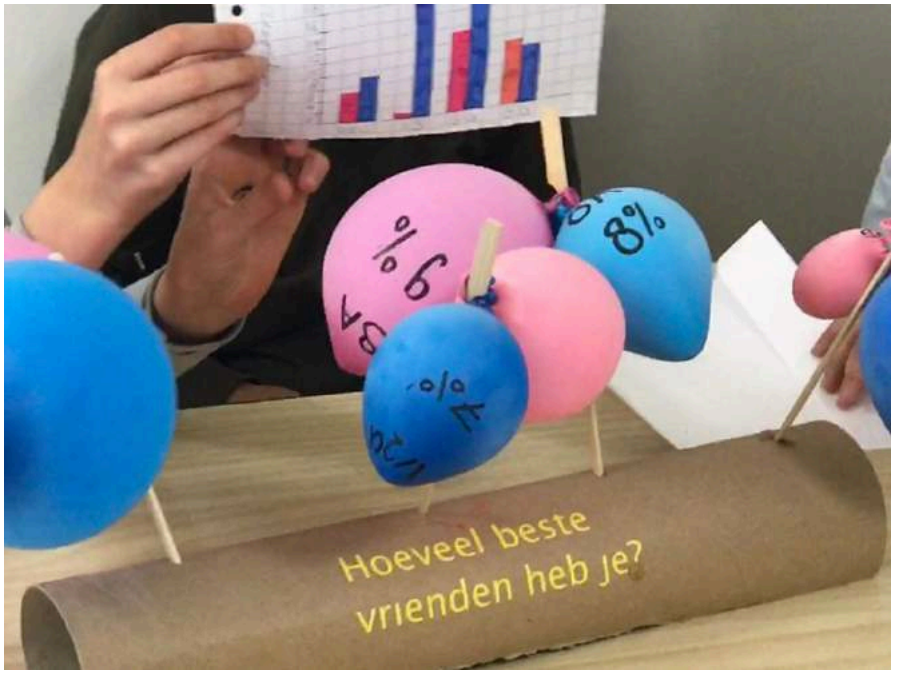
BOYS

Two groups of pupils (girls and boys) demonstrated their data with a mystery grab box, but in different ways.

Physicalization of the question: "How many friends do you need to be happy?"

Creations with the 3Doodler pen were incorporated in the design.

Physicalization by primary school students of the results to the question: *"How many best friends do you have?"*

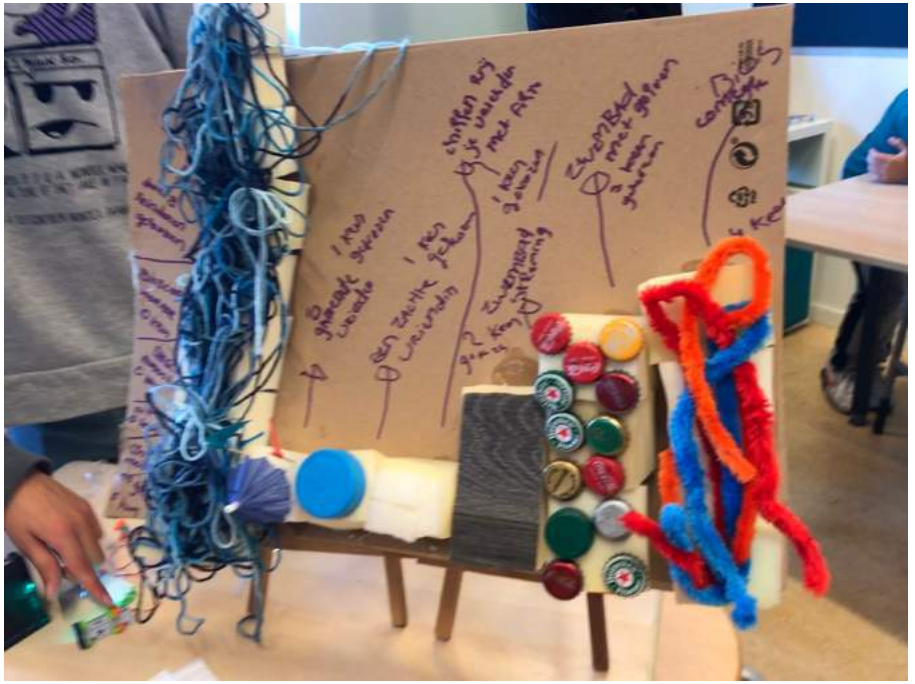


The visualization of the question itself was made with the vinyl cutter.

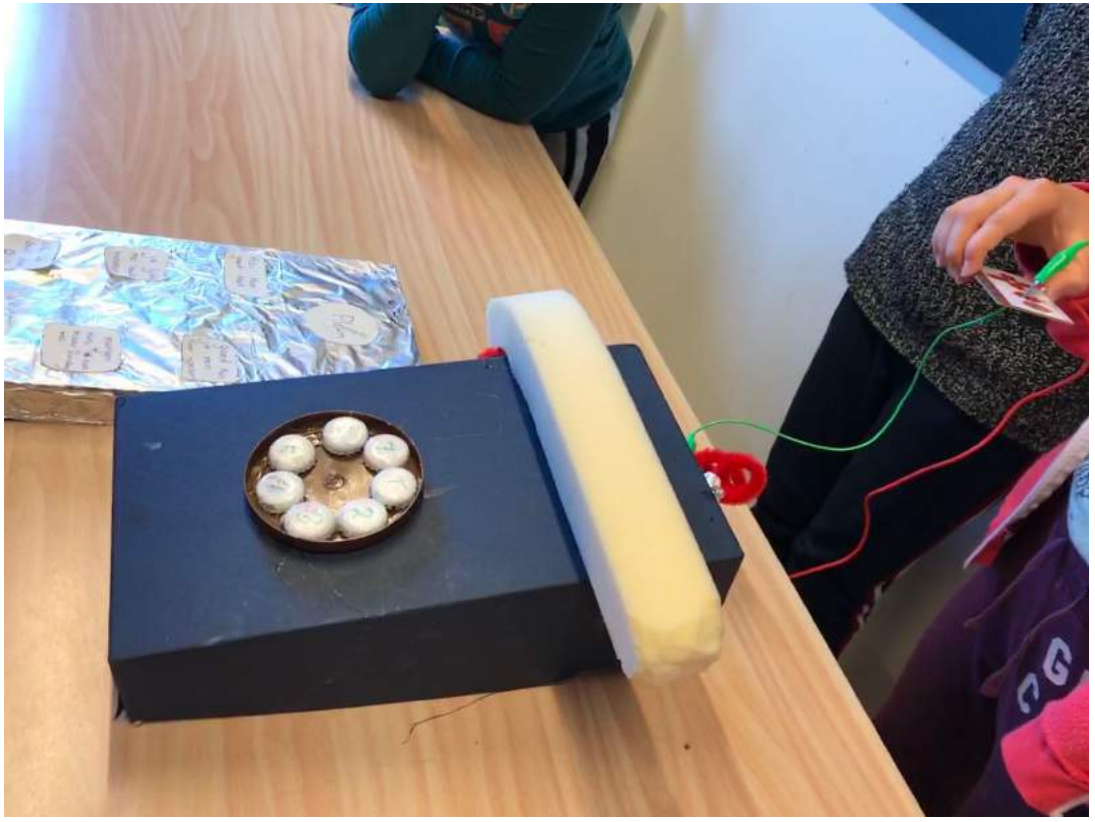
Physicalization by children using liquids and Little Bits for interactively displaying preferences of playing out- or inside with friends.

Physicalization made by the children dealing with question around the perceived importance of being honest.

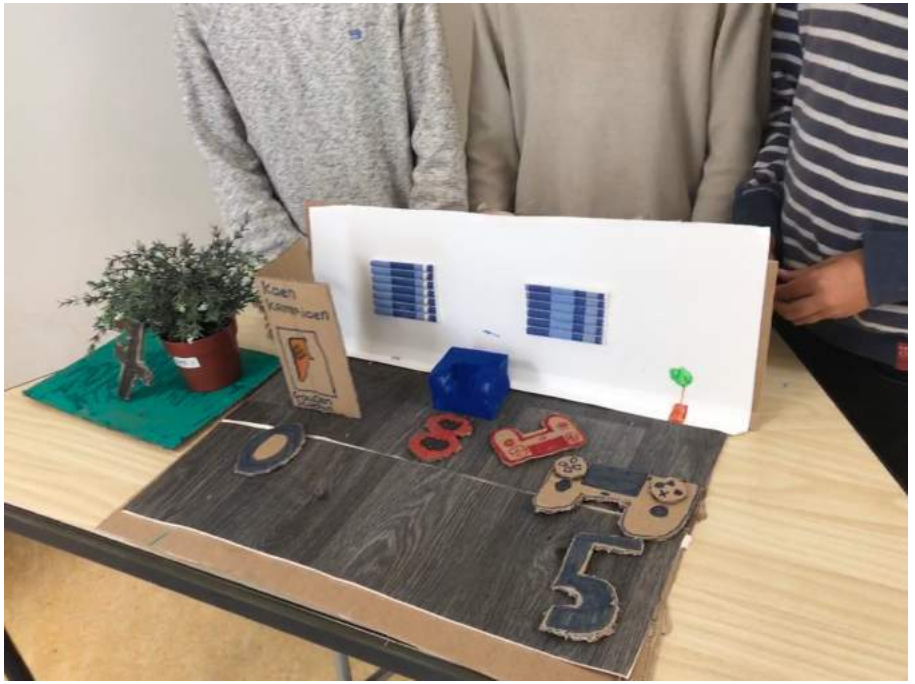
Hier Hebben 10 mensen opgestemd
MakeyMakey



Physicalization by primary school students on whether they prefer to use the phone or WhatsApp.They searched on the Internet to find a picture for learning how to design the old-skool rotary telephone.



The pupils succeeded in adding interactive ring tones with a MaKey MaKey.



Different groups of pupils demonstrated different physical representations around the question of what they preferred to do with their friends such as playing in- or outside.

The pupils used the Little Bits for an interactive count-down curtain display for revealing their physicalization. They physicalized how the new pupils felt about their new school.

WORKSHOP ONDERDELEN

MASTER STUDENTS - TEACHER ECONOMY (*N*=11)

INTRODUCTION

Introduction and presentation with examples. Discussing the potential of this approach.

CHOICE OF DATA/ COLLECTING DATA

Visualizing the results of their own pre-investigations.

MATERIALS & TOOLS

All kinds of materials, such as colored matches, building blocks and small tokens. The addition of digital technology was omitted.

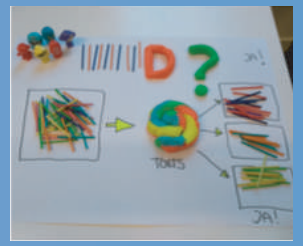
CREATING

Duration: 40 minutes of physicalization.

PRESENTING

Everyone presented their work to each other. Given the size of the group, all physicalisations were discussed together.

REFLECTION & RESULTS

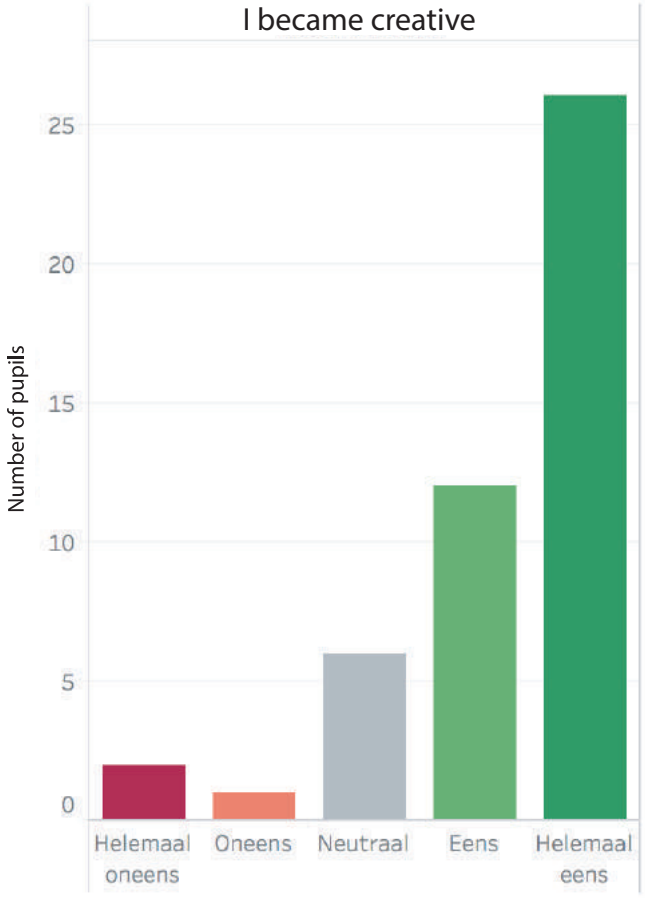


"At first, I had no idea what I wanted to create. I grabbed some material that I liked, and then my result became more clear during the process."

RESULTS

PUPILS - SINT JAN SCHOOL

During class...



" you are free to come up with everything yourself"

"nice assignment"

'BECAME CREATIVE'

This happened because...

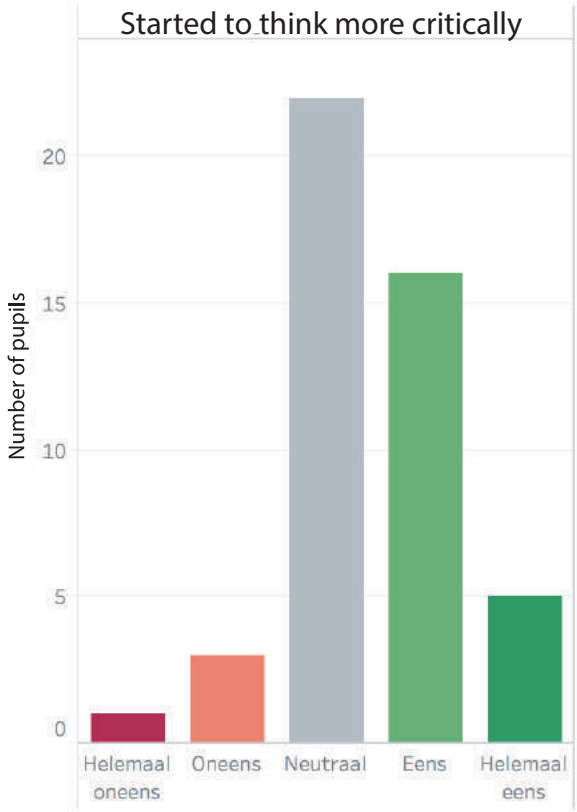
"I became creative"

"I made something cool"

RESULTS

PUPILS - SINT JAN SCHOOL

During class...



"I became sharper"

'STARTED TO THINK MORE CRITICALLY'

This happened because...

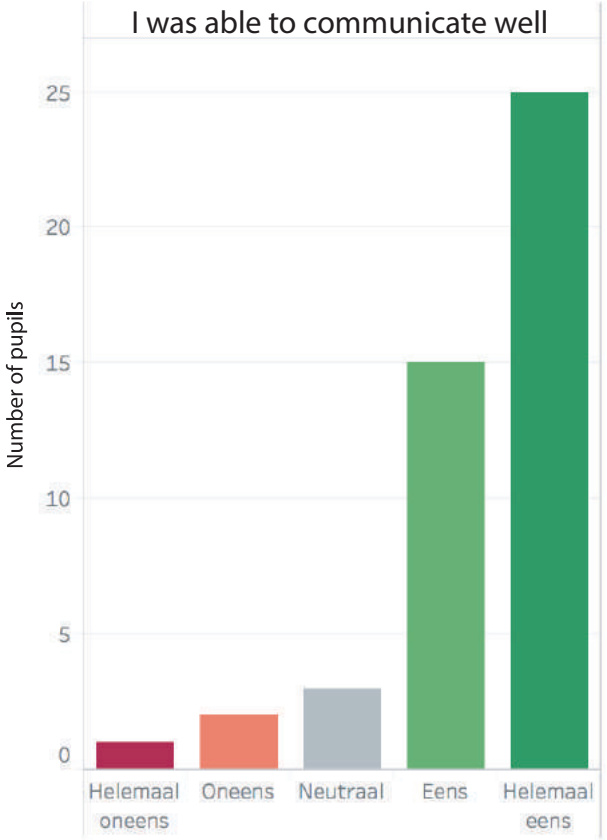
"More ideas came to mind"

"My new ideas"

RESULTS

PUPILS - SINT JAN SCHOOL

During class...



Everyone listened to each other

Everybody was able to understand me

' I WAS ABLE TO COMMUNICATE WELL'

This happened because...

"Crafting together with my group"

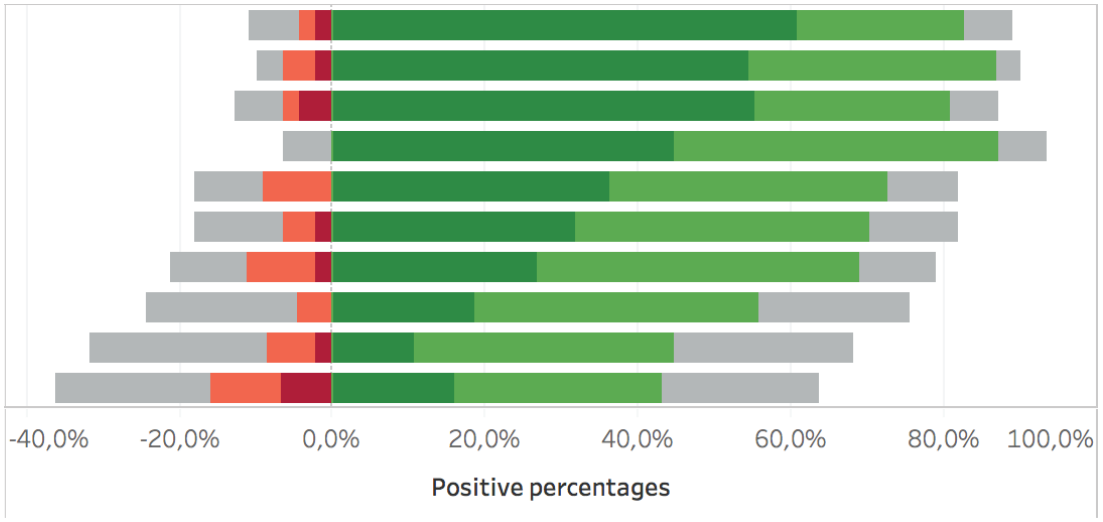
The commitment of the people i work with.

RESULTS

PUPILS - SINT JAN SCHOOL (*n*=47)
Group 7 and 8 (October, 2 and 4)

STATEMENTS **During class....**	**M** (1-5 Likert scale, 5 = Strongly Agree)
I thought it was a nice class	4,4
I was able to work well together	4,3
I became creative	4,3
I could understand the data better	4,3
I am proud of what I have made	4,0
I could explain my idea to someone else	3,9
I got some new ideas	3,8
I have learned from the lesson	3,7
I started thinking more	3,5
I could come up with a solution	3,4

RESULTS

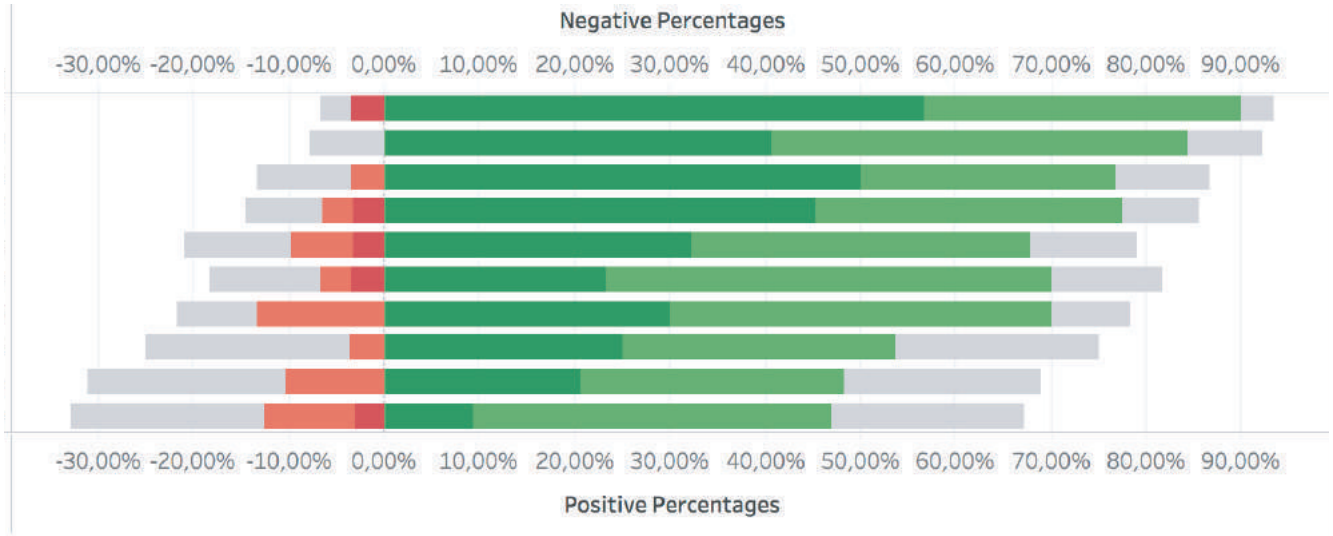


RESULTS

PUPILS SINT JAN SCHOOL

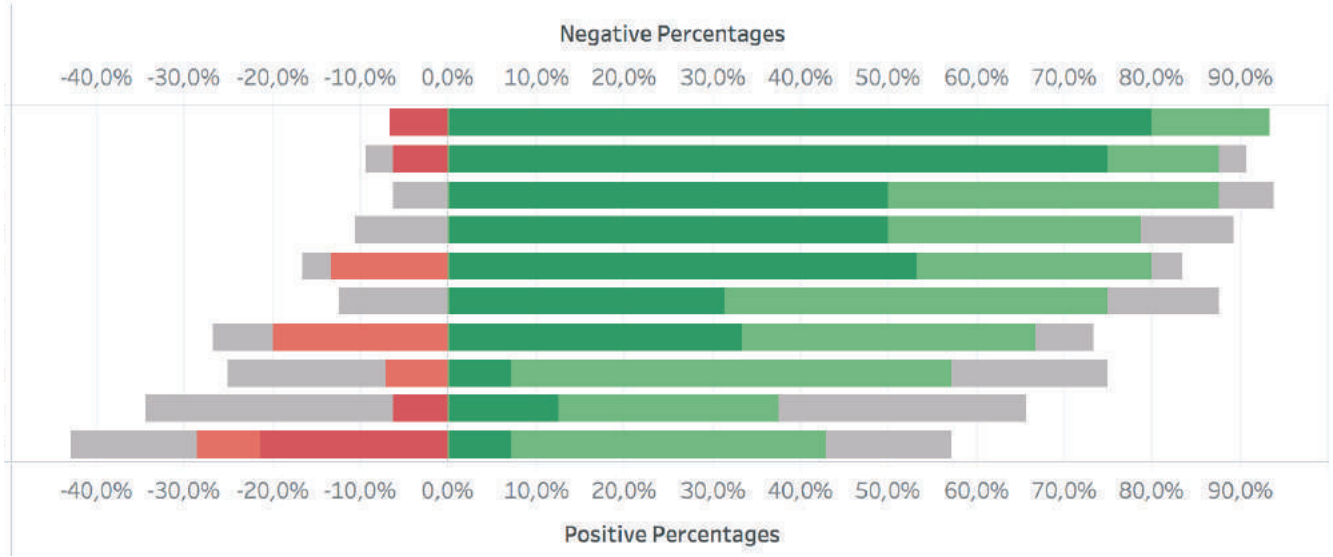
(*N*=31)

Questions	M (1-5 likert scale, 5 = helemaal mee eens)
I was able to work well together	4,4
I could understand the data better	4,3
I thought it was a nice class	4,2
I became creative	4,1
I could explain my idea to someone else	3,8
I got some new ideas	3,8
I was proud of what I've made	3,8
I have learned from the lesson	3,7
I could come up with a solution	3,6
I started thinking more	3,4



(*N*=16)

Questions	M (1-5 likert scale, 5 = helemaal mee eens)
I thought it was a nice class	4,6
I became creative	4,5
I could understand the data better	4,4
I am proud of what I have made	4,3
I was able to work well together	4,2
I could explain my idea to someone else	4,1
I got some new ideas	3,8
I have learned from the lesson	3,6
I started thinking more	3,4
I could come up with a solution	3,0

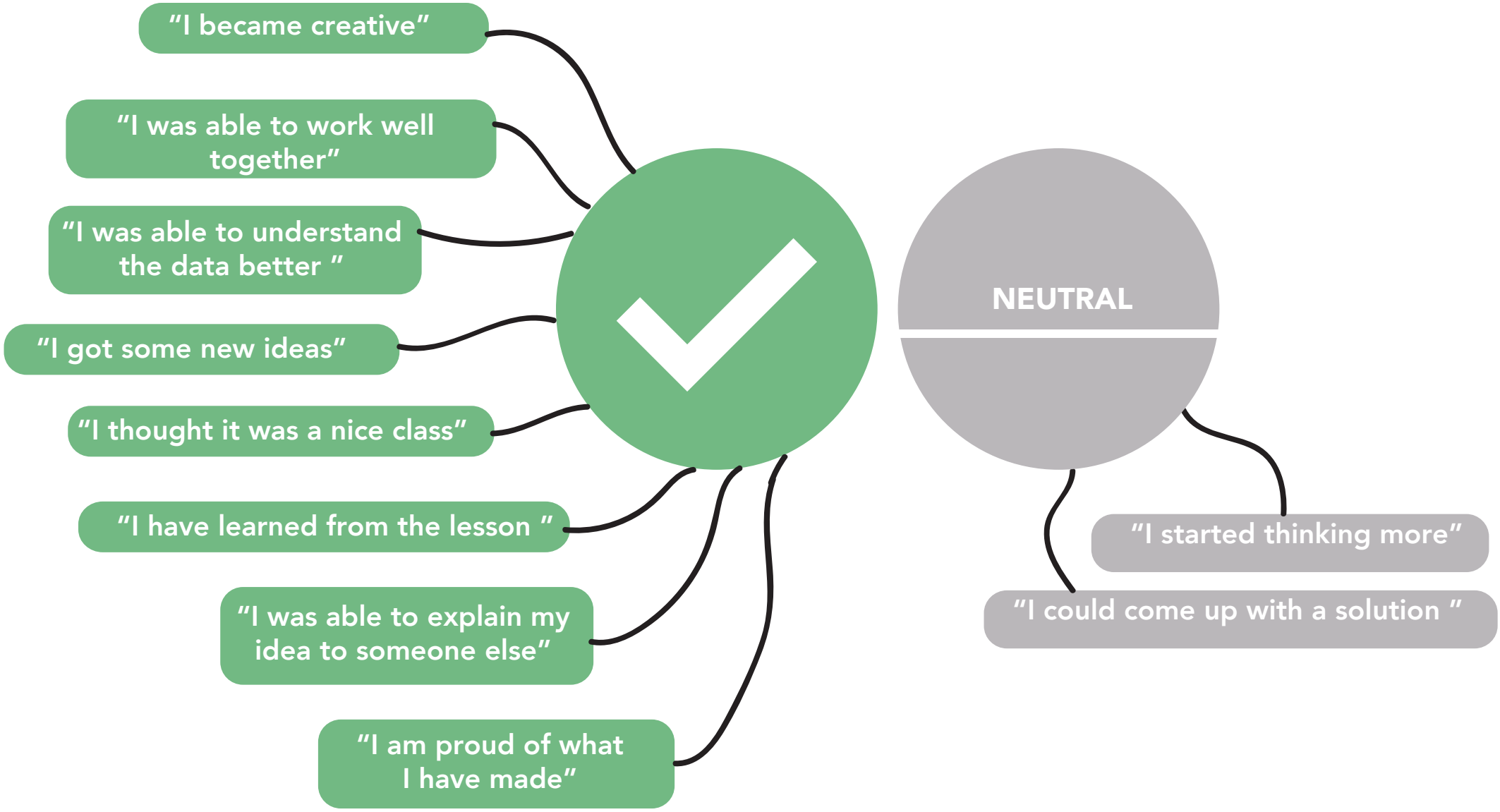


Neutral | Disagree | Strongly disagree | Agree | Strongly Agree

RESULTS

PUPILS SINT JAN SCHOOL (*N*=47)

During class...



THIS IS WHAT I HAVE LEARNED

PUPILS - ST JAN SCHOOL

What data physicalization is

Data is everywhere

That you can use data in a fun way

That friendship is important

to think creatively

Doing research

To bring data to life

How to craft things

Data is information

That you can make things in a fast way

That is doesn't need to be super tidy

How to collect data easily

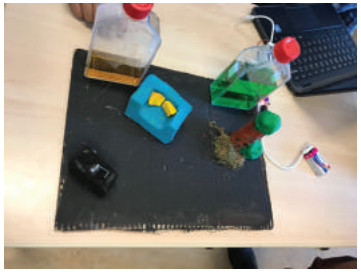
You have to add a bit of humor to the project or it gets boring

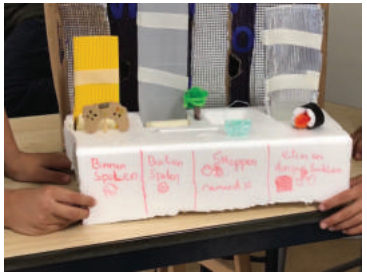
Working together, and listening to each other

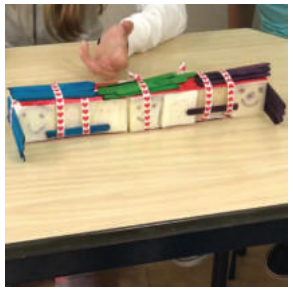
To bring things from paper to life

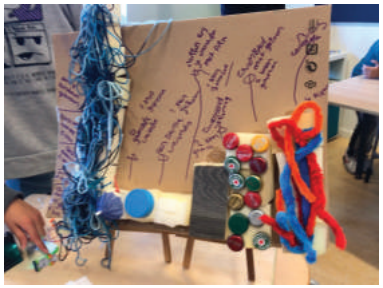
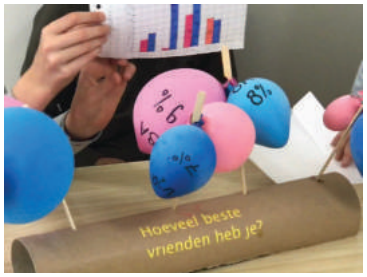
How to come up with good ideas

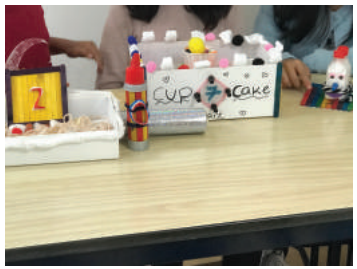
I AM PROUD OF WHAT I HAVE MADE

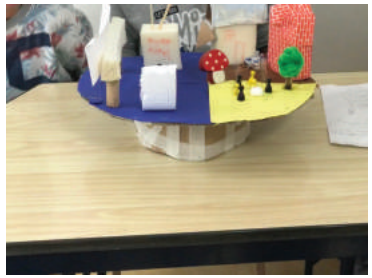
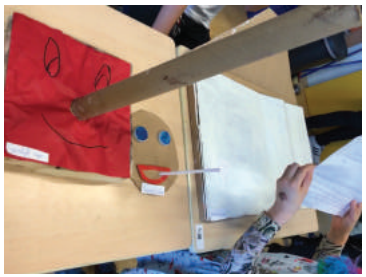




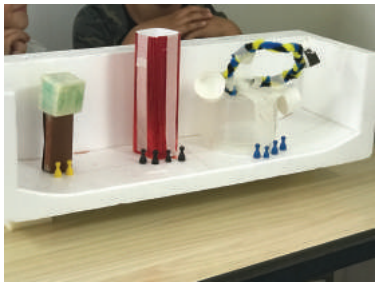
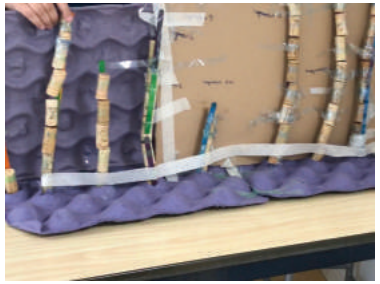




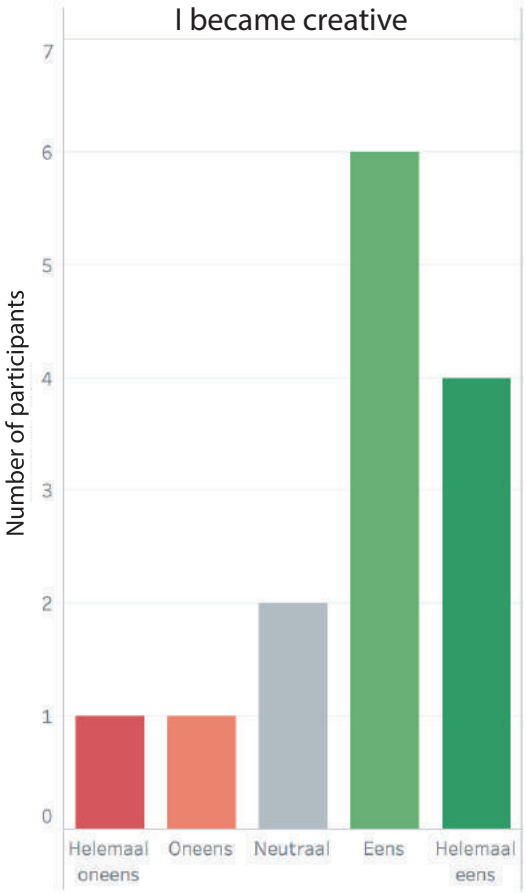
I AM PROUD OF WHAT I HAVE MADE

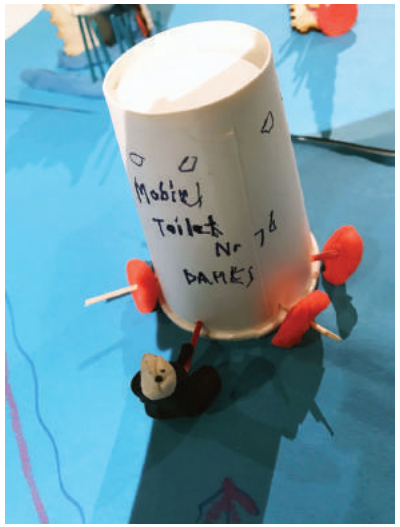



RESULTS

GENERAL PUBLIC WAAG = OPEN

During class...





"Thinking in a group makes you playful"

"Combining things"

'BECAME CREATIVE'

This happened because...

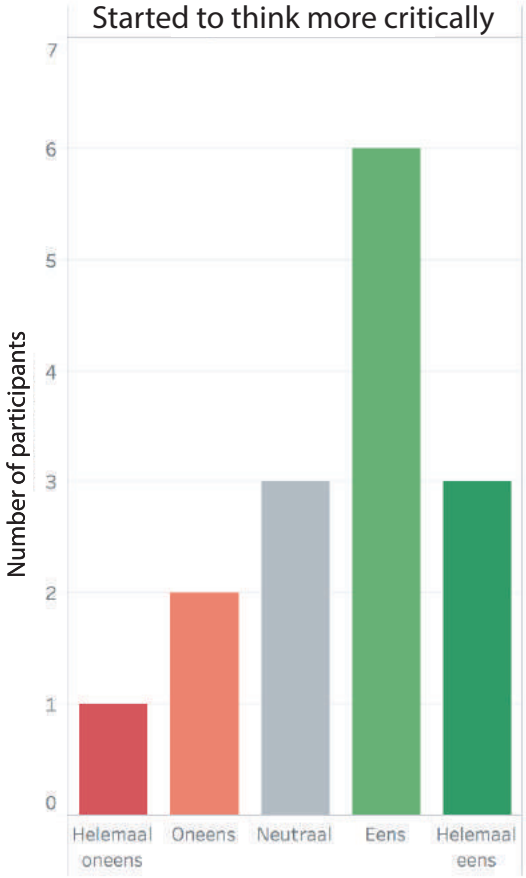
"Finding different ways to visualize certain data types."

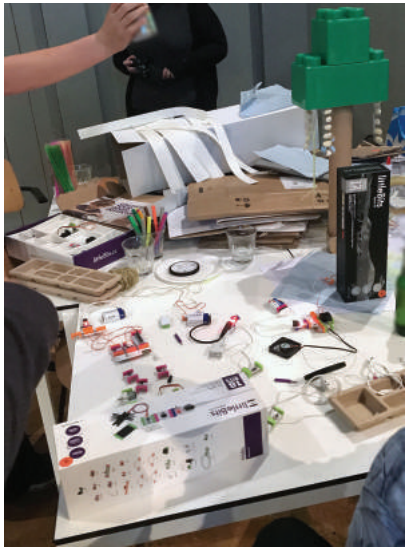
"I became enthusiastic and I started to explore things"

RESULTS

GENERAL PUBLIC WAAG = OPEN

During class...





"I wanted to measure facts"

"I became aware of the proportions"

'STARTED TO THINK MORE CRITICALLY'

This happened because...

"First I started to have good look at the data"

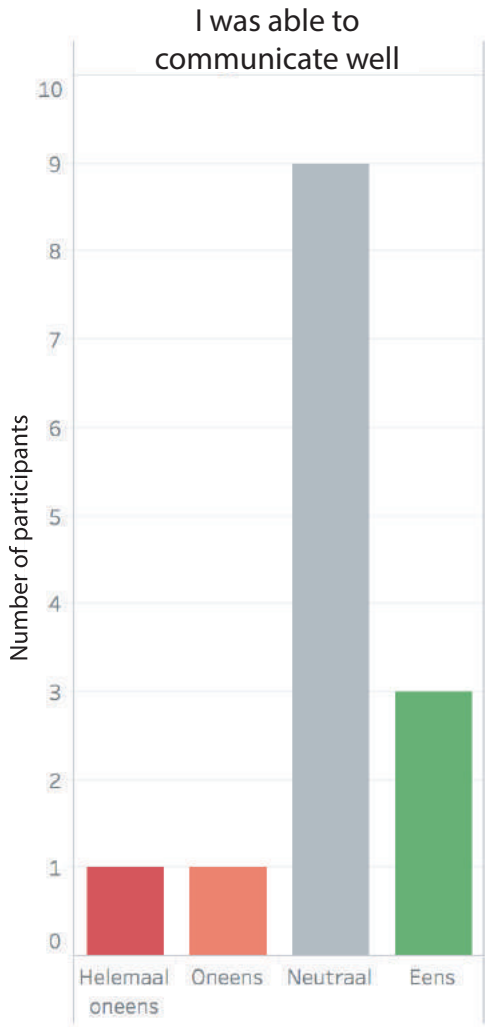
Numbers on its own do not say anything

RESULTS

GENERAL PUBLIC WAAG = OPEN

"More contact with other crafting participants."

During class...



"Different approaches to visualizing."

' I WAS ABLE TO COMMUNICATE WELL'

This happened because...

"Three people know more than one."

RESULTS

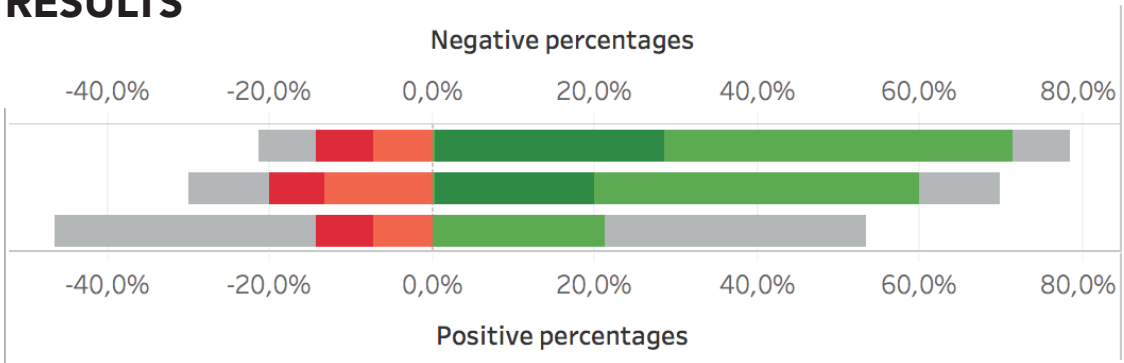
GENERAL PUBLIC WAAG = OPEN (*N*=15)

STATEMENTS
During class....

M
(1-5 Likert scale,
5 = Strongly Agree)

RESULTS

I became creative — 3,7
I started to think critically — 3,5
I was able to communicate well — 3,0

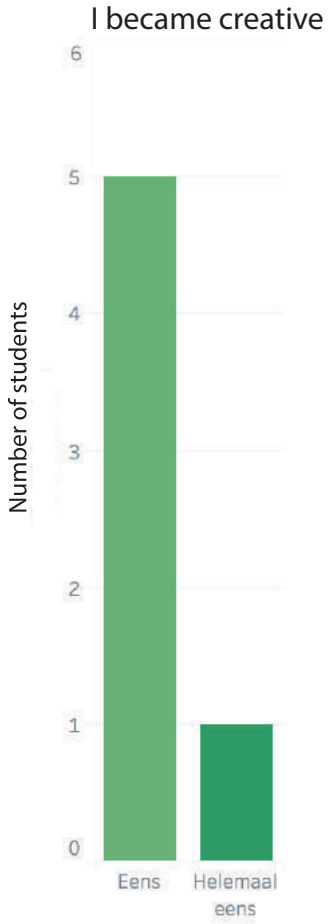


Neutral | Disagree | Strongly disagree | Agree | Strongly Agree

RESULTS

PRIMARY SCHOOL TEACHERS - SINT JAN SCHOOL

During class...



"Using different materials"

"I quickly had an idea what we could make"

'BECAME CREATIVE'

This happened because...

"We wanted to visualize the data and we wanted to craft the objects"

RESULTS

PRIMARY SCHOOL TEACHERS - SINT JAN

During class...

"Analyzing the graphs"

"Viewing charts and background data."

'STARTED TO THINK MORE CRITICALLY'

This happened because...

"Reading critically and consulting"

RESULTS

PRIMARY SCHOOL TEACHERS - SINT JAN

"A lot of discussion"

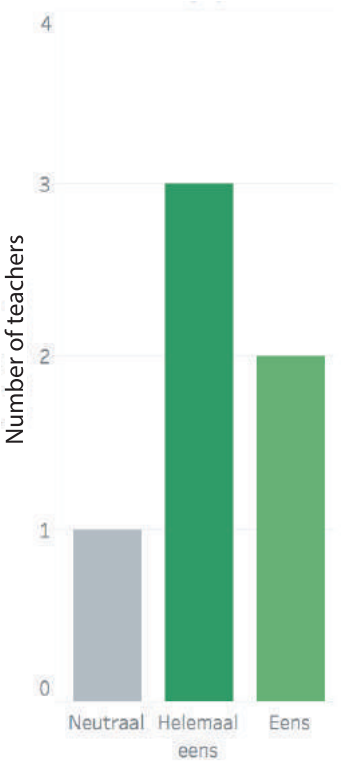
During class...

"I enjoyed working together with a colleague that I normally don't work with"

' I WAS ABLE TO COMMUNICATE WELL'

This happened because...

I was able to communicate well

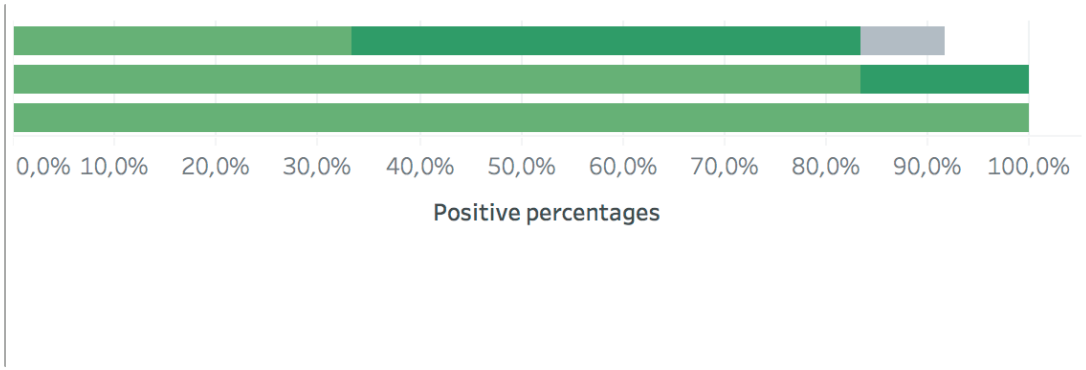


"Nice to have someone that complements your weaknesses"

RESULTS

PRIMARY SCHOOL TEACHERS - SINT JAN SCHOOL (*N*=6)

STATEMENTS During class....	M (1-5 likert scale, 5 = Strongly Agree)	RESULTS
I was able to communicate well	4,3	
I became creative	4,2	
I started to think critically	4,0	

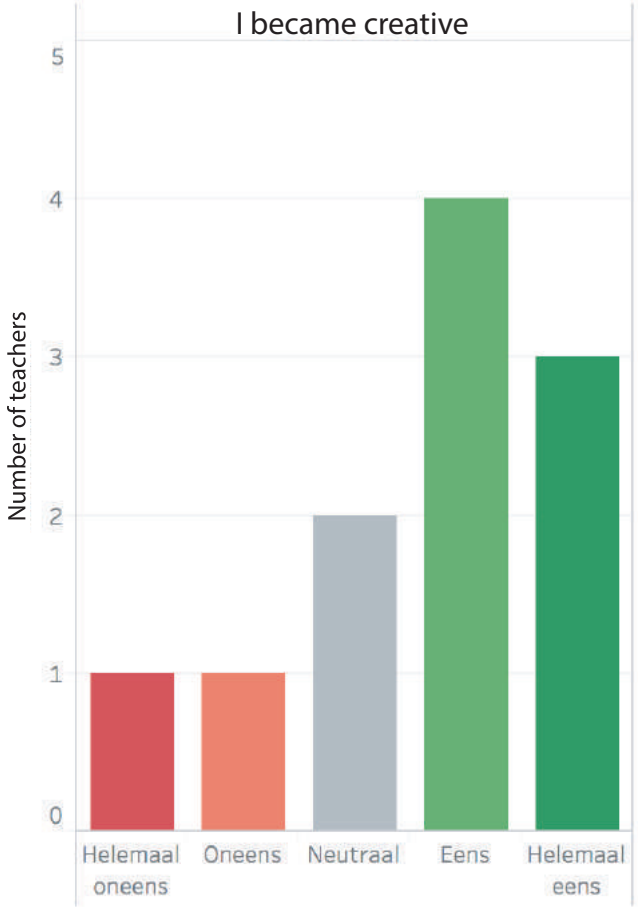


Neutral Disagree Strongly disagree Agree Strongly Agree

RESULTS

MASTER STUDENTS - TEACHER ECONOMY

During class...



"I got creative ideas"

"I am not that creative, I need more time for that."

'BECAME CREATIVE'

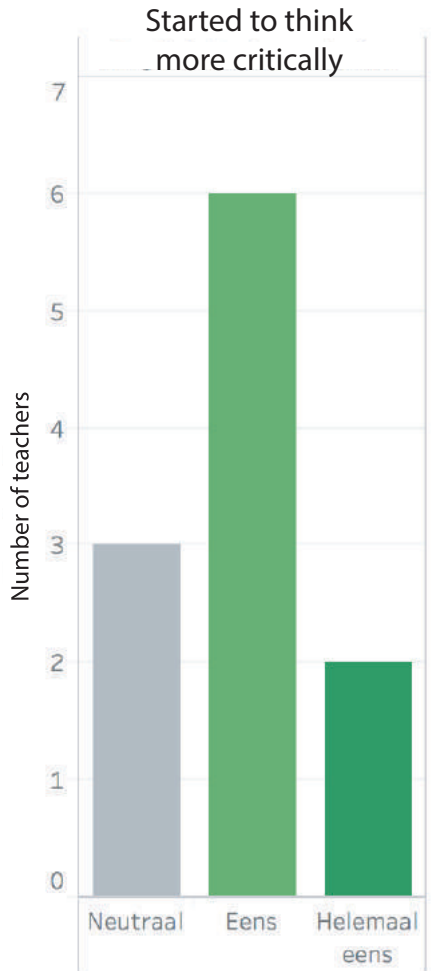
This happened because...

" I always thought I wasn't creative"

RESULTS

MASTER STUDENTS - TEACHER ECONOMY

During class...



"Converting numbers into visible images"

"Because of the questions from fellow students, I started to think more about my research"

'STARTED TO THINK MORE CRITICALLY'

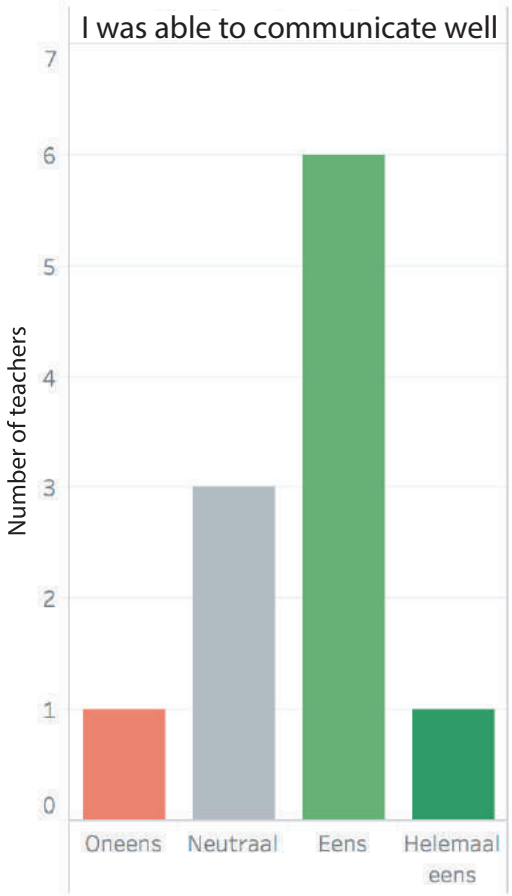
This happened because...

"Looking at data in a different way"

RESULTS

MASTER STUDENTS - TEACHER ECONOMY

During class...



"Back to the basics"

"The majority was able to communicate well, during the workshop"

' I WAS ABLE TO COMMUNICATE WELL'

This happened because...

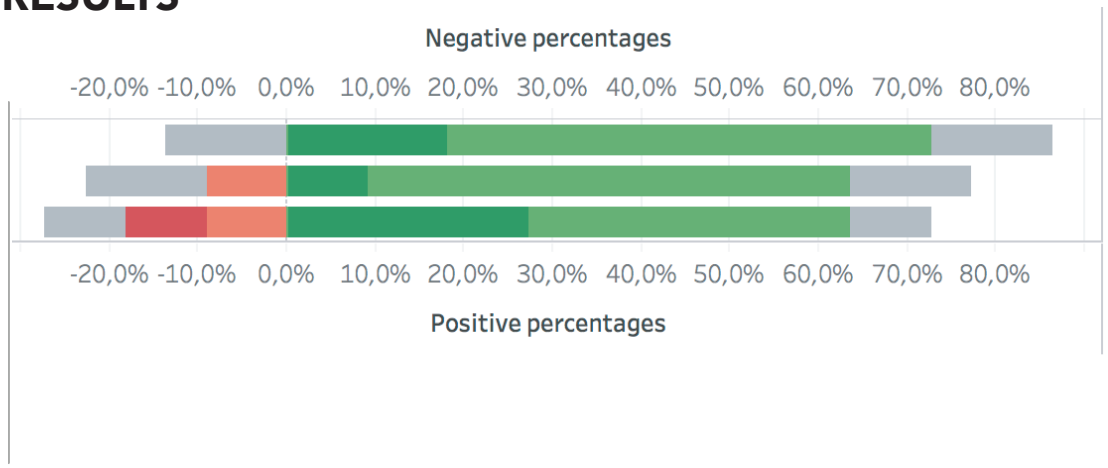
"Collaboratively looking at the results"

RESULTS

MASTER STUDENTS - TEACHING ECONOMICS (*N*=11)

STATEMENTS **During class....**	**M** (1-5 likert scale, 5 = Strongly Agree)
I started to think critically	3,9
I was able to communicate well	3,6
I became creative	3,6

RESULTS

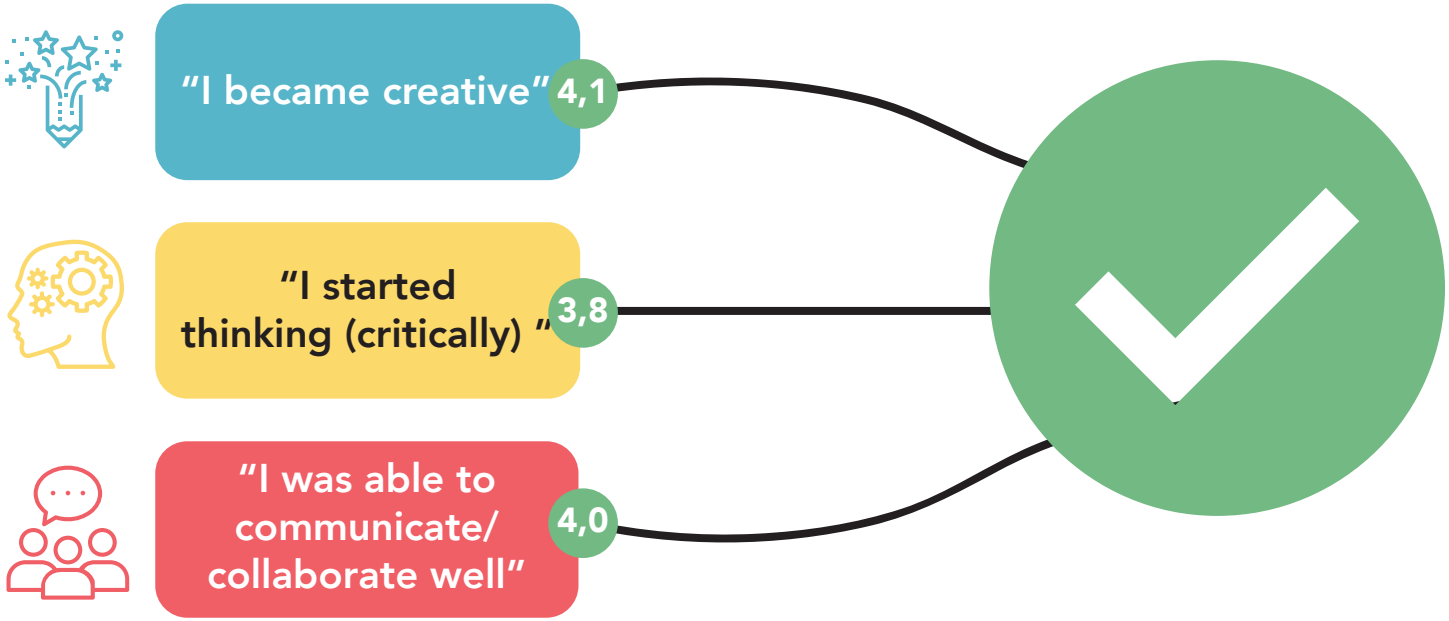


Neutral Disagree Strongly disagree Agree Strongly Agree

RESULTS

TOTAL OF ALL PARTICIPANTS THAT COMPLETED THE QUESTIONNAIRES (*N*=79)
PRIMARY SCHOOL PUPILS ST JAN SCHOOL (***n***=47)
PRIMARY SCHOOL TEACHERS ST JAN SCHOOL (***n***=6)
GENERAL PUBLIC WAAG (***n***=15)
MASTER STUDENTS TEACHING ECONOMICS (***n***=11)

DURING CLASS...



M =Average 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Goal (function)

Usable

Fitting

Useful

Materials

Physical form

Aesthetic

Structure

Appearance

Sensory

Big

Interactive

Dynamic

Behavior

Amusing

Presentation

Technical ingenuity

Discussion/Thought provoking

Information (data)

Objective

Self-collected

Reliable

Accurate

Transparent

Successful physicalization

Place your 10x15 photo of physicalization here

Story (concept)

Interesting

Relevant

New

Meaningful

Surprising

What makes a good physicalization?

What -according to you- are the ingredients, that lead to a successful physicalization?
Feel free to adjust this and fill in this form.

WORKSHOP FORMAT

INTRODUCTION	CHOICE OF DATA/ COLLECTING DATA	MATERIALS & TOOLS	CREATING	PRESENTING	REFLECTION & RESULTS
Explaining with (Lego) examples.	Preparing data on data cards or self-collect	Conscious with materials and tools	In groups of two.	Presenting to each other.	Creativity Critical thinking Collaboration

What makes a good data physicalization class ?....

.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
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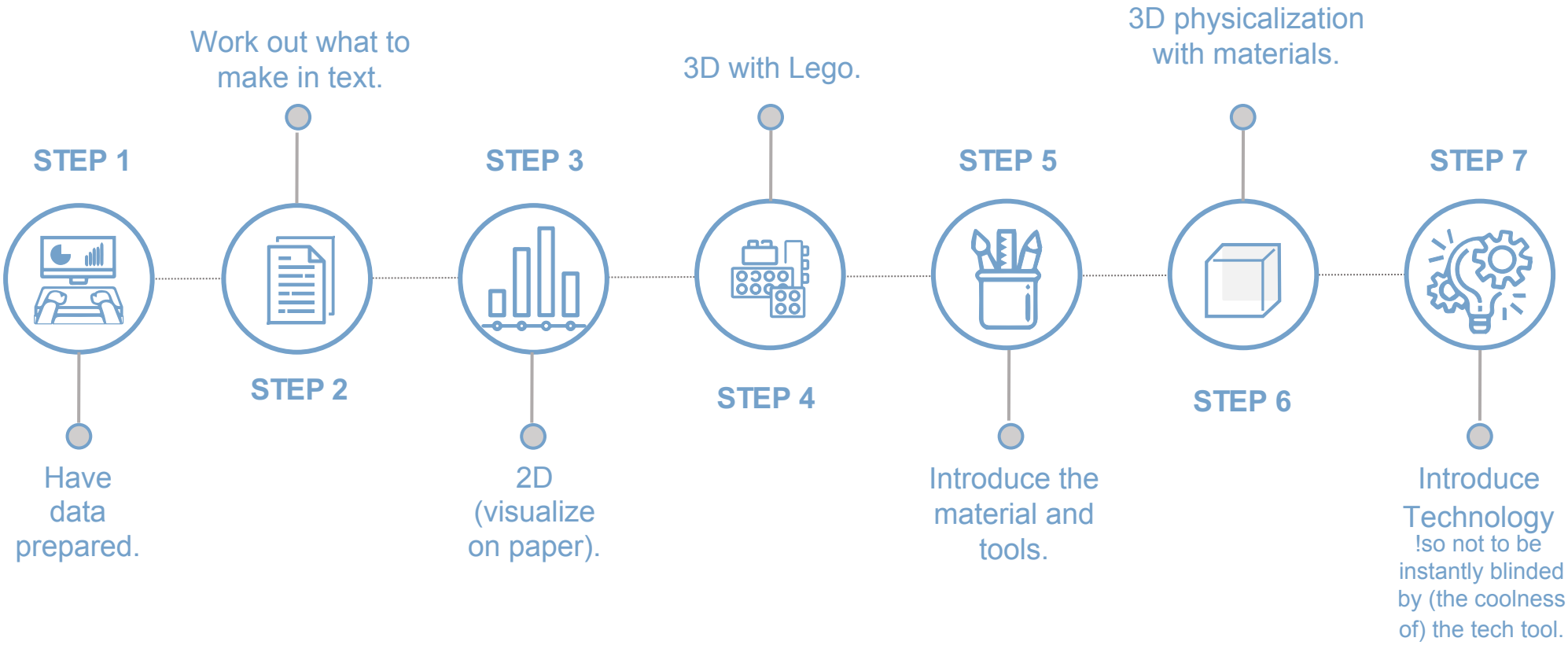
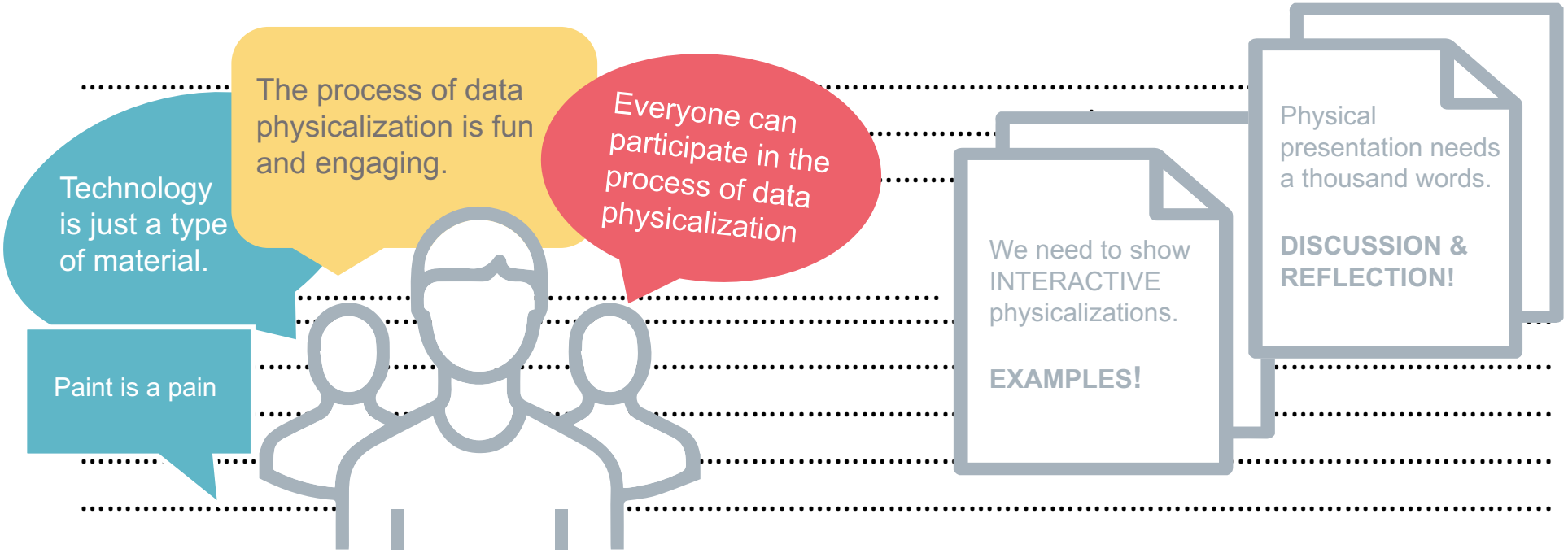


PHYSICALIZATION PROCESS



The process of data physicalization contributes to 21st-century skills.

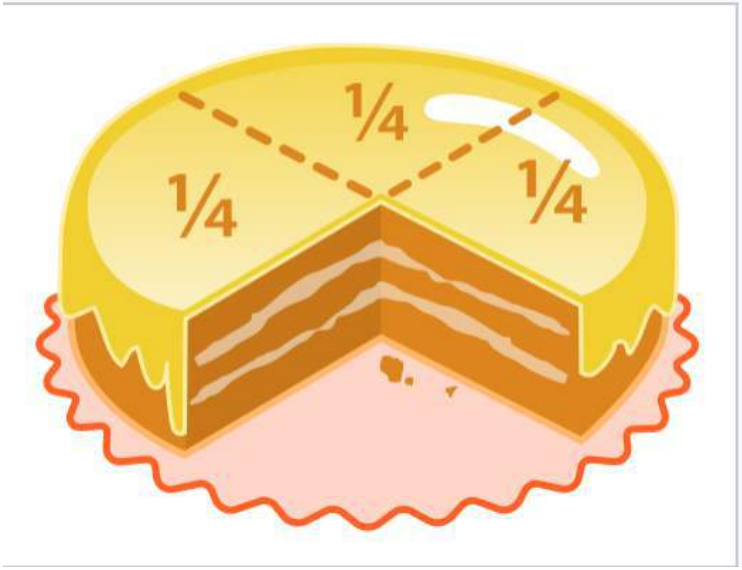
RECOMMENDATIONS & CONCLUSION

EXAMPLES
DATA PHYSICALIZATION

SEE ALSO

The Pinterest bord datafysicalisatie (https://www.pinterest.com/wissendenken/data-physicalisation-graffiti) the specially made Information Physicalisation bord (https://www.pinterest.com/mekanis/information-physicalization) and Dataphys (http://dataphys.org/list)

2D → 3D



CAKE IN EDUCATION

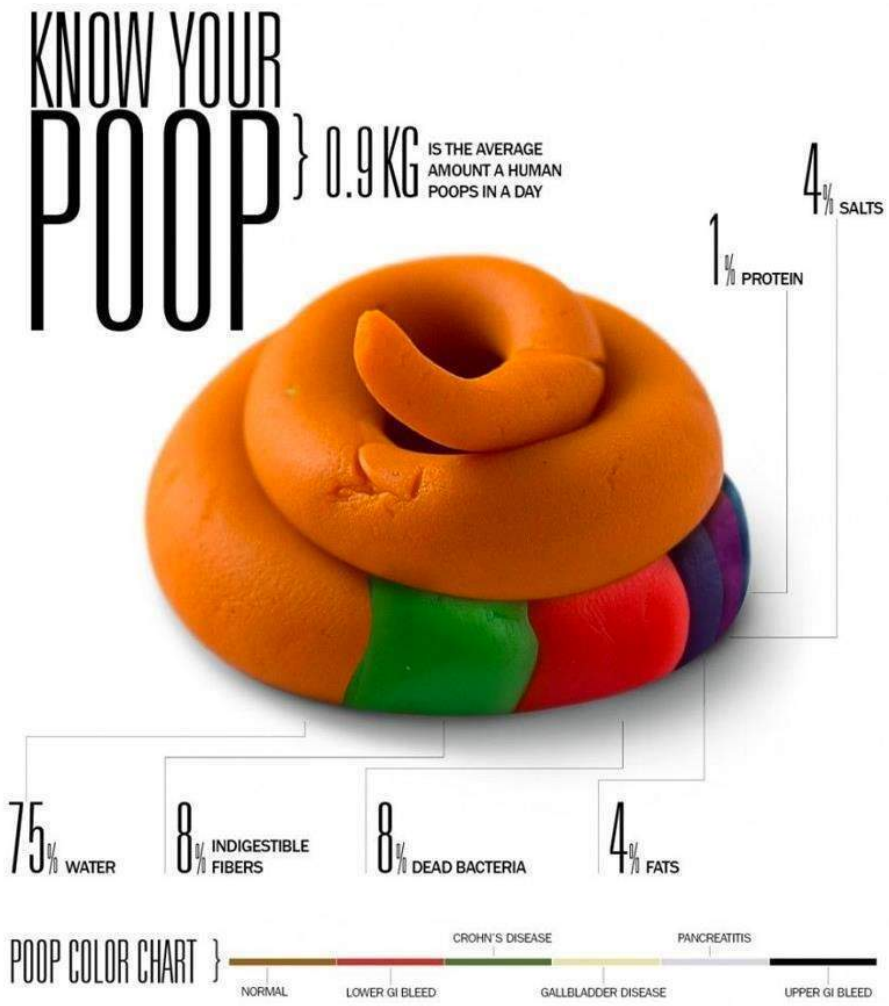
EXPLAINING FRACTIONS. EDUCATIONAL PURPOSE

Credits: Findystoys

KEYBOARD FREQUENCY

SCULPTURE

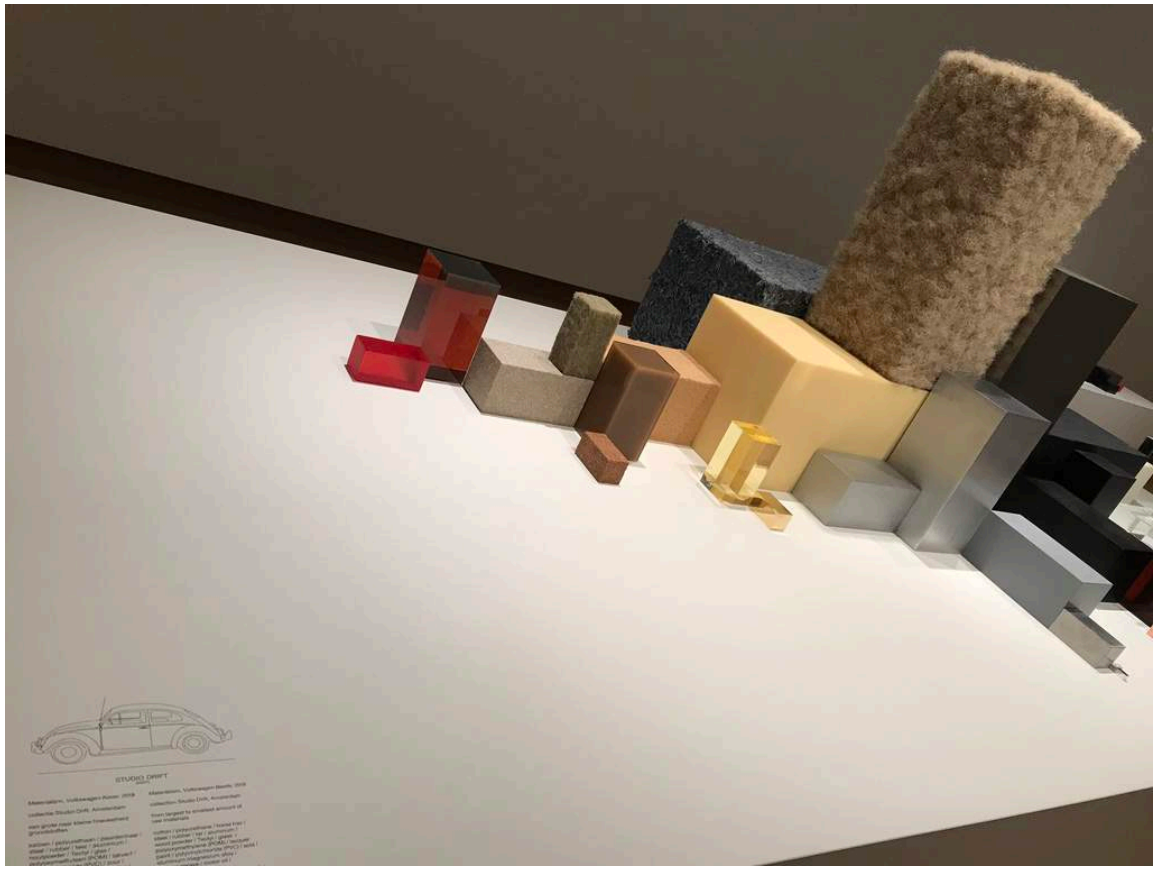
Credits: Mike Knuepfel

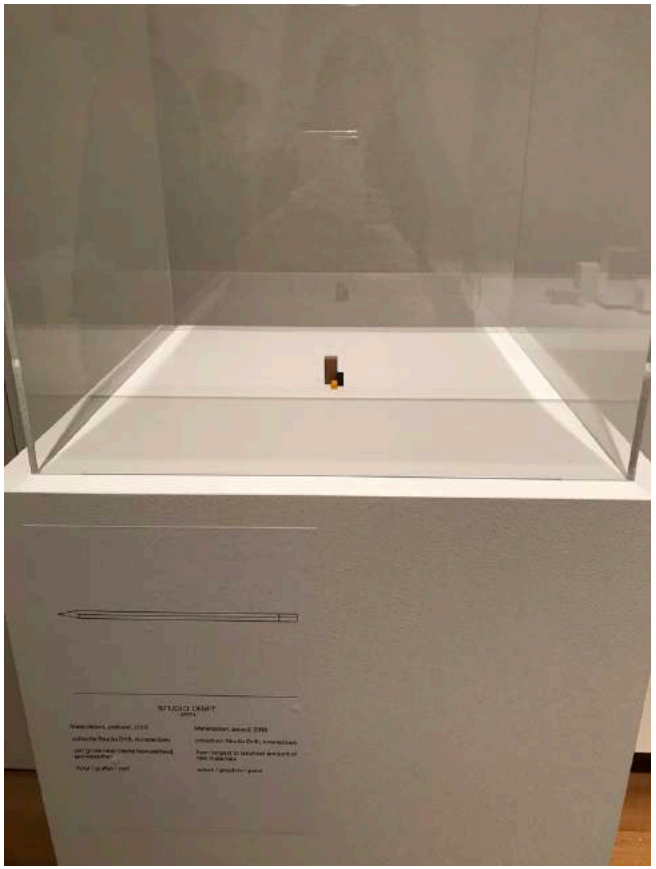


KNOW YOUR POOP

PHYSICAL REPRESENTATION OF CONTENTS

Credits: Various graphics - Raj





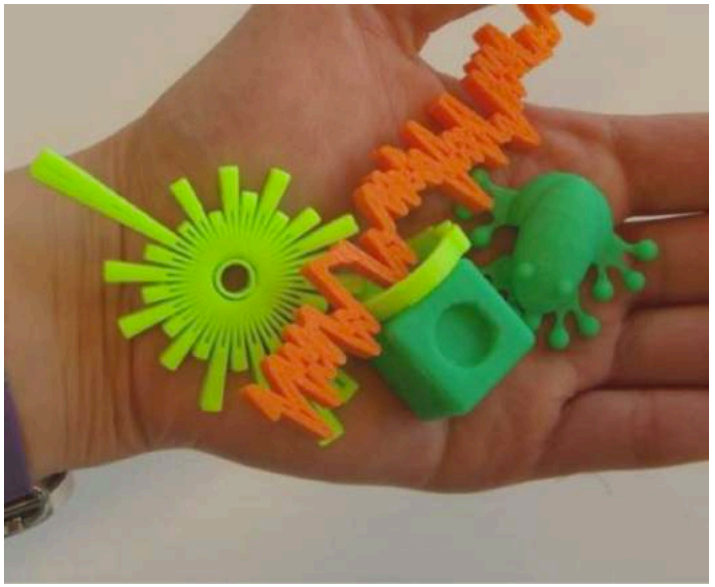
STUDIO DRIFT

HOW MANY MATERIAL DOES AN OBJECT CONTAIN?

@Stedelijk: MATERIALISM | Photo credits: Marije Kanis

HOW MUCH SUGAR IS IN YOUR FOOD?

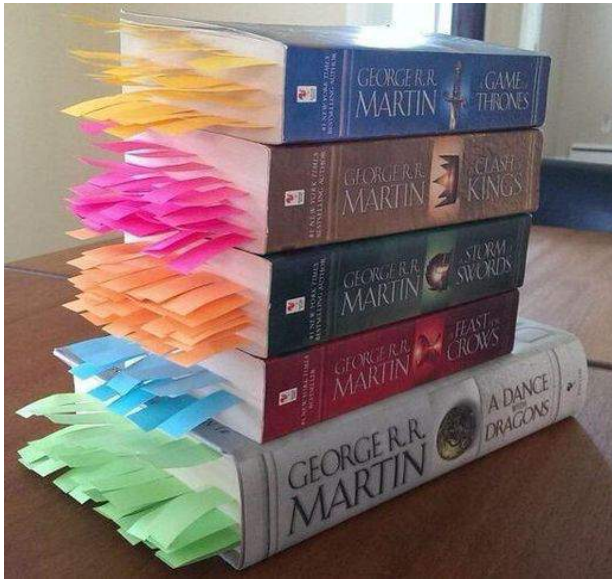
Credits: Sugar stack



3D PRINTED REWARD

BASED ON WORK-OUT DATA | WITH DIGITAL FABRICATION & INTERACTIVE TECHNIQUES

Credits: Rohit Ashok Khot



GAME OF THRONES

LEFT: EVERY DEATH IN THE GAME OF THRONES NOVELS, BOOKMARKED
RIGHT: BRAIDED HAIR IS A REPRESENTATION OF BATTLES WON

Credits: Waterstonesdork

EXAMPLES PHYSICALIZATION

SEE ALSO

The **Pinterest bord datafysicalisatie** (https://www.pinterest.com/wissendenken/data-physicalisation-graffiti)
the specially made **Information Physicalisation bord** (https://www.pinterest.com/mekanis/information-physicalization) and
Dataphys (http://dataphys.org/list)

INTERACTIVE MODEL

DEMONSTRATING SENSOR TECHNOLOGY IN THE HOME

Credits: Marije Kanis et al

SAVE THE PLANET

PHYSICALIZATION OF SAVING PAPER

Credits: Simon Wooller, WWF

INTERACTIVE SHIRT

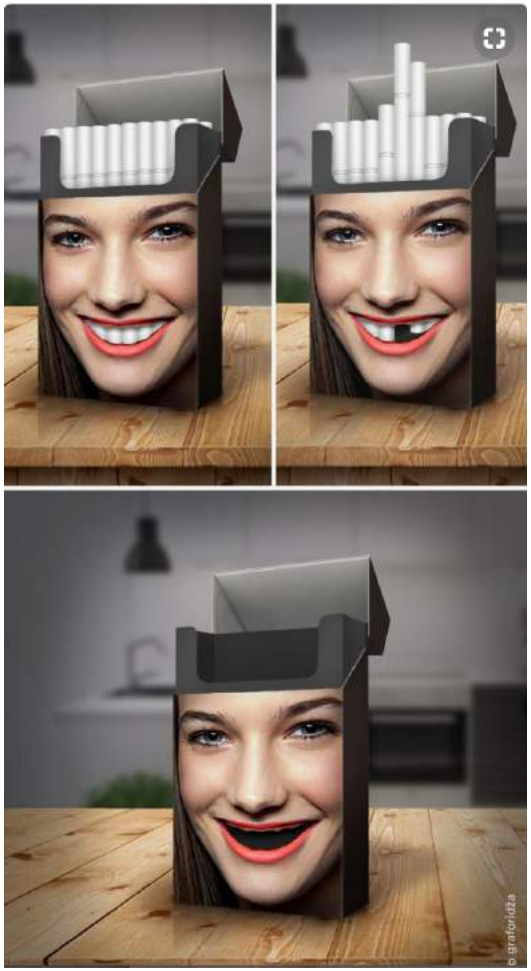
SHOWS HIDDEN BODY PROCESSES

Credits: L. Norooz et al

INTERACTIVE SHIRT

SHOWS POLLUTION

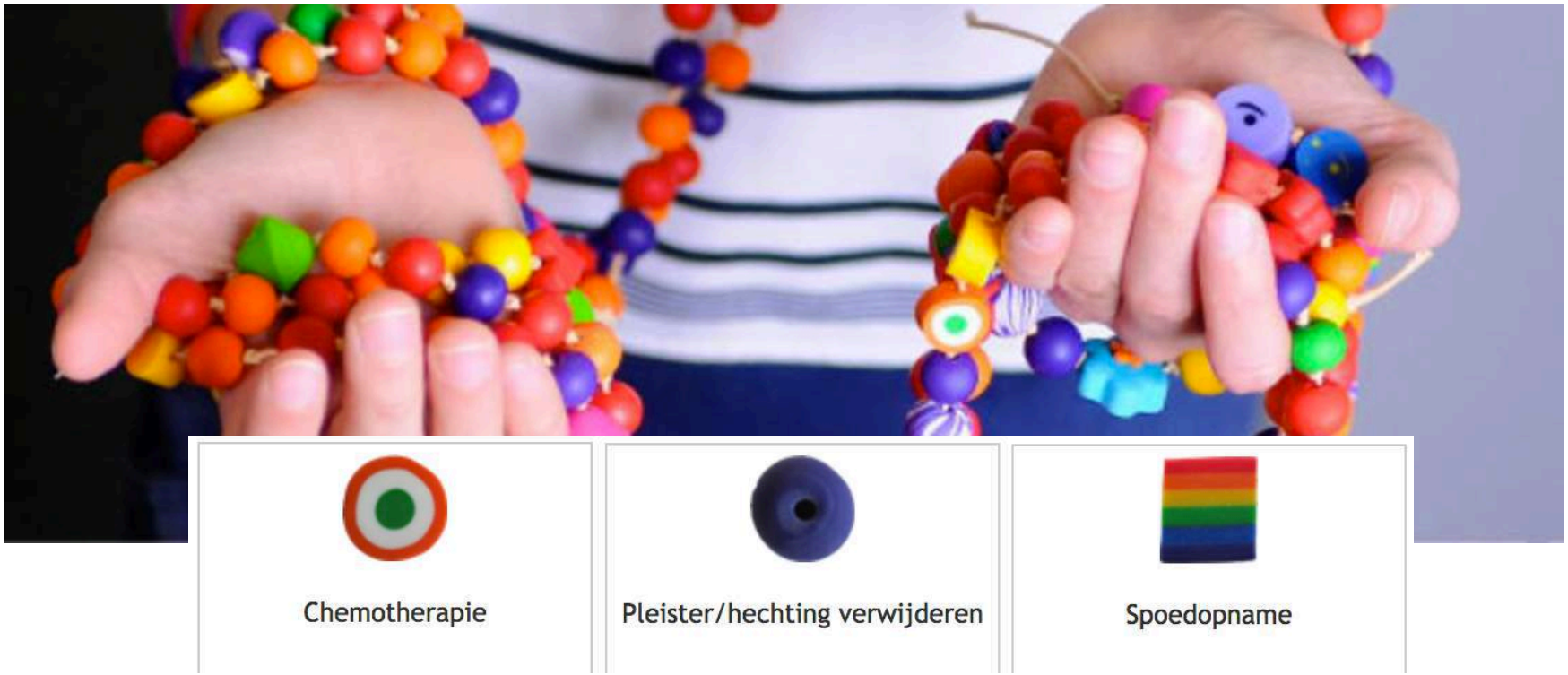
Credits: Nien Lam & Sue Ngo



TOBACCO TEETH | BALLOT BIN

PHYSICALIZATION SMOKING BEHAVIOR

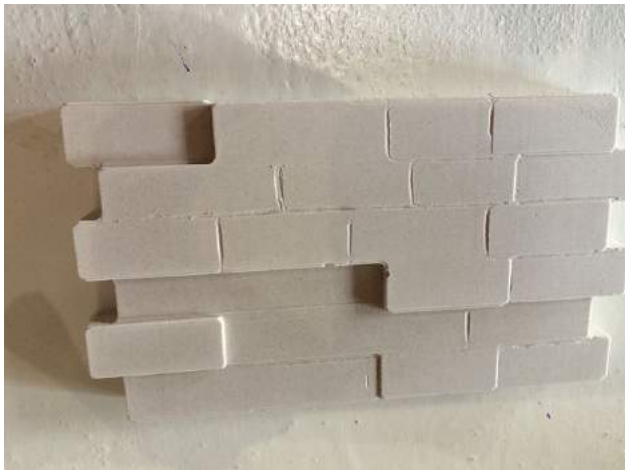
Credits: Miroslav Vujovic Graforidza | Hubbub

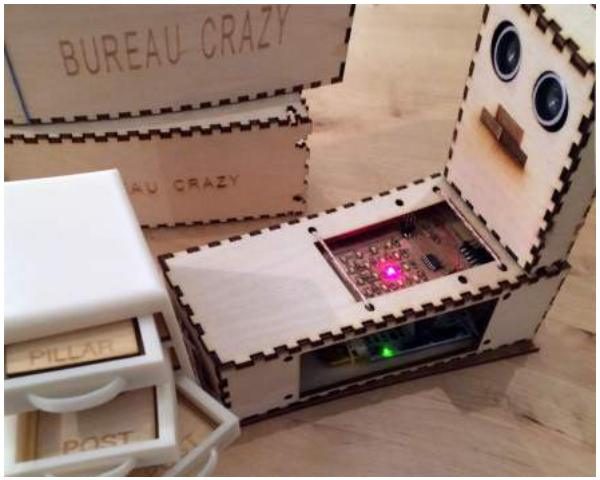


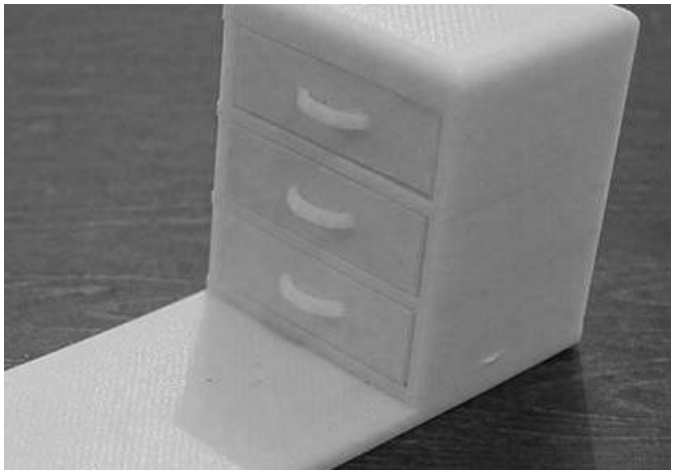
KANJERKETTING

PHYSICALIZATION OF MEDICAL JOURNEY FOR CHILDREN WITH CANCER

Credits: Kanjerketting.nl







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BUREAUCRAZY

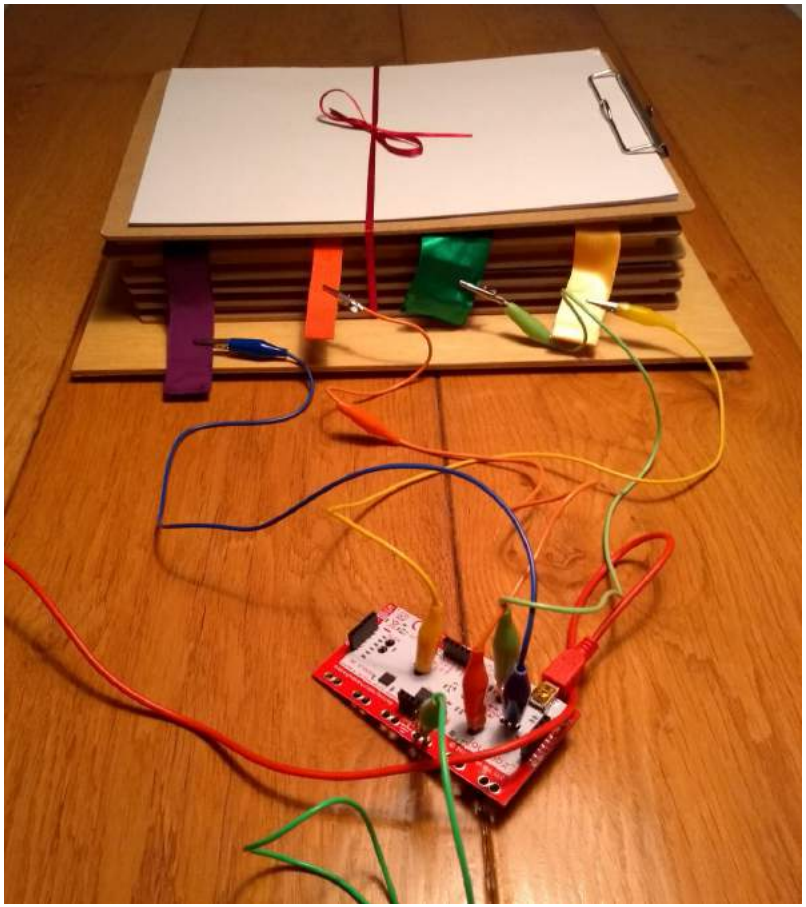
INTERACTIVE PHYSICALIZATION OF BUREAUCRACY

Credits: Marije Kanis

EXPLAINING BIOLOGY

AN INTERACTIVE PHYSICAL MODEL OF AN AUDITORY SENSORY HAIR CELL

Credits: Jelka Lustenhouwer



PHYSICALIZATION OF COLLECTED DATA

OF QUESTIONNAIRES FROM THE REVEALING DESIGN STUDY

Credits: Monique Pijls