EPFL

Educational robotics

June 3rd, 2025

Francesco Mondada

EPFL

Introduction to educational robotics

(from a very personal perspective ☺)

Goal: address…

- …some definitions
- …some basic concepts and methodologies related to robot design
- …some hints related to a PhD
- …some case studies

…hoping all this make sense to you
and will be useful in your PhD work.

Could we start with a short presentation?

Introduction to educational robotics

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‘Educational Robots’ OR ‘Educational Robotics’ OR ‘Robotics Education’ OR ‘Robotics Learning’ OR ‘Robotics Teaching’ (query Q1 on Scopus)

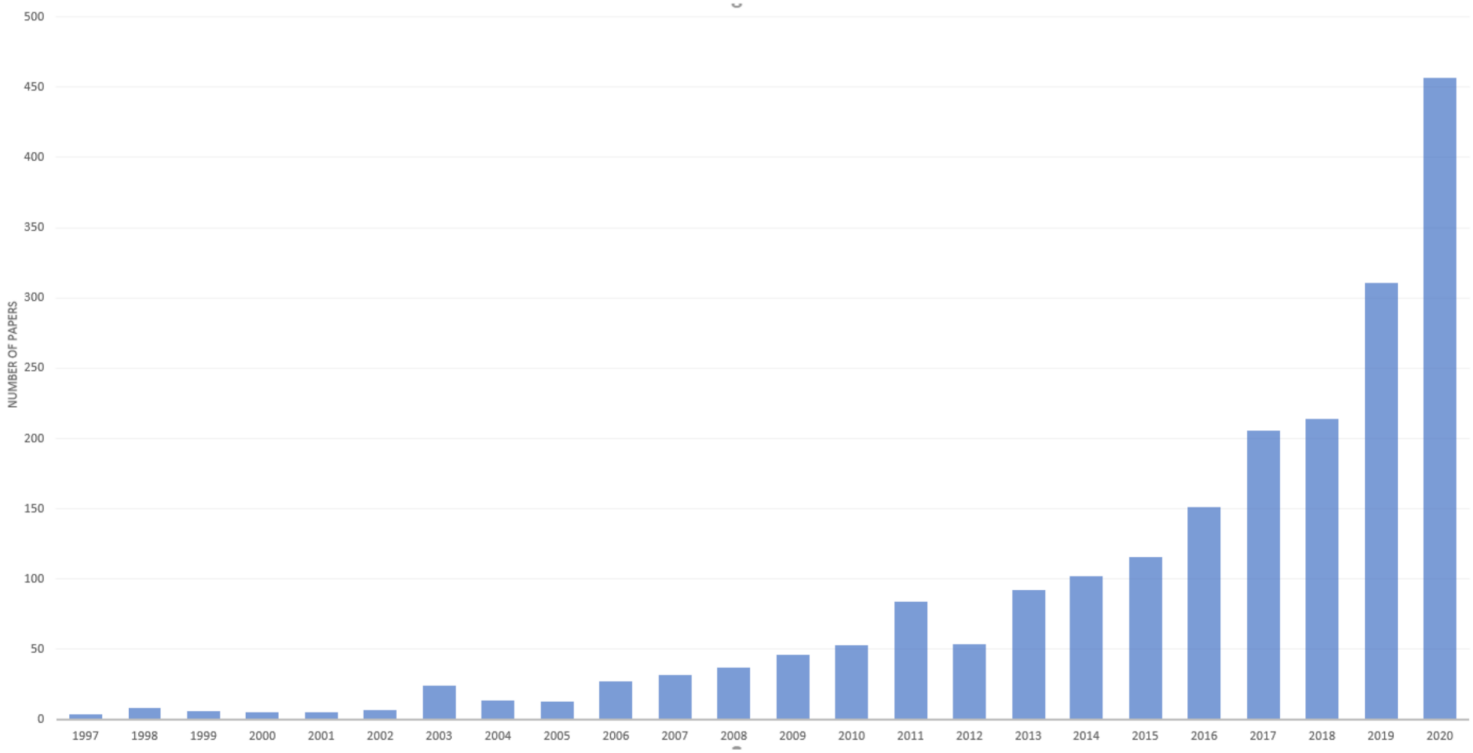

FIGURE 1. Number of Publications Related to Query Q_1 Per Year, Based on Scopus Data.

Evripidou, Salomi & Georgiou, Kyriakoula & Doitsidis, Lefteris & Amanatiadis, Angelos & Zinonos, Zinon & Chatzichristofis, Savvas. (2020). Educational Robotics: Platforms, Competitions and Expected Learning Outcomes. IEEE Access. 8. 219534-219562. 10.1109/ACCESS.2020.3042555.

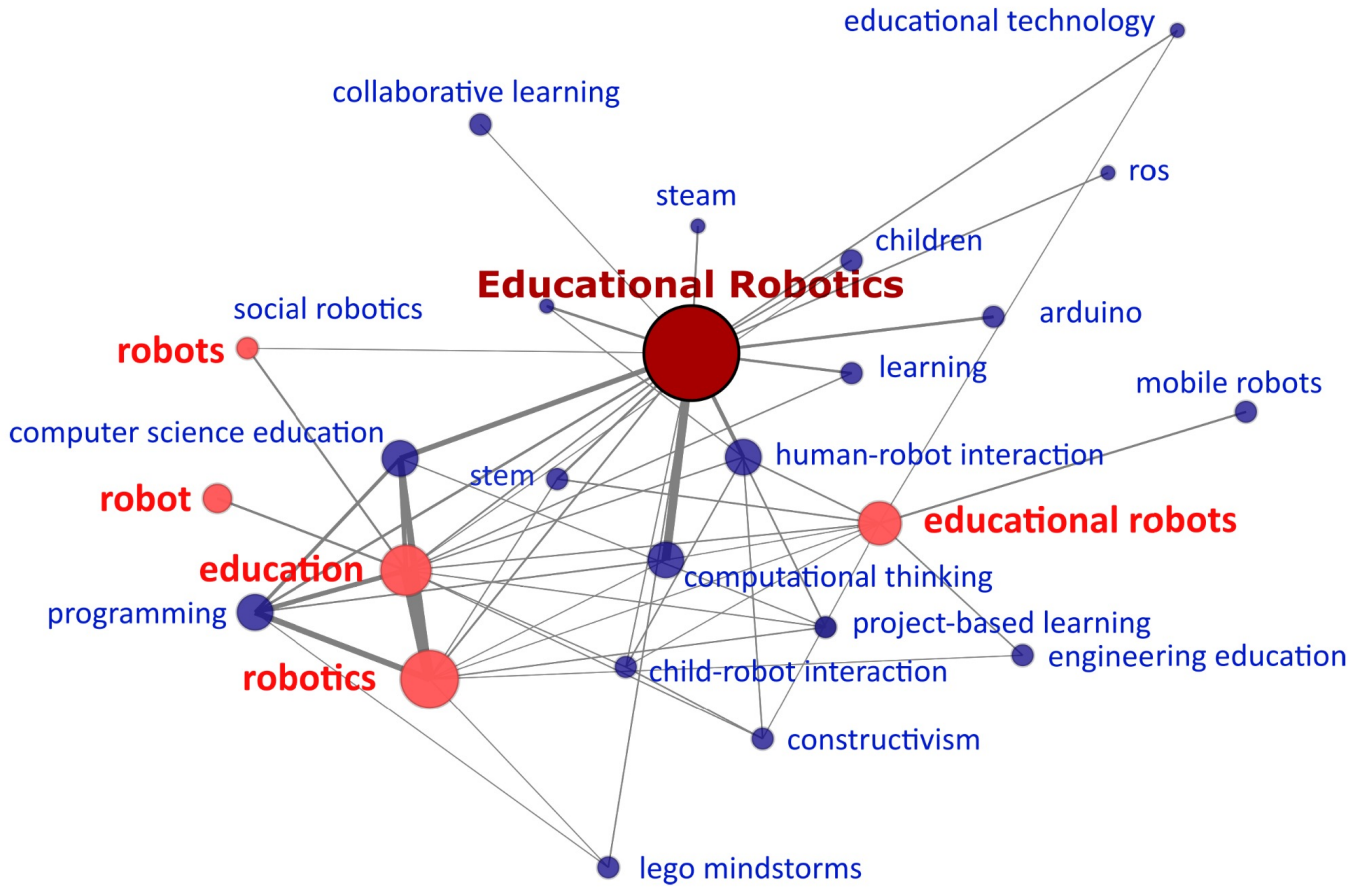

FIGURE 2. Overview of *'Educational Robotics'* - (Q1) Index Term Bibliometric Map based on Scopus data.

Evripidou, Salomi & Georgiou, Kyriakoula & Doitsidis, Lefteris & Amanatiadis, Angelos & Zinonos, Zinon & Chatzichristofis, Savvas. (2020). Educational Robotics: Platforms, Competitions and Expected Learning Outcomes. IEEE Access. 8. 219534-219562. 10.1109/ACCESS.2020.3042555.

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Table 1.2

Classification of service robots by application

-consumer applications-

Application		Description
AC	**Consumer robots**	**Robots intended for use by everyone. No professional training required.**
AC1	Robots for domestic tasks	Robots for housekeeping and similar tasks around the house
AC11	Domestic floor cleaning (indoor)	Wet and dry cleaning of floors, e.g. vacuuming and wiping of floors
AC12	Domestic window cleaning	Cleaning of windows
AC13	Gardening	Gardening tasks, e.g. lawn mowing
AC14	Domestic cleaning (outdoor)	Outdoor cleaning tasks around the home, e.g. pool cleaning, yard cleaning
AC19	Other domestic tasks	Domestic tasks other than AC11 to AC14
AC2	Social interaction, education	Robots with social interaction functions, robots for children and student education
AC21	Social interaction, companions	Main purpose of the robot is to interact with and entertain users at home
AC22	Education	Robots desigend specifically to educate children or students
AC3	Care at home	Robots that support people in need of care (e.g. seniors or handicapped people) in their homes or home-like environments (e.g. retirement homes)
AC31	Mobility assistants	Robotic wheelchairs, robotic rollators/walkers, exoskeletons for walking disabilities. Includes robotic devices.
AC32	Manipulation aids	Robots that support seniors or disabled people in the manipulation of their environment (e.g. meal assistance robot, manipulators mounted to wheelchairs). Includes robotic devices.
AC39	Other care robots	Robots for care at home that do not fit into AC31 or AC32. Includes robotics devices.
AC9	Other consumer robots	Consumer robots that do not fit into any of above classes
AC99	Other consumer robots	Consumer robots that do not fit into any of above classes

Source: IFR

IFR International Federation of Robotics

Robotics in educational robots





Robotics in educational robots

ROOT from iRobot

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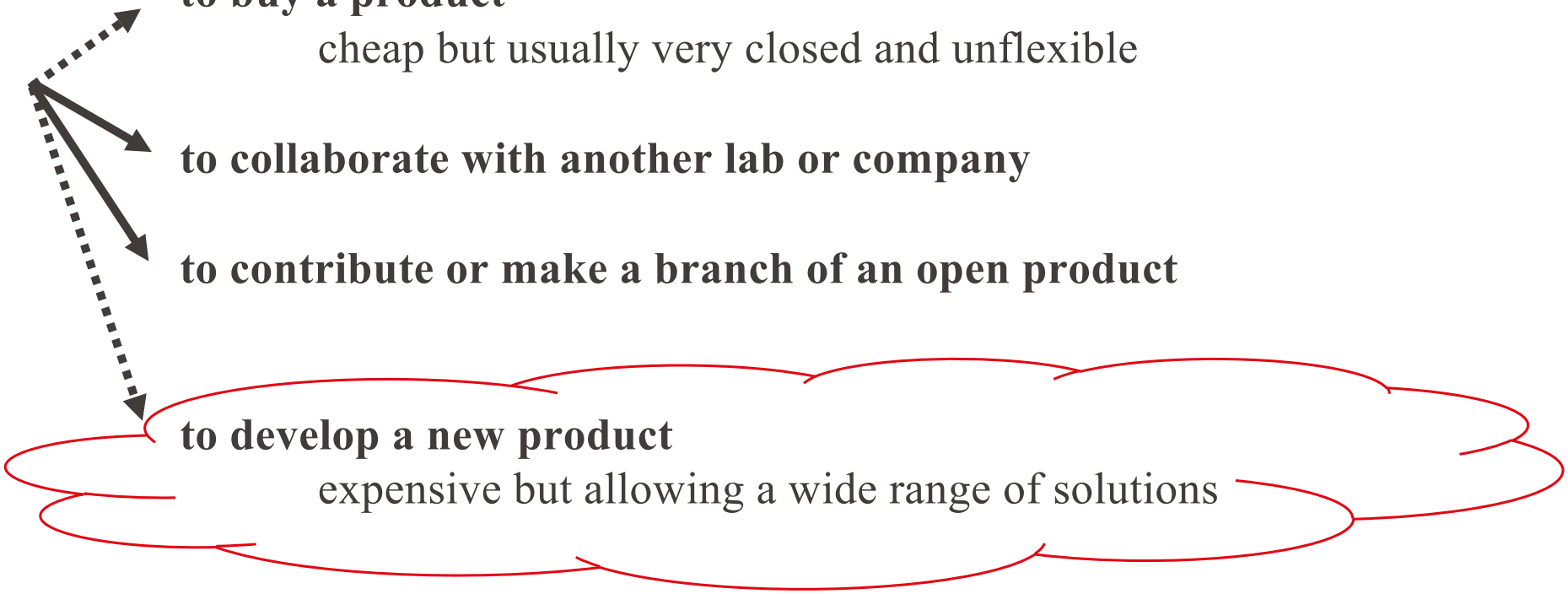
I want to check educational principles using robotics

I want to check XXX using robotics

A choice between:



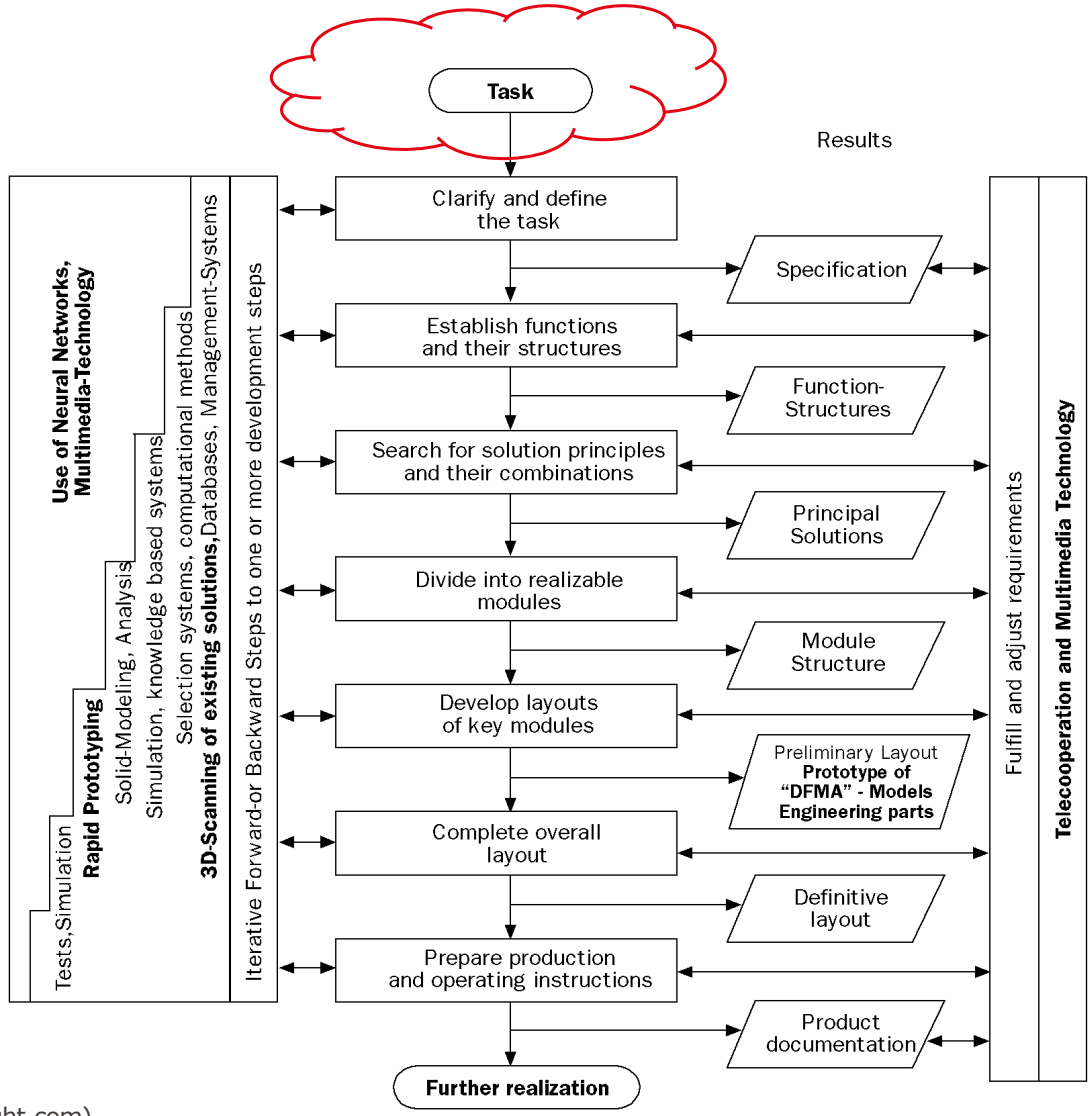
Product development

There are some methods to design **innovative products**

Thomas Owen

Hyundai

Global view



norm: VDI2221
(http://www.emeraldinsight.com)

How do we define the goals/task we want to achieve?

Classical answer of the researcher: we aim at filling research gaps

Then a totally not-useful research has quite some chances to not be well covered and therefore be a nice research issue, right?

Science Robotics

Current Issue Archive About Submit manuscript

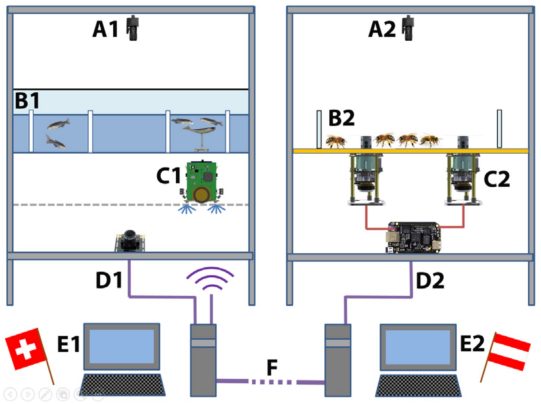
HOME > SCIENCE ROBOTICS > VOL. 4, NO. 28 > ROBOTS MEDIATING INTERACTIONS BETWEEN ANIMALS FOR INTERSPECIES COLLECTIVE BEHAVIORS

RESEARCH ARTICLE | ANIMAL ROBOTS

Robots mediating interactions between animals for interspecies collective behaviors

FRANK BONNET, ROB MILLS, MARTINA SZOPEK, SARAH SCHÖNWETTER-FUCHS, JOSÉ HALLOY, STJEPAN BOGDAN, LUÍS CORREIA, FRANCESCO MONDADA, AND THOMAS SCHMICKL Authors Info & Affiliations

SCIENCE ROBOTICS • 13 Mar 2019 • Vol 4, Issue 28 • DOI: 10.1126/scirobotics.aau7897

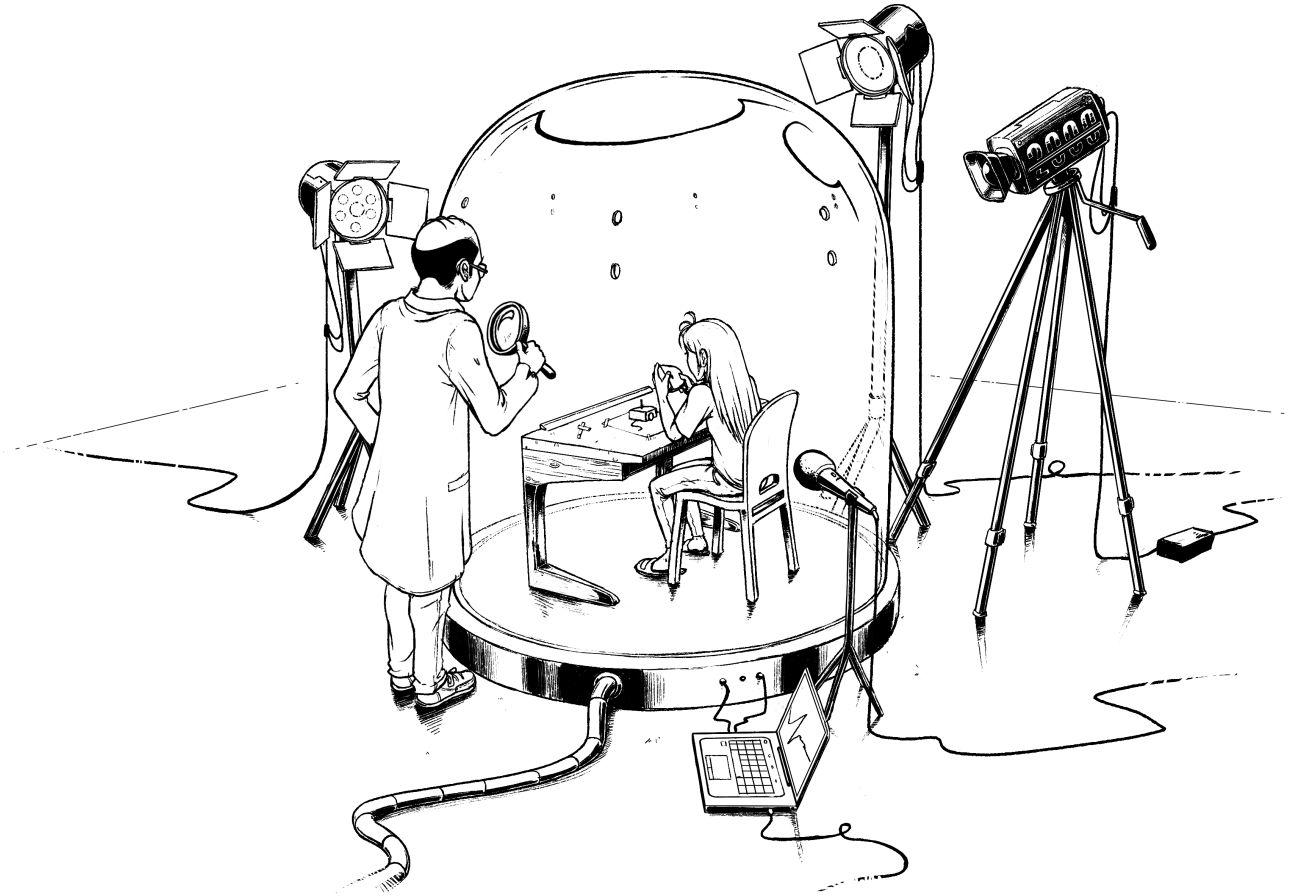


How do we define the goals we want to achieve?

And if we want our research to be useful?

Who can take advantage of our research?

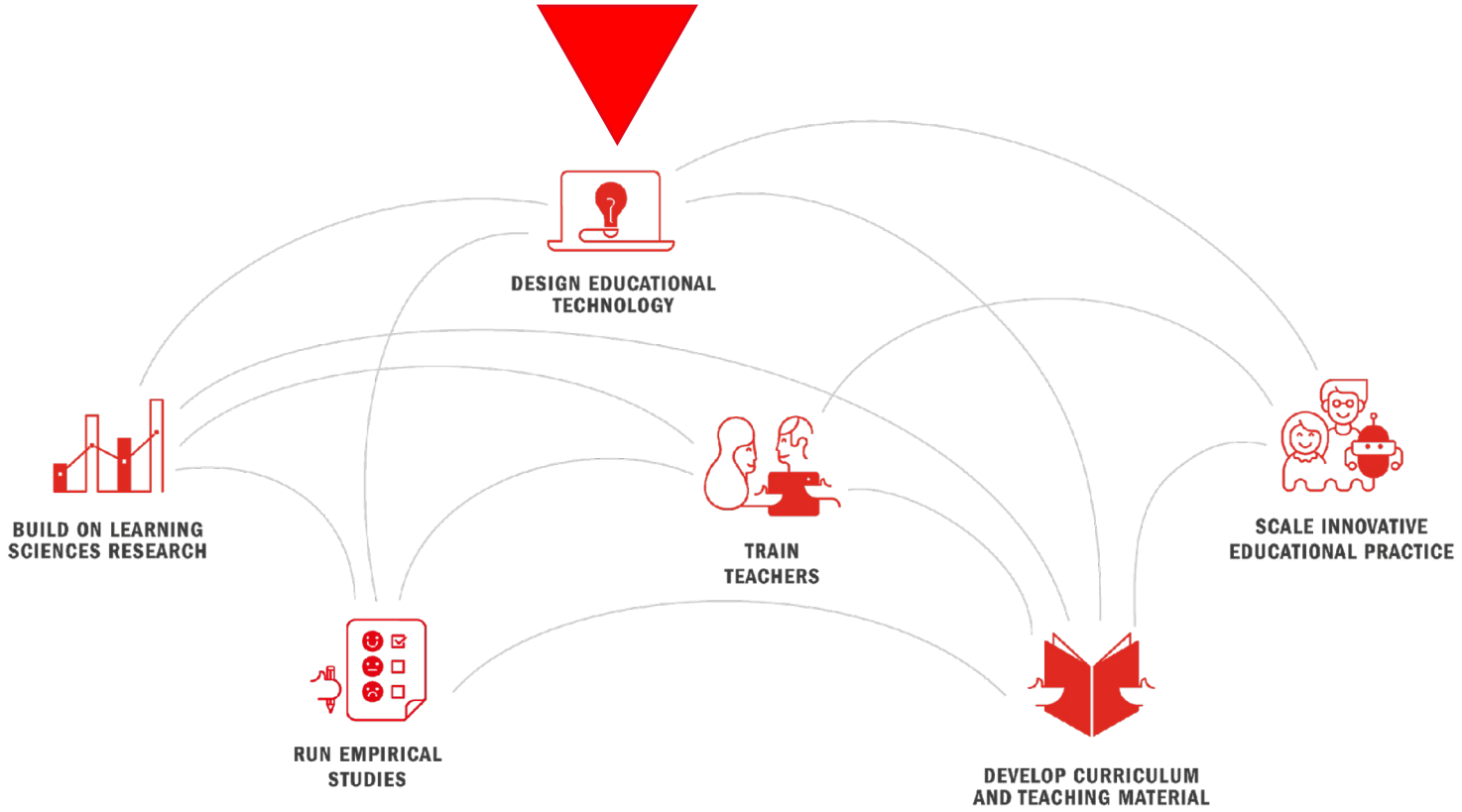
One possible answer in formal education is «children are our customers»



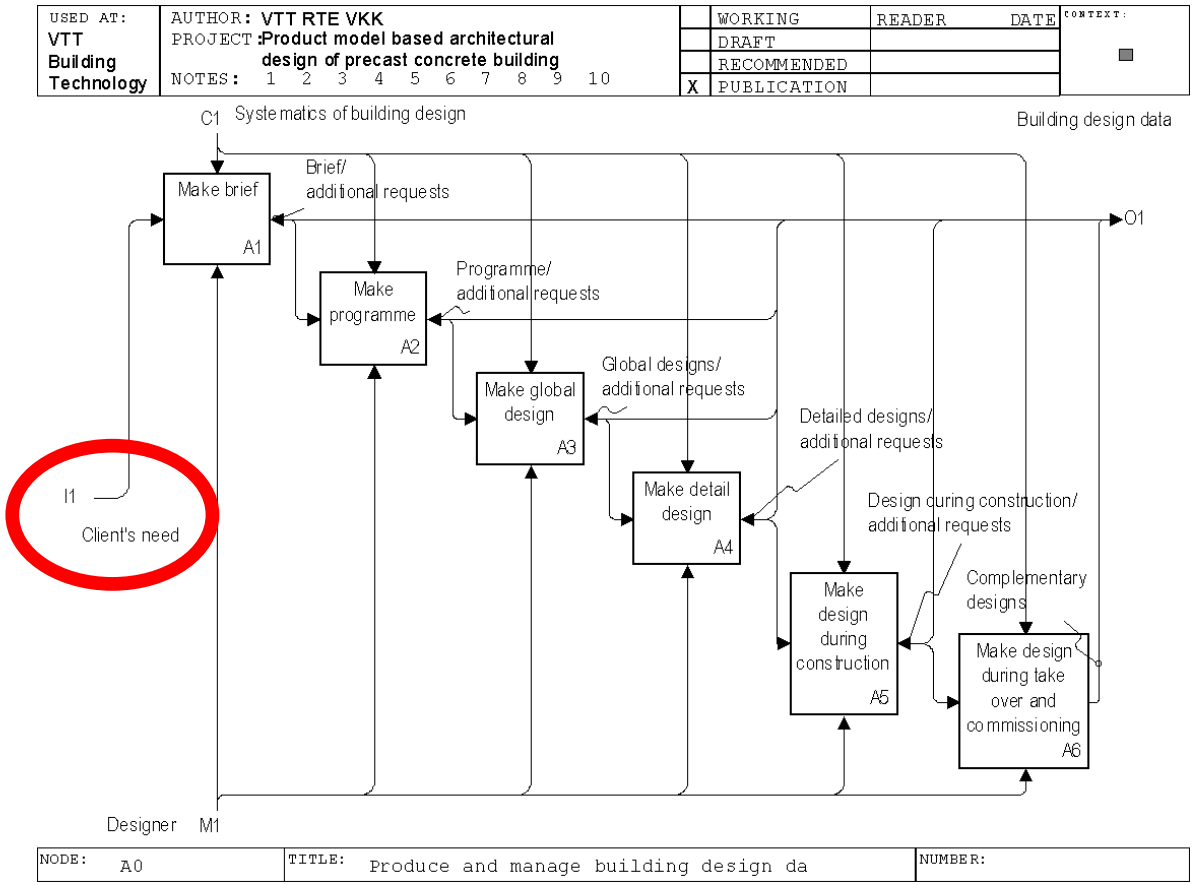
In which framework are children educated?

16

Translational Research Approach in Education



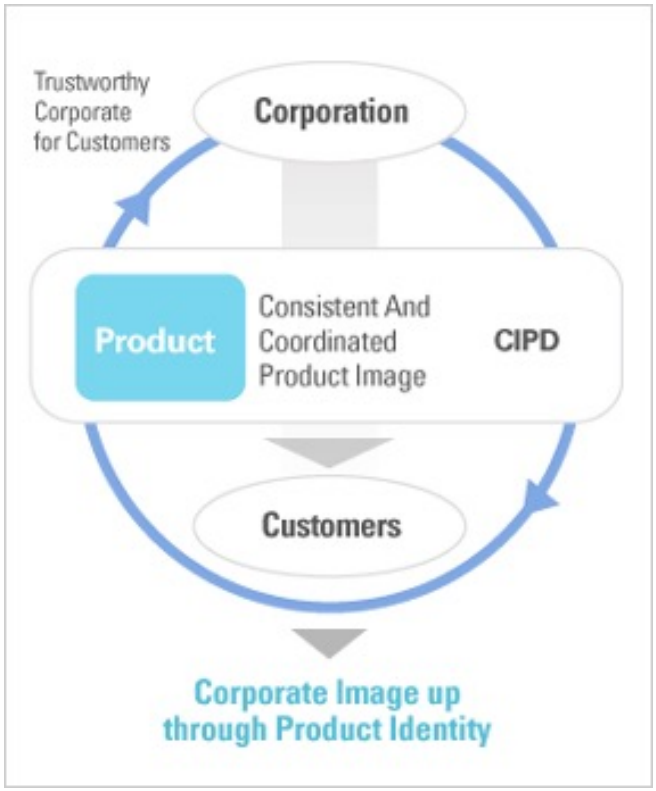
How do we run our design / research?



Product Model Based Design of Precast Facades, Vesa Karhu,
VTT Building Technology, Technical Research Centre, Espoo, Finland
www.itcon.org/1997/1/paper.htm

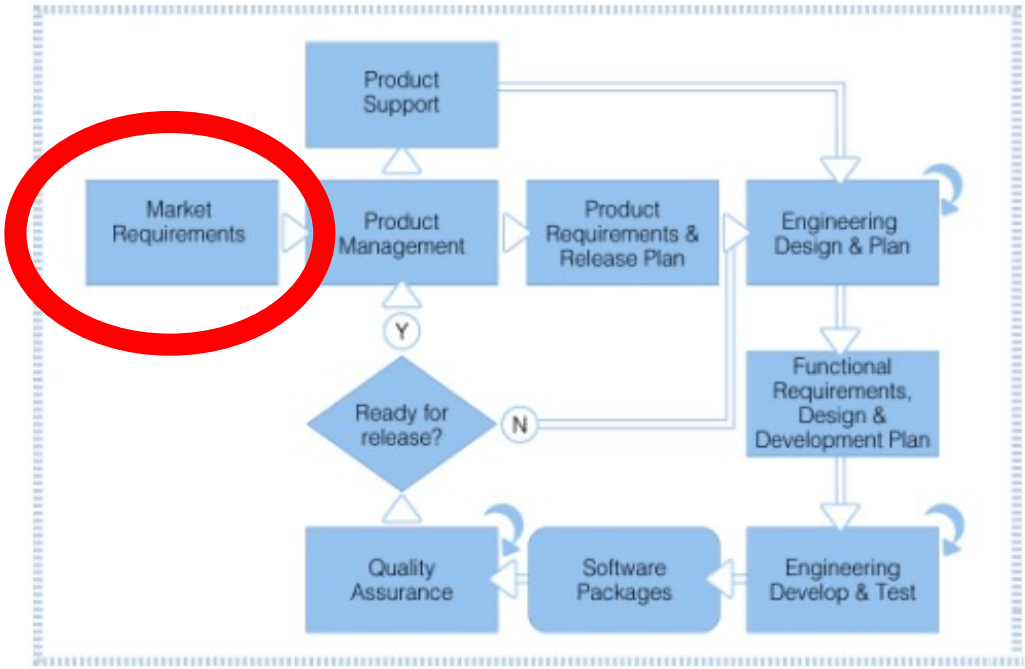
How do we run our design / research?

KYOCERA

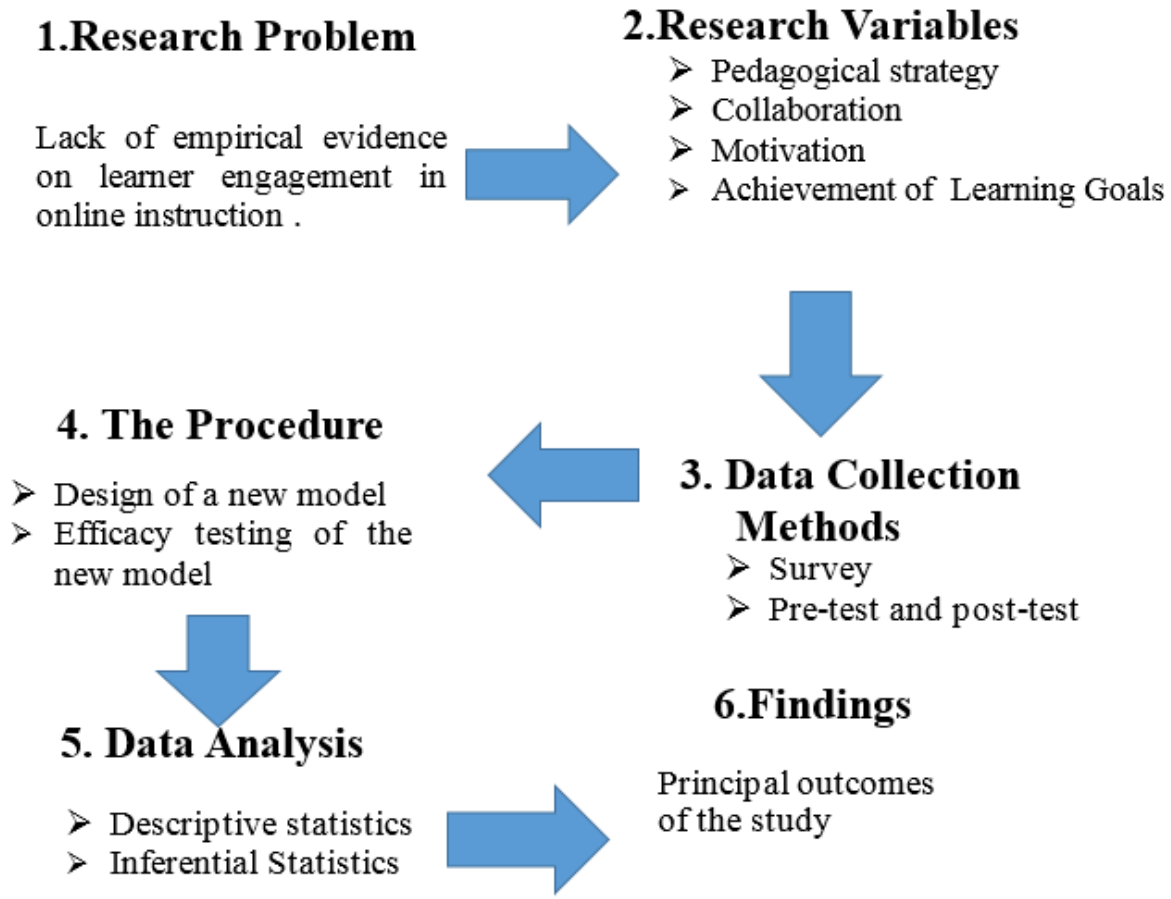


LG Electronics

How do we run our design / research?

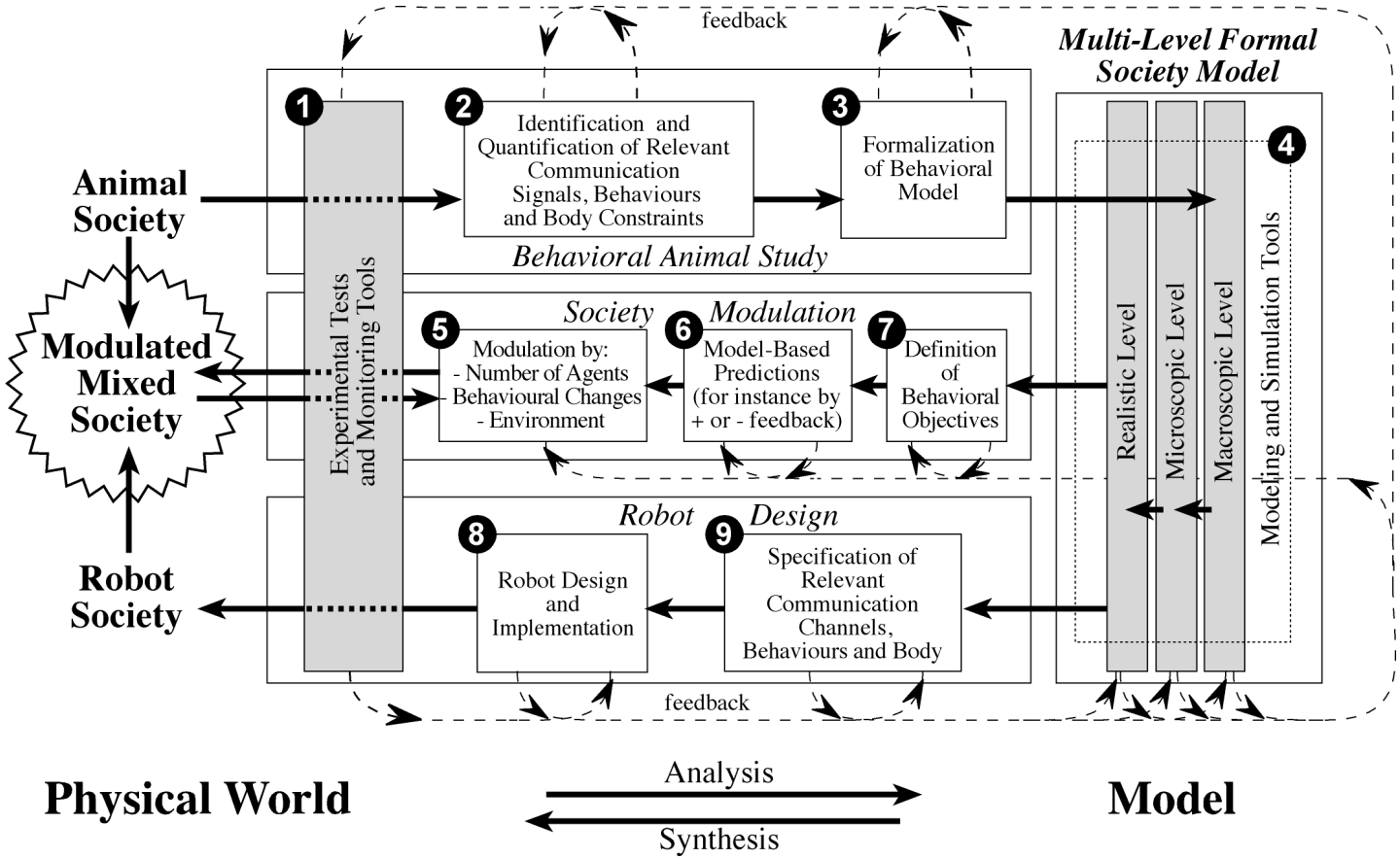


How do we run our design / research?

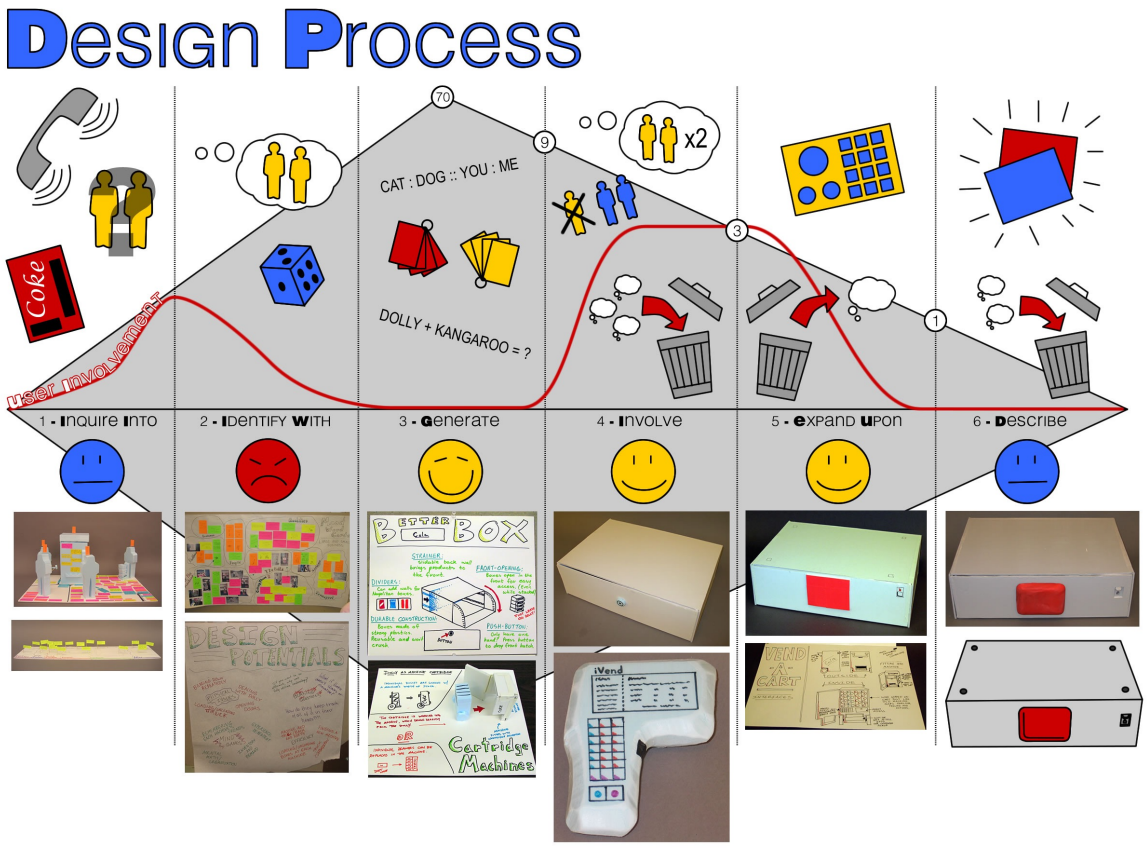


Selvaraj, Vijayakumar & Varshini.P, & P, Tamilarasan. (2020). Integrative Model for Online Learning: An Intervention Research. Xi'an Dianzi Keji Daxue Xuebao/Journal of Xidian University. 14. 1003-20. 10.37896/jxu14.5/109.

How do we run our design / research?

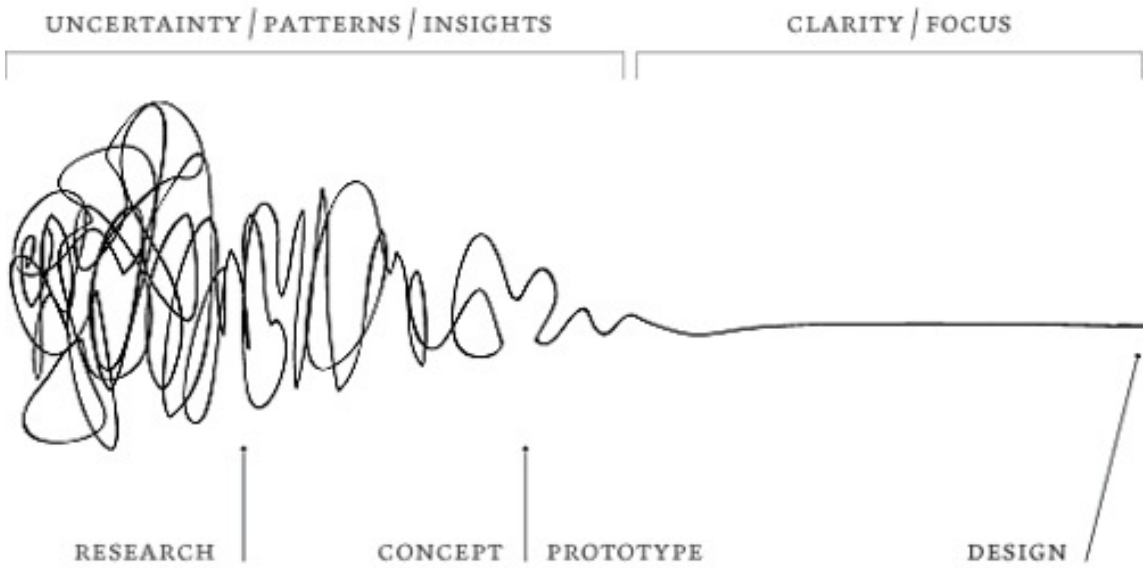


The process has phases! Creativity is a key element



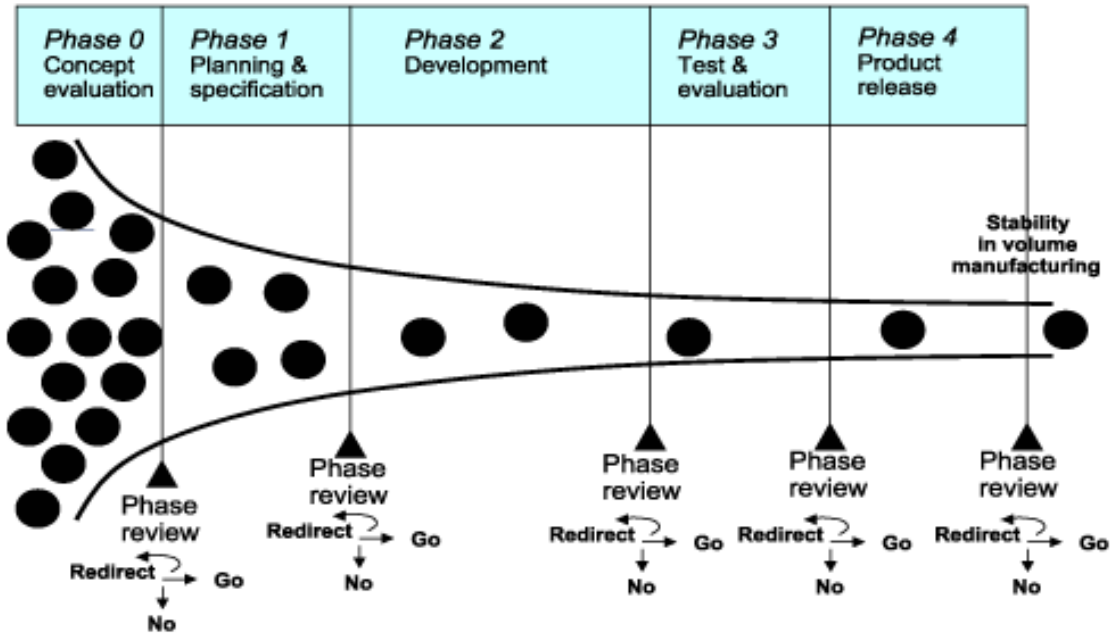
seanmcb.com/portfolio/uocd-better-box

The process has phases! Creativity is a key element



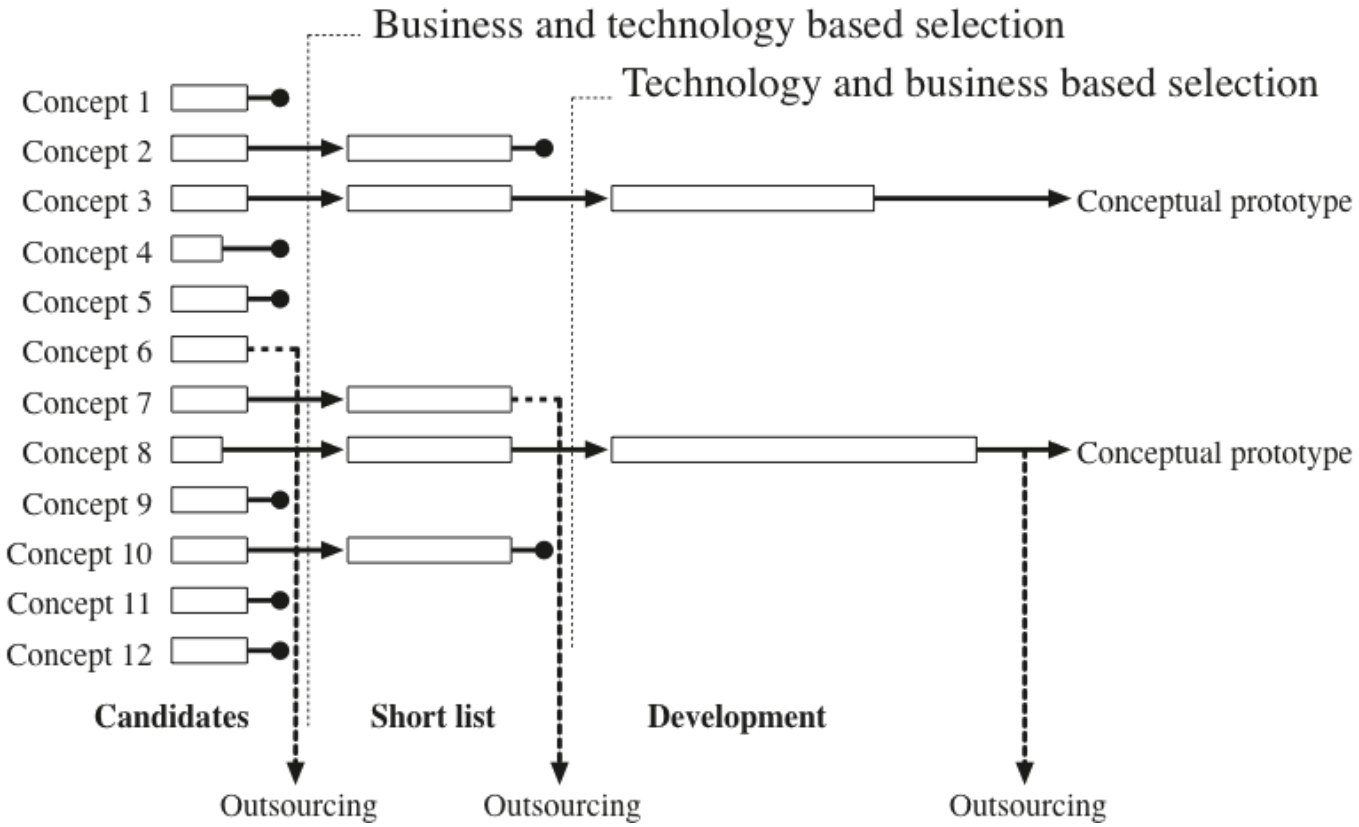
www.leadershipnow.com

The process has phases! Milestones…

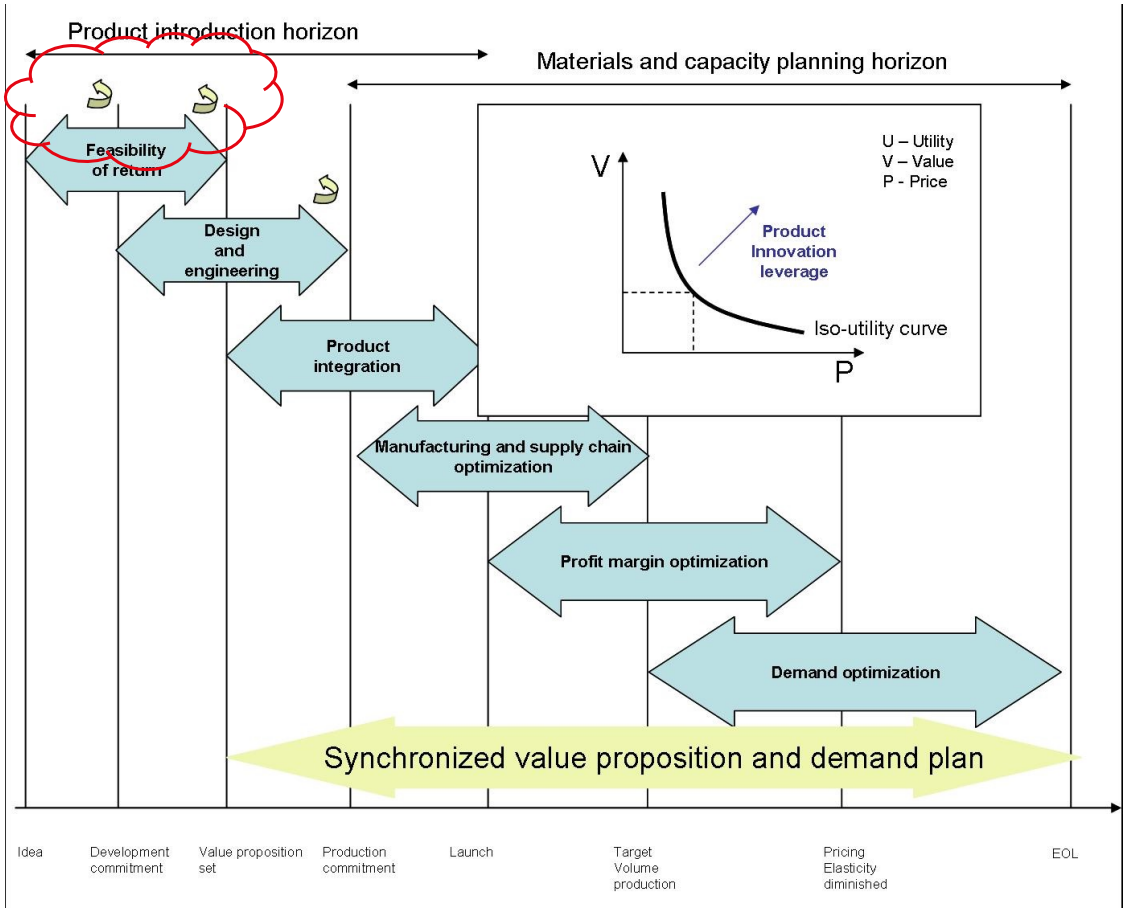


herkules.oulu.fi/isbn9514264509/html/c635.html

The process has phases! Milestones…

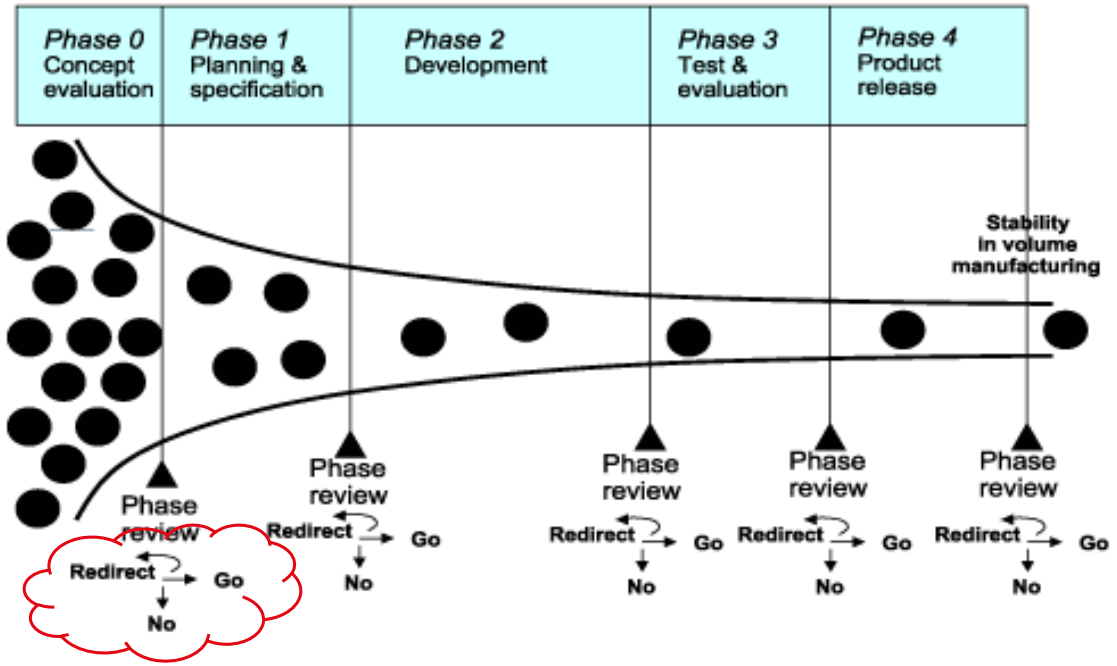


Is the design process linear?



http://cpd-associates.com

Is the design process linear?



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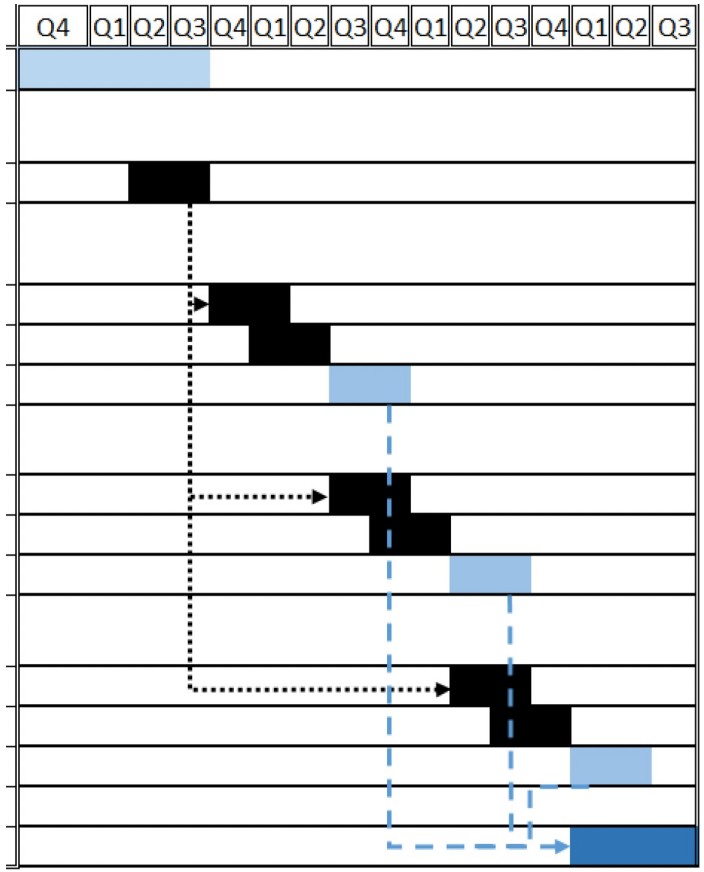
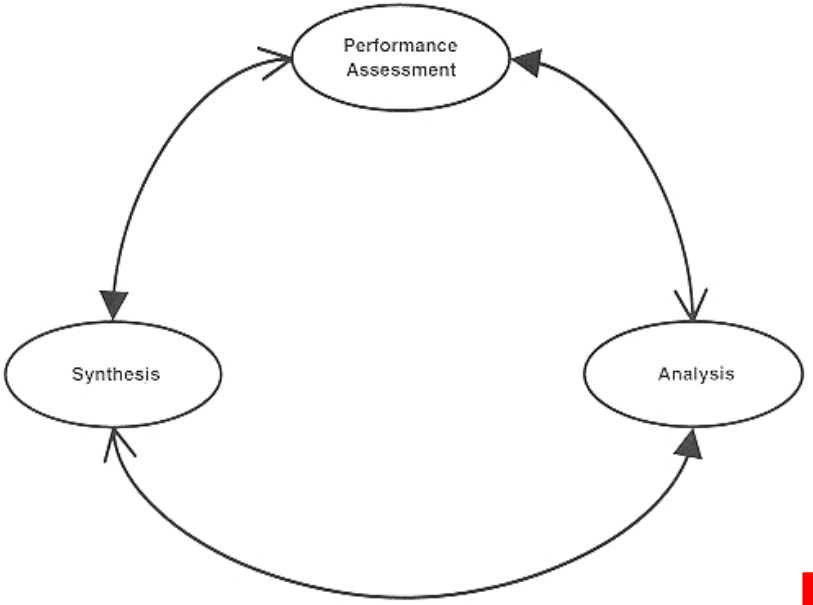
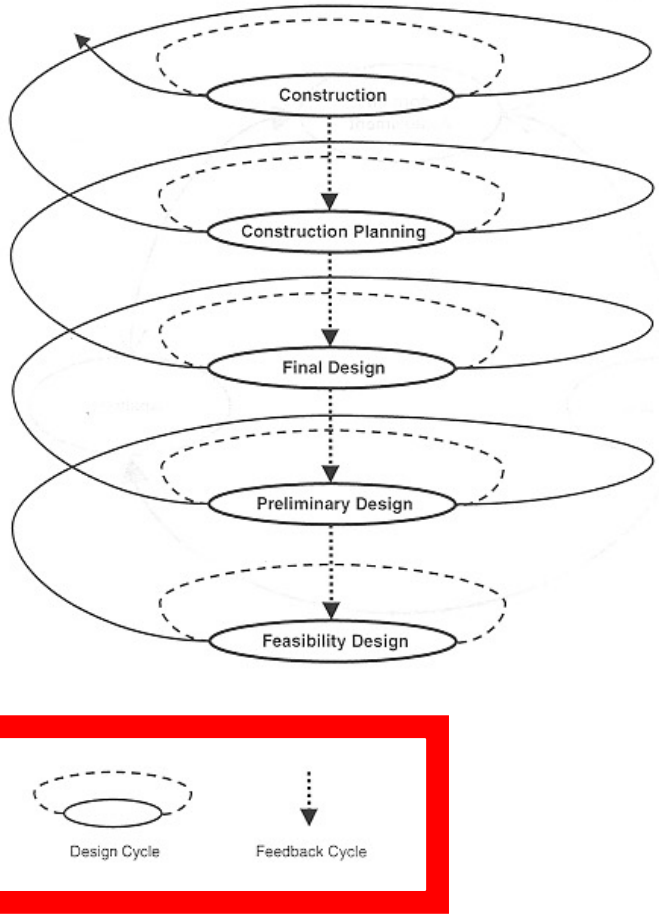


Anonymized EPFL PhD student

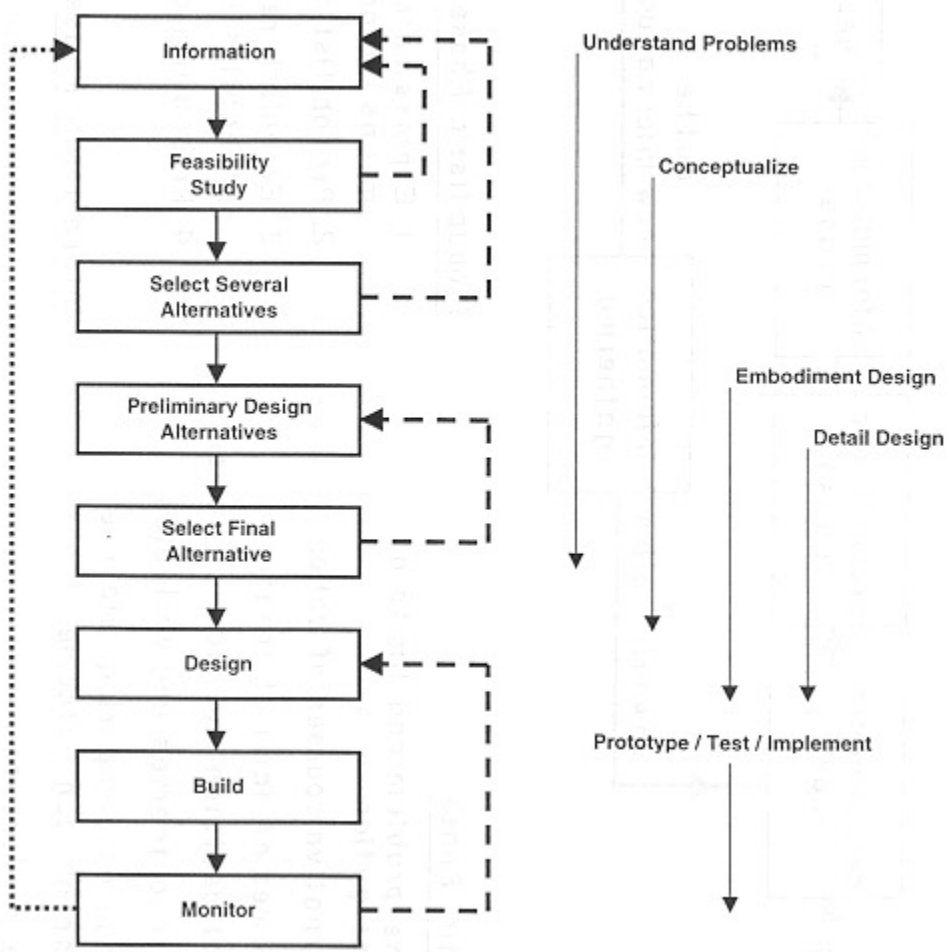
The process is iterative!





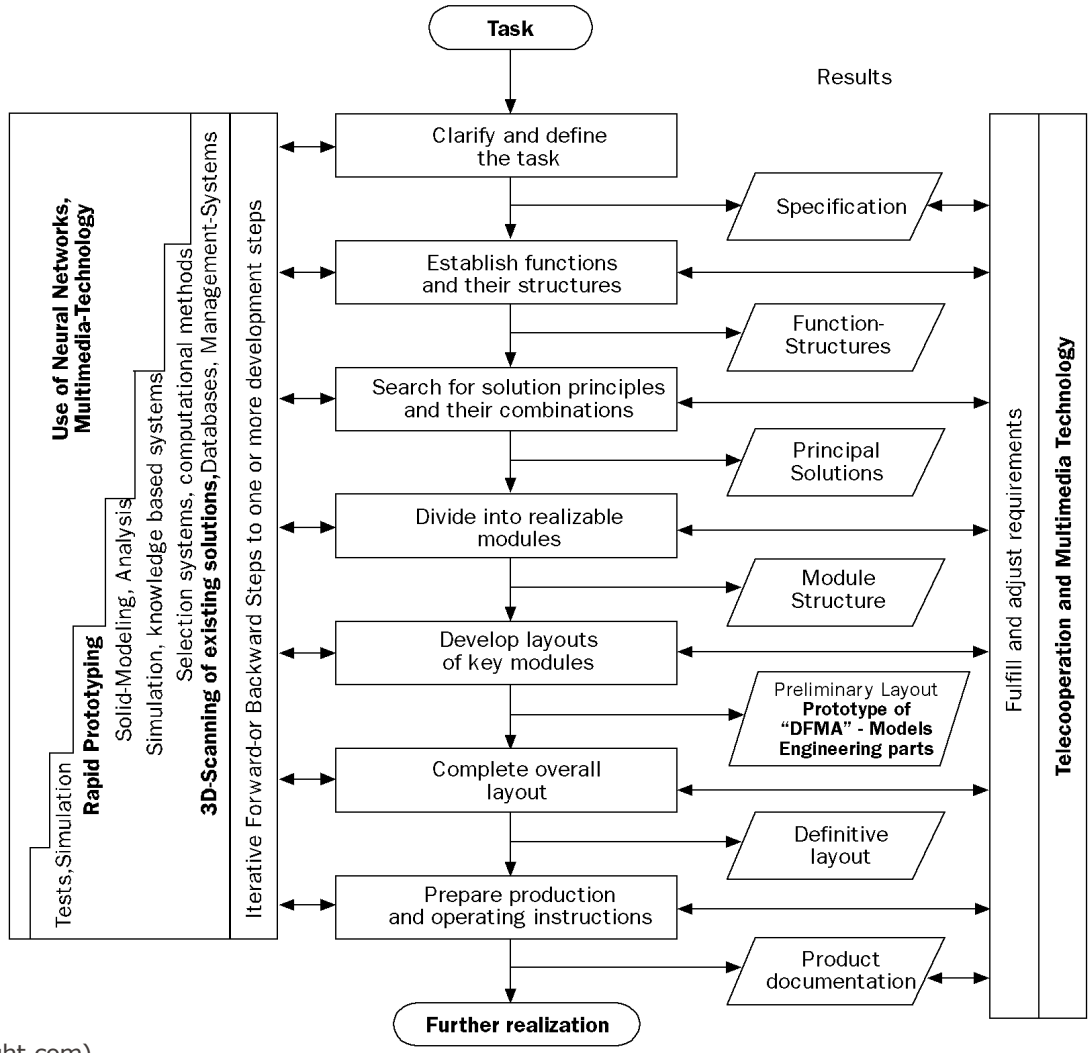
ocw.mit.edu/

Global view



ocw.mit.edu

Global view



norm: VDI2221
(http://www.emeraldinsight.com)

Example: window cleaning robot

euron.org

Suction pads

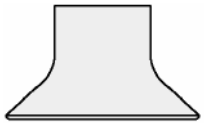
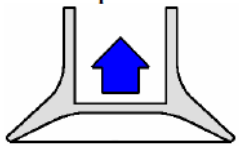
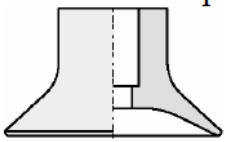
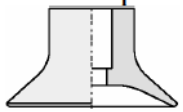
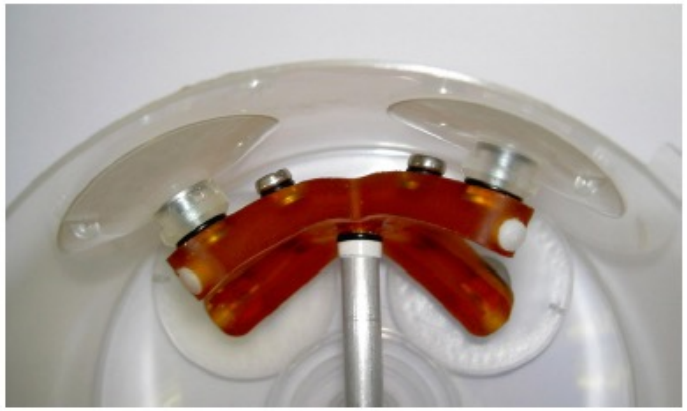
Concept	Characteristic	Constraints/Disadvantages
Passive suction pad 	The pad is pushed and pulled against a wall to crate and remove the fixation.	Smooth wall. We need a strong bi-directional controlled force to create and remove the fixation. [Cleanbot]
Deformable suction pad 	The pad is able to augment the internal volume (reducing the pressure) trough an active device. This can make the fixation stronger and the detachment easier.	Smooth wall. Activation-deactivation mechanism.
Vacuum suction pad 	The inner part of the pad is connected to a miniature electric vacuum pump (piston or diaphragm) that can be switched on or off.	Smooth wall. Miniature vacuum pump. [Darpa, Biggalo, Mrwallspect3, Ninja]
Sliding vacuum suction pad  Little μ_d	The pad is a vacuum type and has, on the wall, a little dynamical friction coefficient. The pad could alternatively be fixed or could slide in function of the level of the vacuum.	Very smooth wall (window) Miniature vacuum pump. [Clim@tron]

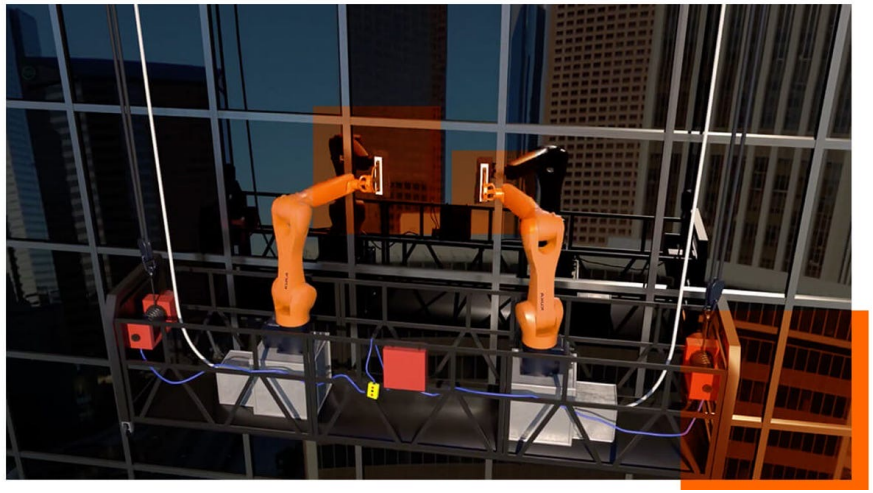
Table 4: Holding mechanisms based on suction pads



Combination of concepts:

- adhesion
- lifting
- energy
- …

Skyline



cleanup.expert/

gulfnews.com

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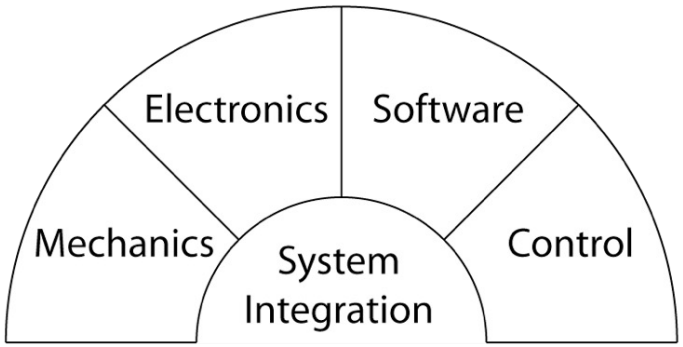
Methodology in interdisciplinary project: flexibility required…

Adopt **existing design approach**, adapt for your specific situation / project

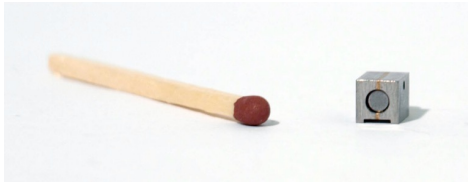
Bring (your) **core competences**, take advise on other fields (not everybody agrees or can afford this, complex partnerships)

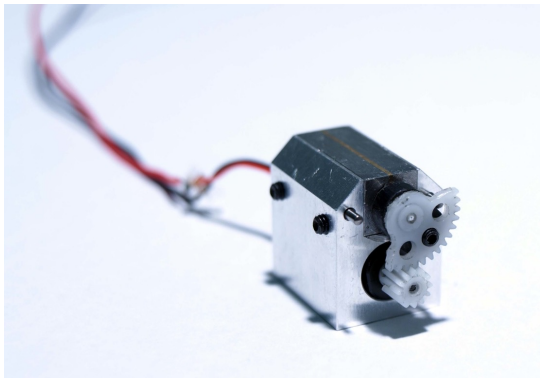
Often a methodology is defined in the project or in the community

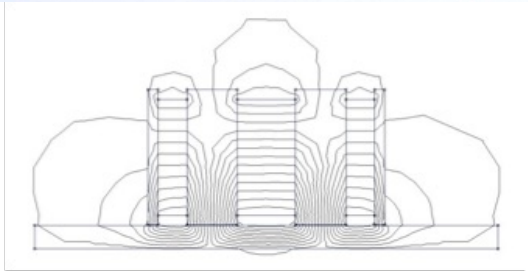
Core competences:

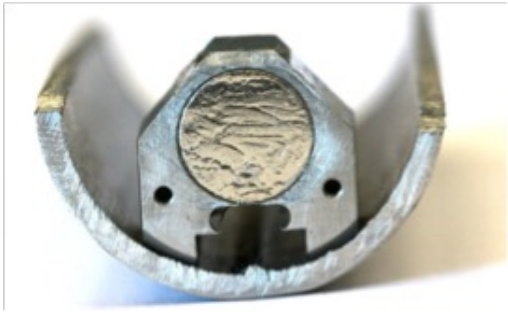


Core competences:

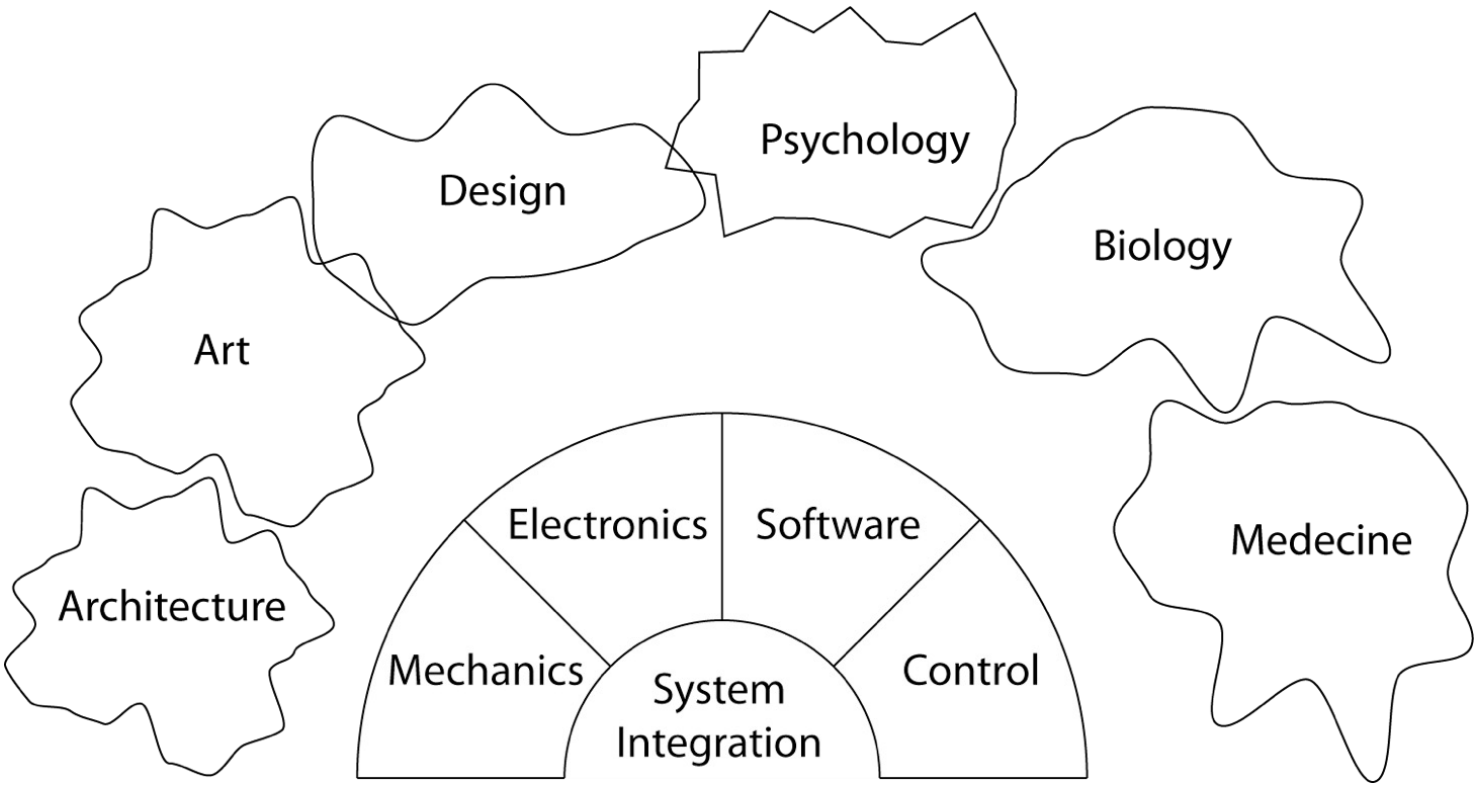








Interdisciplinary work



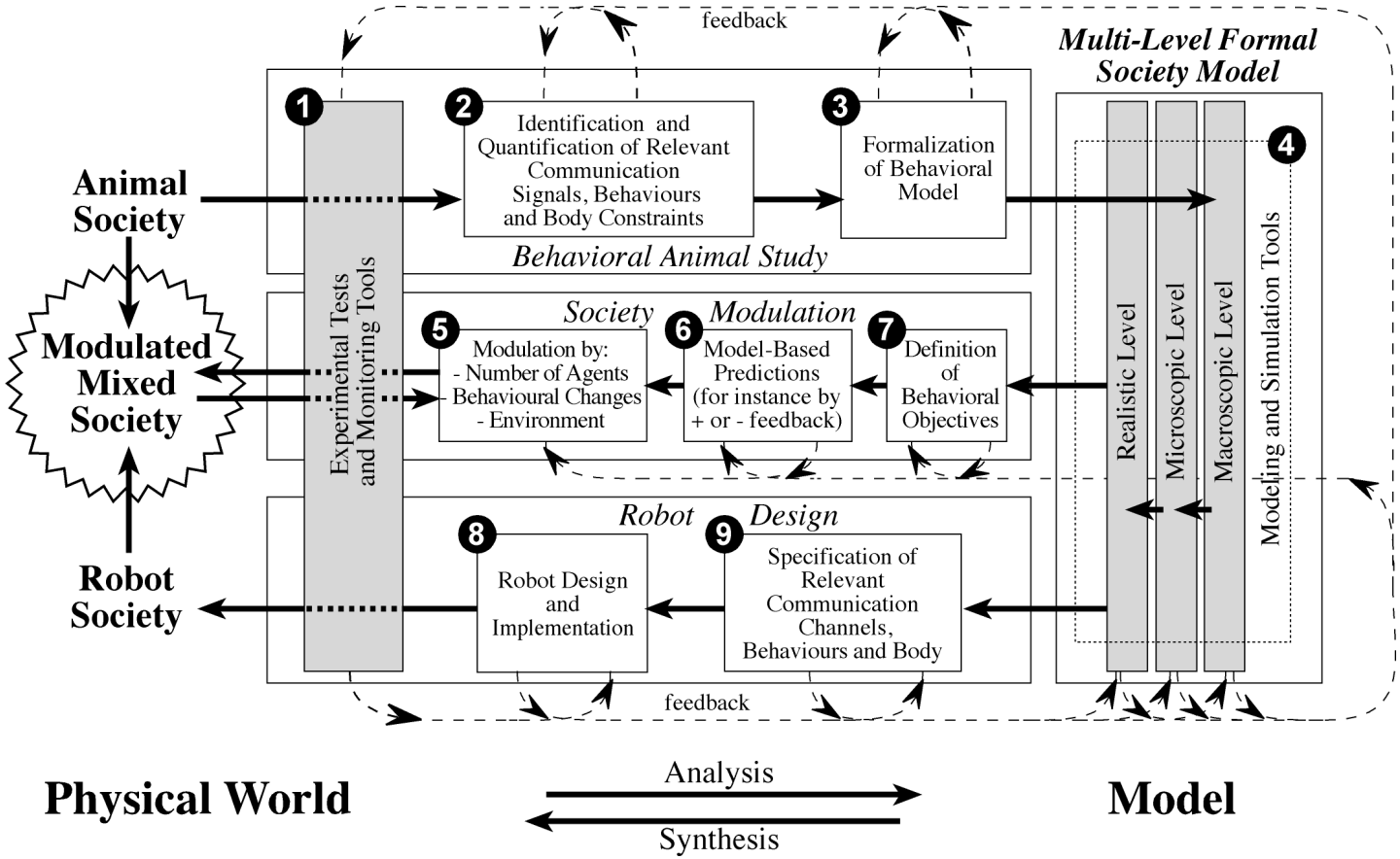
Methodology in interdisciplinary project: flexibility required…

Different fields have different:

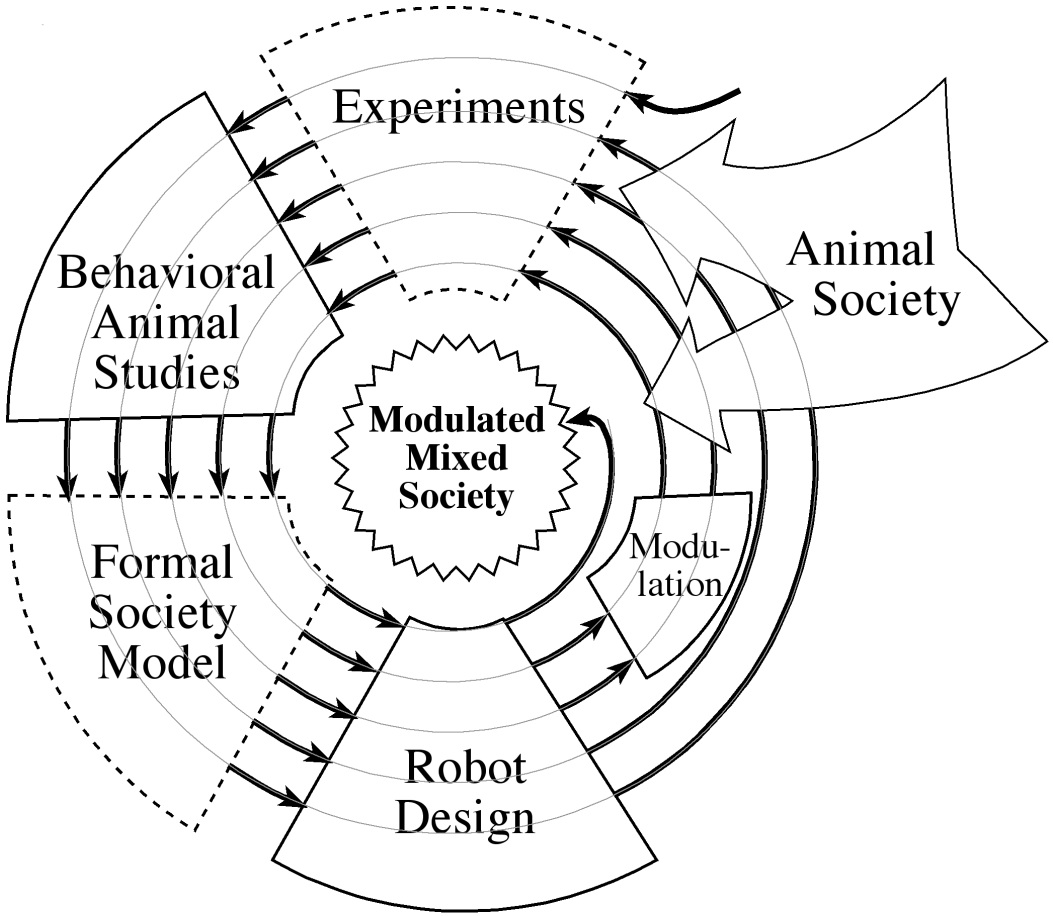
- Standards (publications, authorship, …)
- Publication venues
- Perception of the same element (bees bio < > eng)
- Methodologies (learning sciences vs engineering)
- Values ….

Those elements can cause a lot of frictions

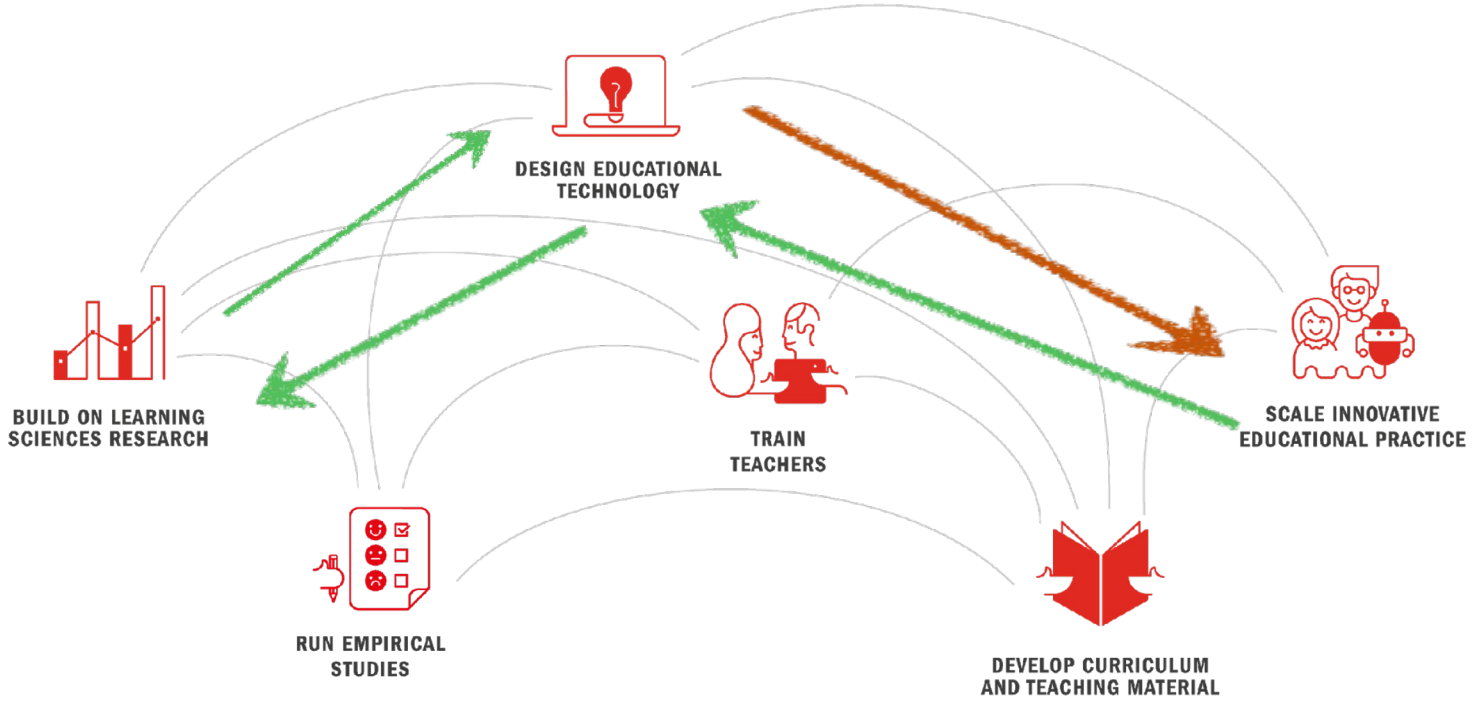
Leurre project: methodology



Leurre project: methodology



Translational Research Approach



Design process / milestones

Milestones / Deliverables are classical steps

Often presented to experts

Form depends on field and of the experts

Selling the idea

Common in engineering (eng. to eng.)

Can become more complex when selling to:

- Your colleague doing behavioral studies
- The reviewers / stakeholders
- The funding agency
- Those who will read your (interdisciplinary) articles

Open / proprietary IP

OPEN:

- very common in the academic world
- welcome by funding agencies
- not compatible with industrial applications
- Can be well compatible with your spinoff

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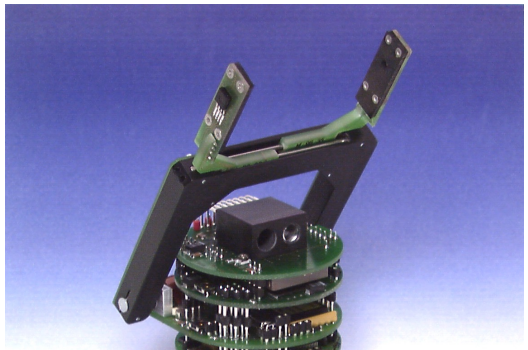
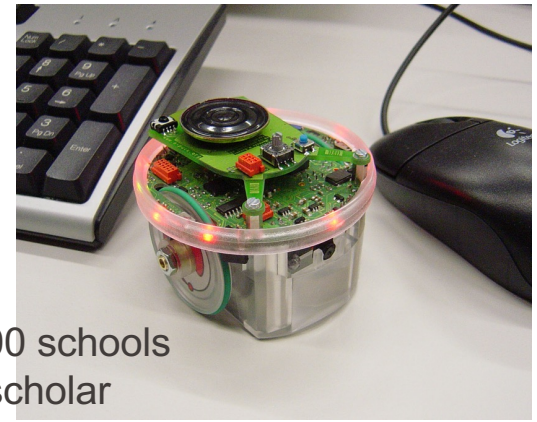
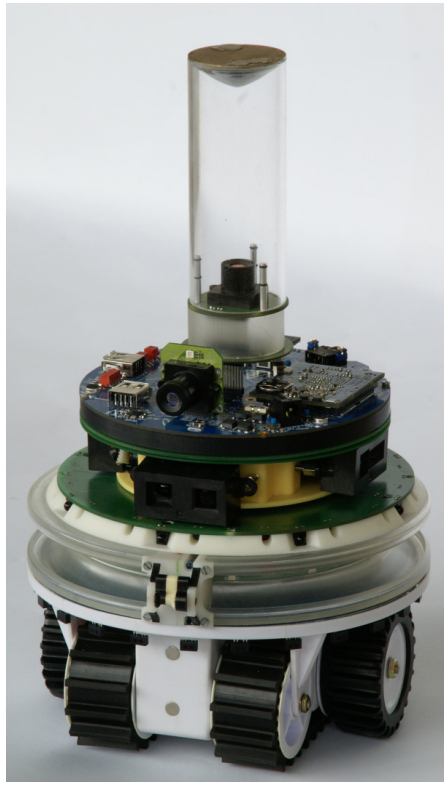
Common element: all produced and used in real educational frameworks



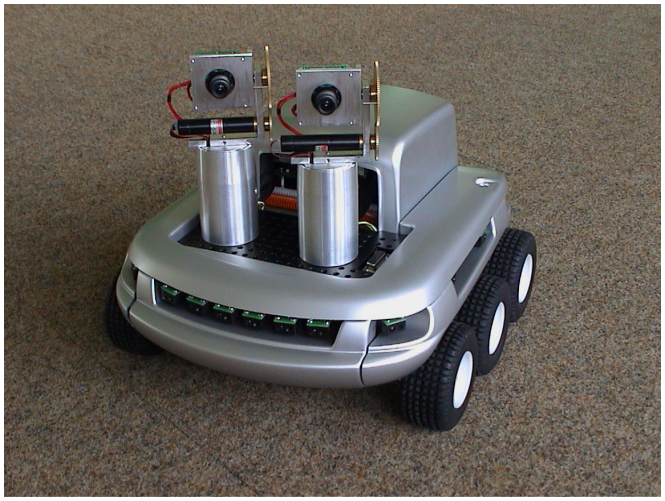
Khepera:
>1000 univ.
>7k mentions



E-puck
>4430 Sold, >300 schools
>3k5 mentions scholar



MarXbot: For friends….
>400 mentions



Koala: Flop….

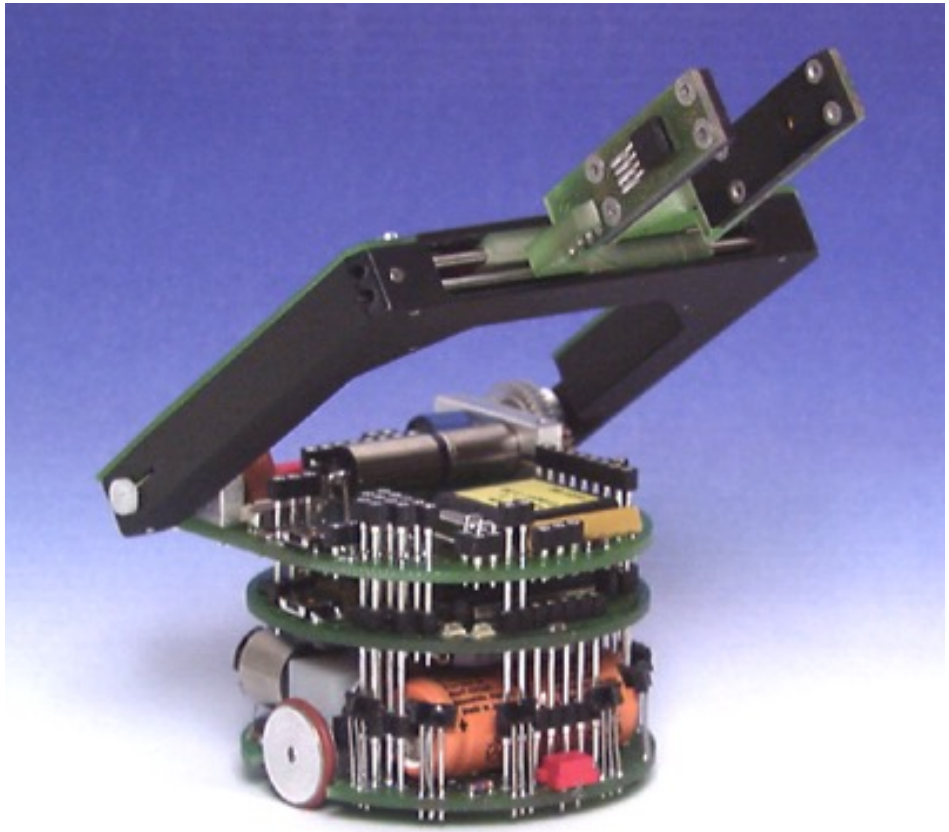
Thymio
>90k Sold
>1k4 mentions

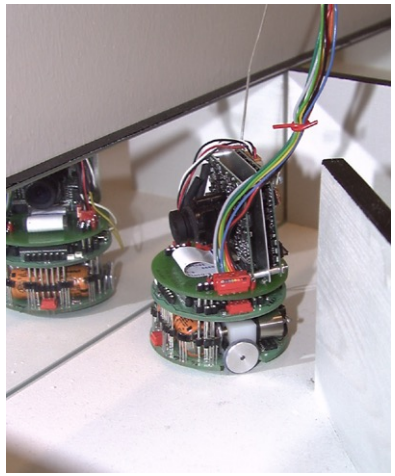
50

EPFL

Khepera

(1995-



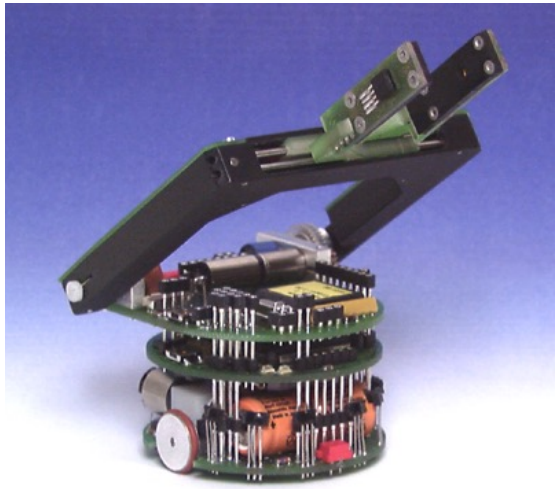


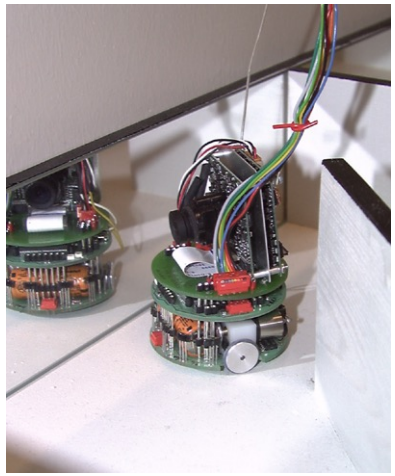
EPFL

Khepera miniature mobile robot

Scientific impact:

- Worldwide switch from simulation to Khepera
- ~1000 laboratories acquired Khepera
- Khepera in >7000 publications (on Google scholar)
- Khepera methodology is a standard in AI research
- 2 edited books (proceedings), 4 book chapters,
  4 journal papers, 13 conferences
- Core paper with 756 citations (google scholar)
- Created one conference (AMiRE, 6 editions)
- Cover of several robotics+ journals (Nature in 2000)



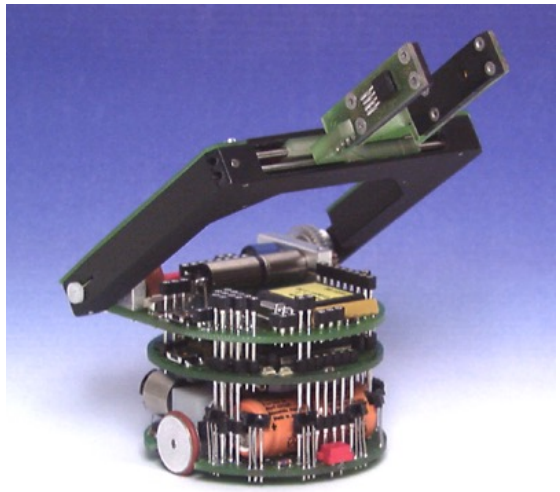


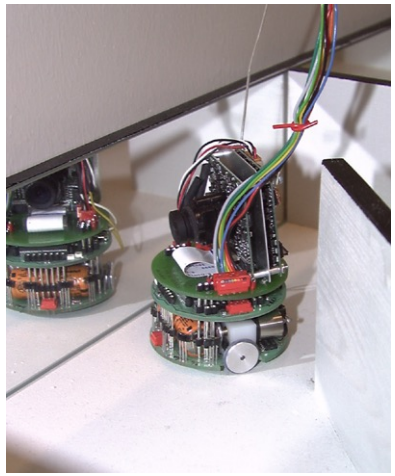
EPFL

Khepera miniature mobile robot

The customer?

- Us as researchers in a given project
- Our boss
- The SNF
- Colleagues in Biology ans CS (neural networks research)
- More and more universities
- PhD education, a bit of undergraduate



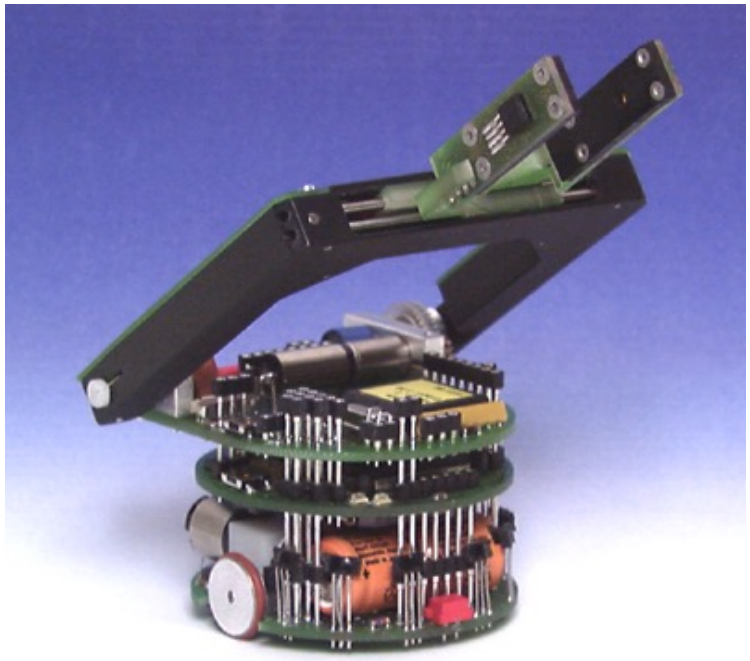


EPFL

Khepera miniature mobile robot

Specifications: where are they?

- Based on some good and innovative ideas
- Defined during the project
- Based on **our own** needs, related to our research
- Based on our design experience
- Based on our vision of “nice design”

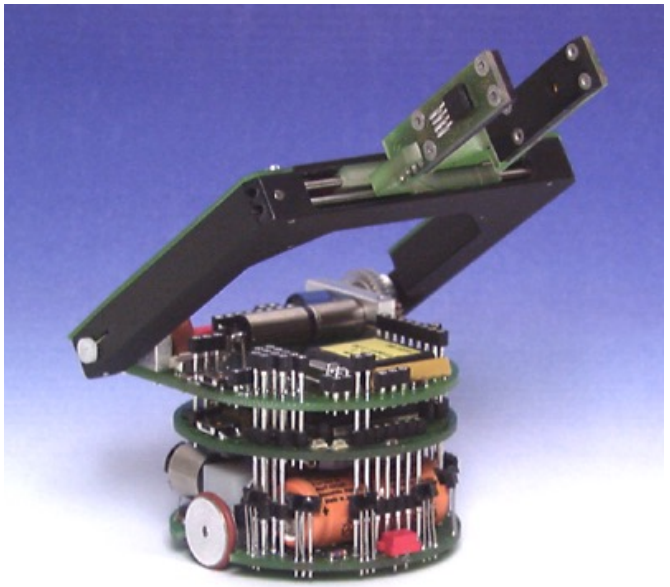


EPFL

Khepera miniature mobile robot

Methodology
Design process / milestones

- Classical engineering process based on
  - Research of solutions
  - Comparison of several solutions
  - Choice and integration
- Design by iterations



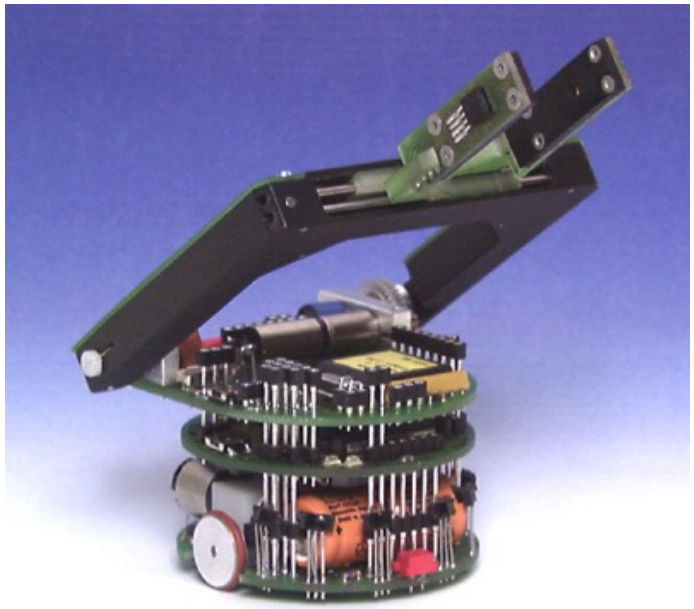
EPFL

Khepera miniature mobile robot

Open / proprietary IP

- Proprietary (EPFL)
  schematics, implementation and code
- Agreement with K-Team company
- Royalties from K-Team company

Was this the right approach for EPFL ? Not sure….



Khepera miniature mobile robot

Selling the idea:

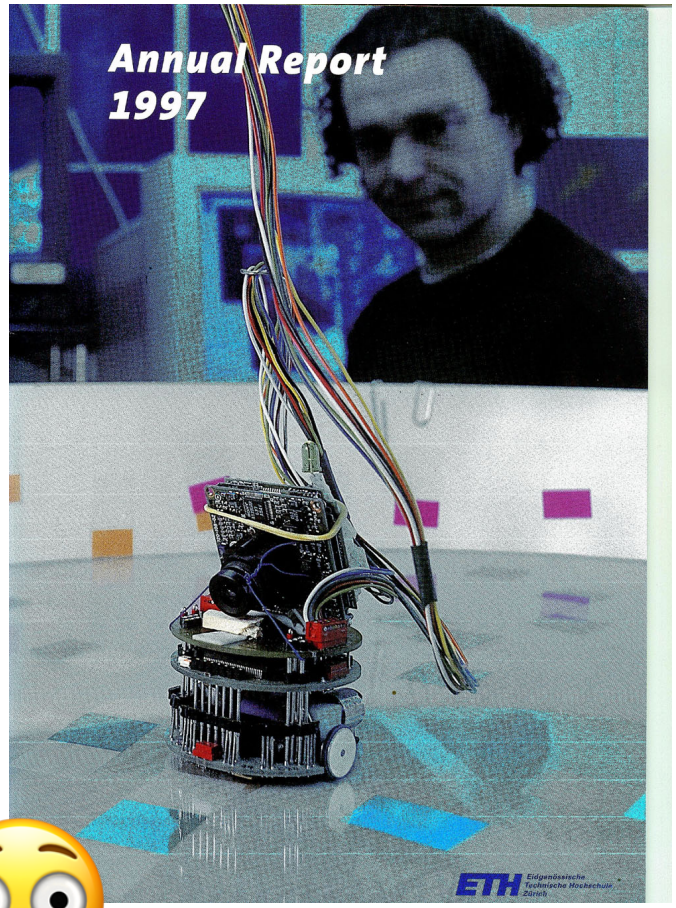
- based on scientific results
- answering to strong needs
- corresponding to a trend (Alife - robotics)
- becoming the tool of a community

EPFL

Khepera miniature mobile robot

Selling the idea:

- based on scientific results
- answering to strong needs
- corresponding to a trend (Alife - robotics)
- becoming the tool of a community

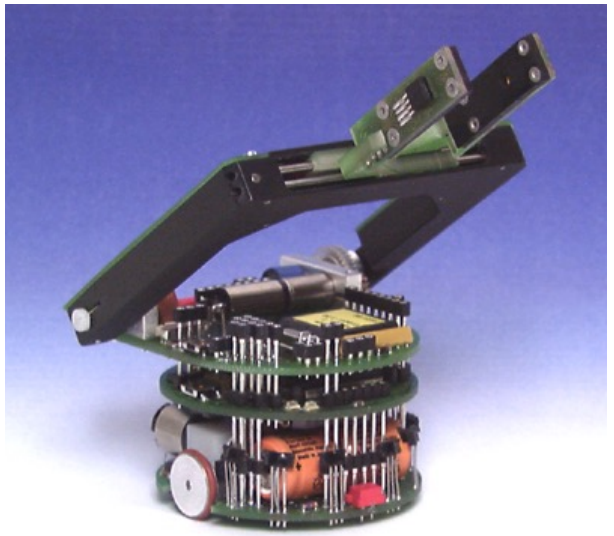


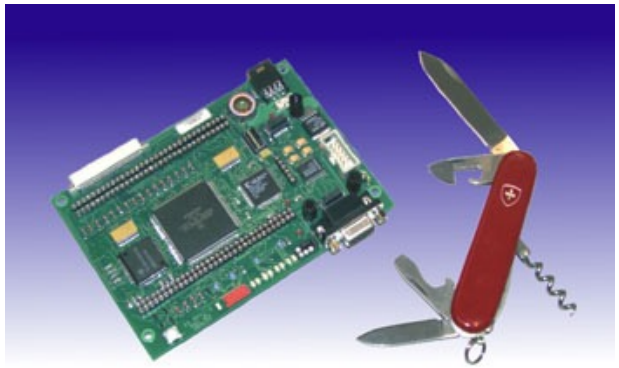
EPFL

Khepera miniature mobile robot

A good example?

Perhaps, but has not been repeated in K-Team
2nd - 3rd … attempts failed:

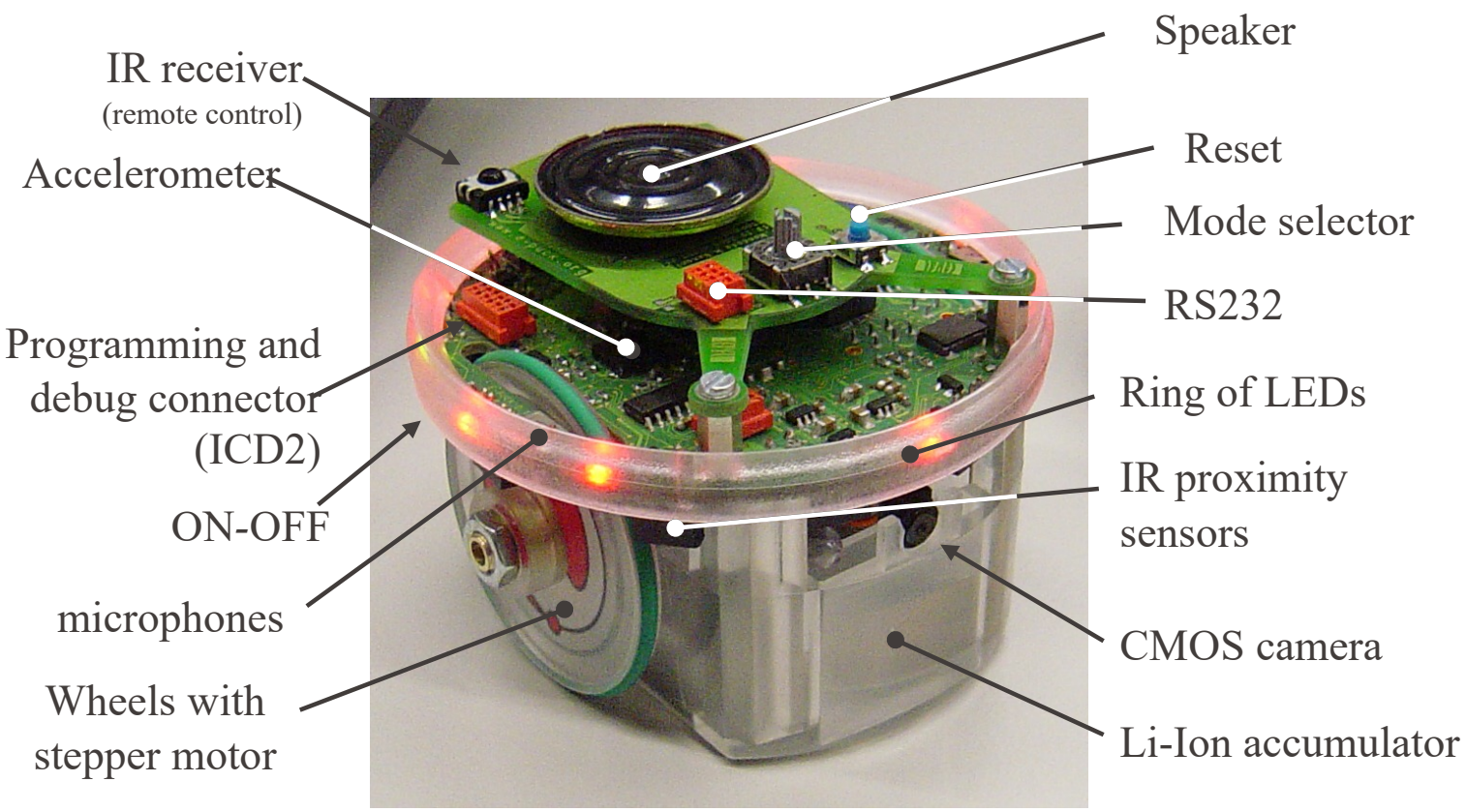




EPFL

E-Puck robot (2004 -

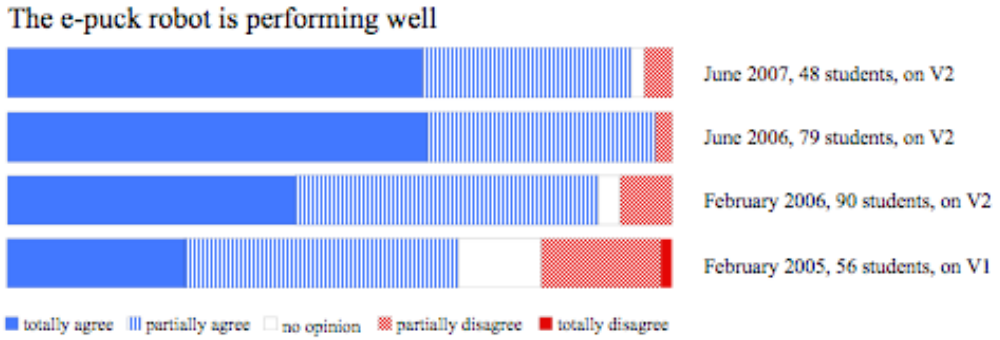
Overview


IR receiver
(remote control)
Accelerometer
Programming and
debug connector
(ICD2)
ON-OFF
microphones
Wheels with
stepper motor
Speaker
Reset
Mode selector
RS232
Ring of LEDs
IR proximity
sensors
CMOS camera
Li-Ion accumulator

e-puck education robot

Achievements:

- Open robot platform for a large number of EPFL courses
- Excellent feedback from students:



- ~100 laboratories using it
- A companies producing it, several resellers

EPFL

Robot design

Clean mechanical structure.

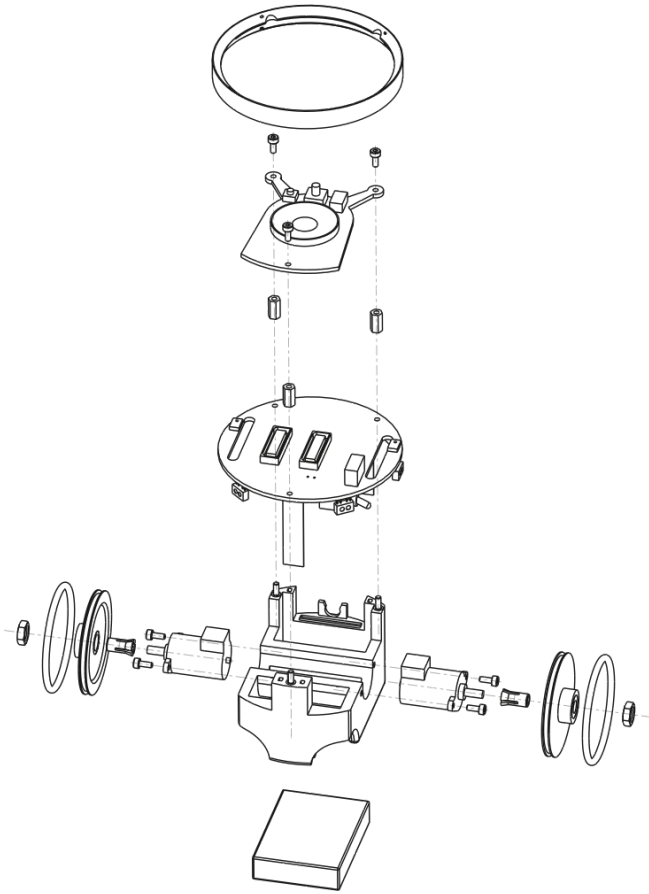
Modern electronics, processor and software.

Flexible to teach many fields.

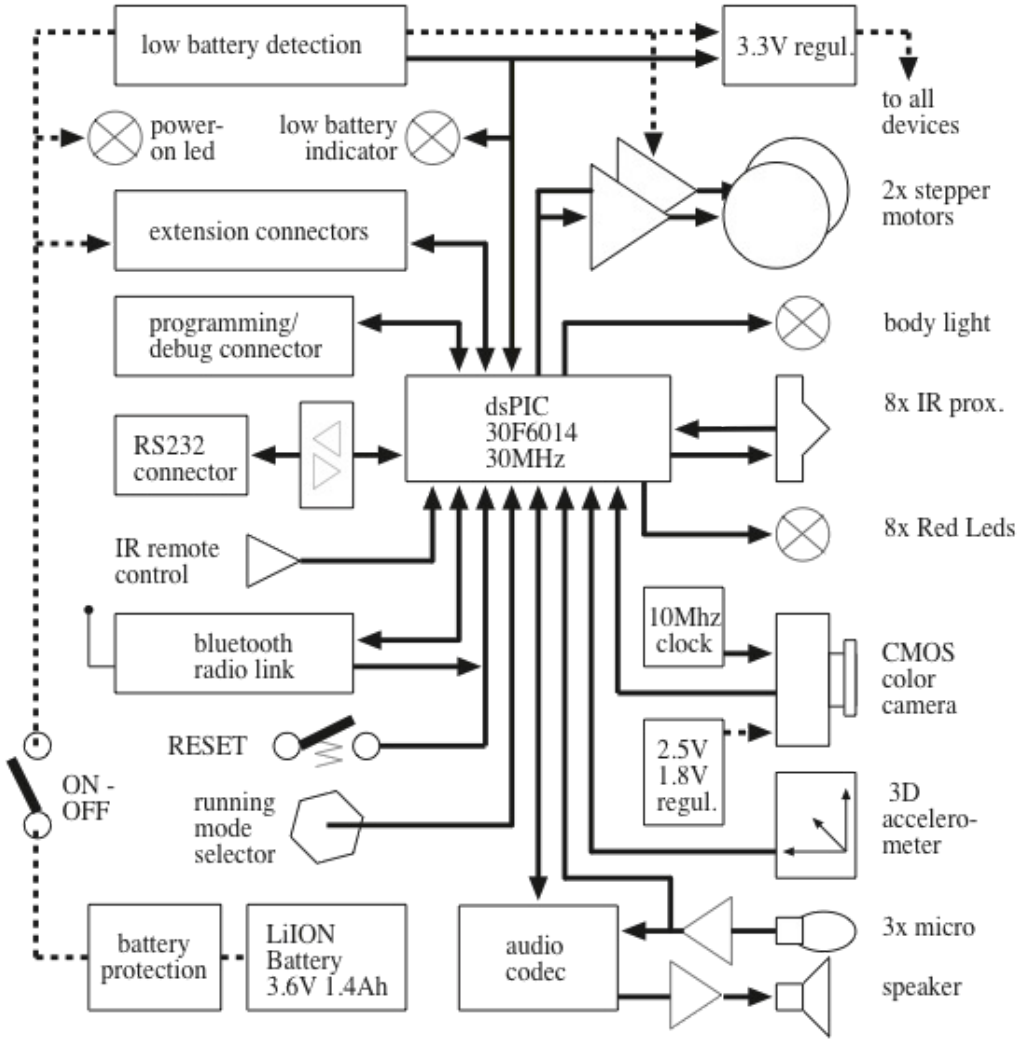
User friendly.

Good robustness and simple maintenance.

“Cheap” at time of desing (<500 euro)



Electronics



EPFL

Methodology, milestones

Interative process implemented in an EPFL project

"Classical" design methodology with a strong interaction with potential users, both teachers and classes

Milestones in term of validation into courses

EPFL

Dissemination and visibility

Collaboration with existing company?

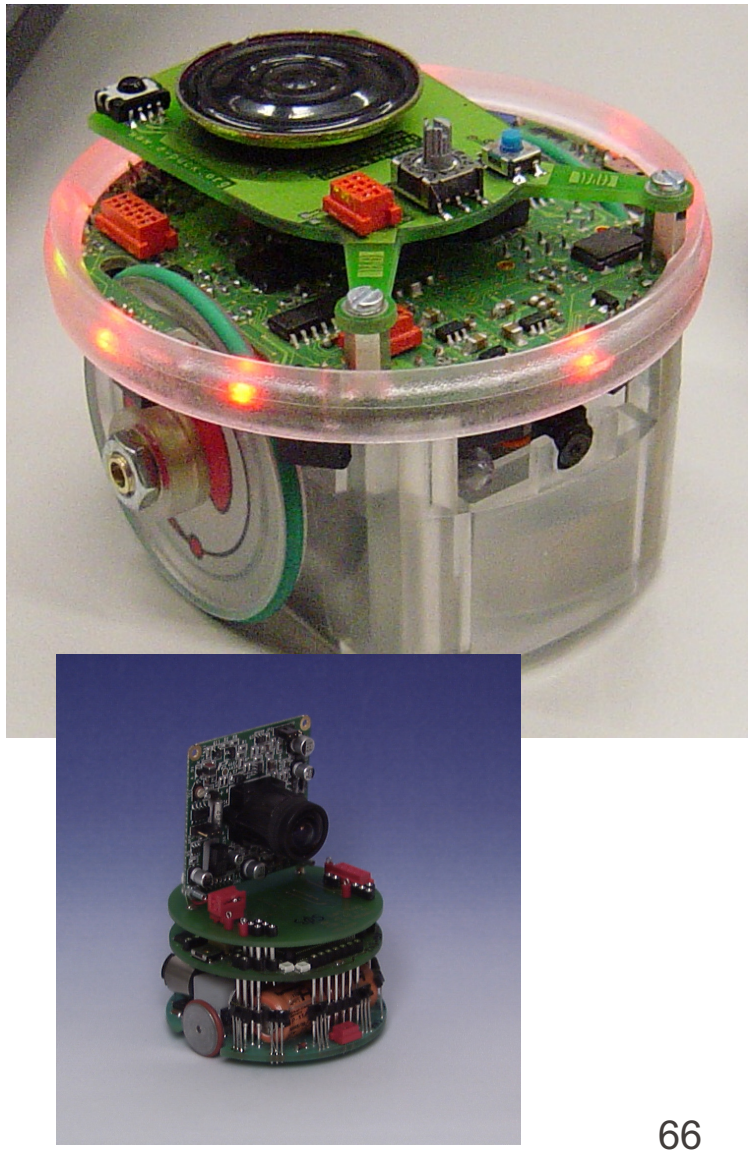
- Khepera: failed
- E-puck: success

New spin-off?

- Khepera: success
- Thymio: success

Open product?

- Khepera : no
- E-puck: success in visibility, ~development
- Thymio: success in visibility, less in development



e-puck as Open Hardware

Advantages:

- Drive hardware developers into “open” dynamics
- Community providing quality and energy
- Perfect spreading in academic environment
- Fully transparent for education
- Lower support costs
- Manufacturers: competition on service quality, reduction of vendor locking

Challenges:

- Invest to spread, not common reflex
- Finding right manufacturer, business model
- Coordinate the community

Lesson learned

Open hardware does not mean “everybody can manufacture it”

Open documentation, open production files, open access to manufacturer, open …?

Control or not control your community? Sort or not sort your manufacturers?

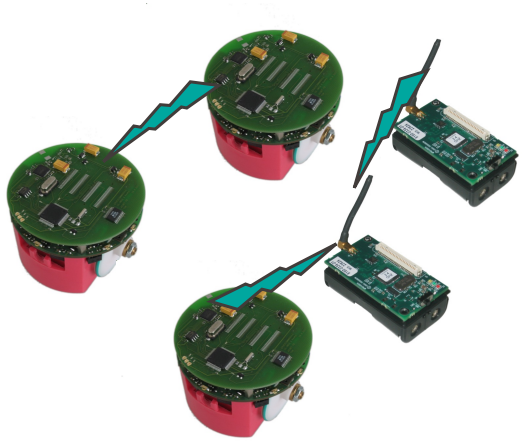
Few real feedback, people use and do not contribute => importance of contributive tools

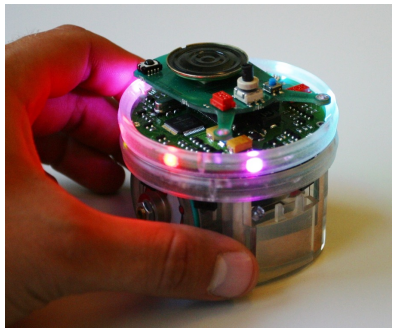
How to maintain the community on the long term?

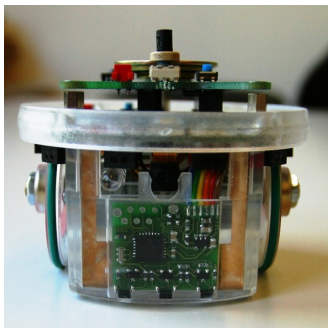
EPFL

Contributions in hardware

Extension turrets:







EPFL

Contributions in software

Developing environments

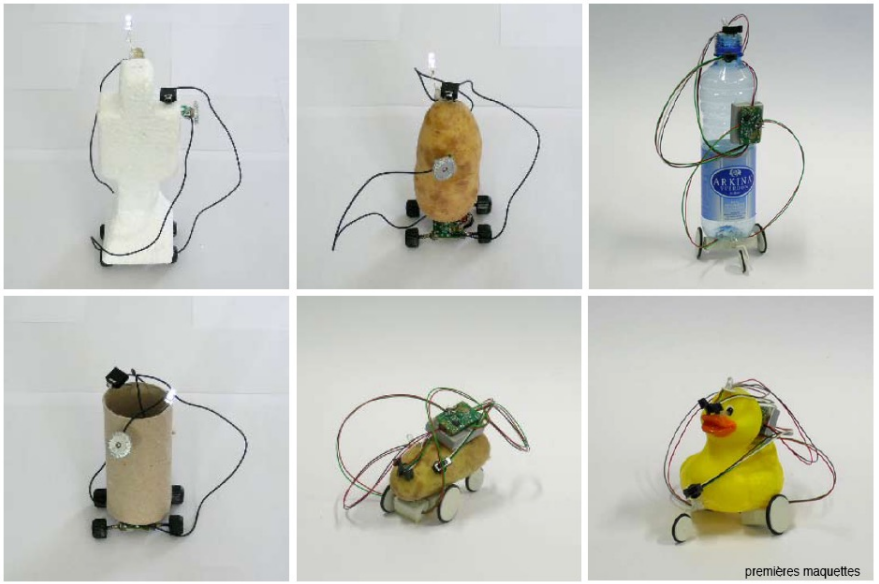
Low level libraries

Demos

EPFL

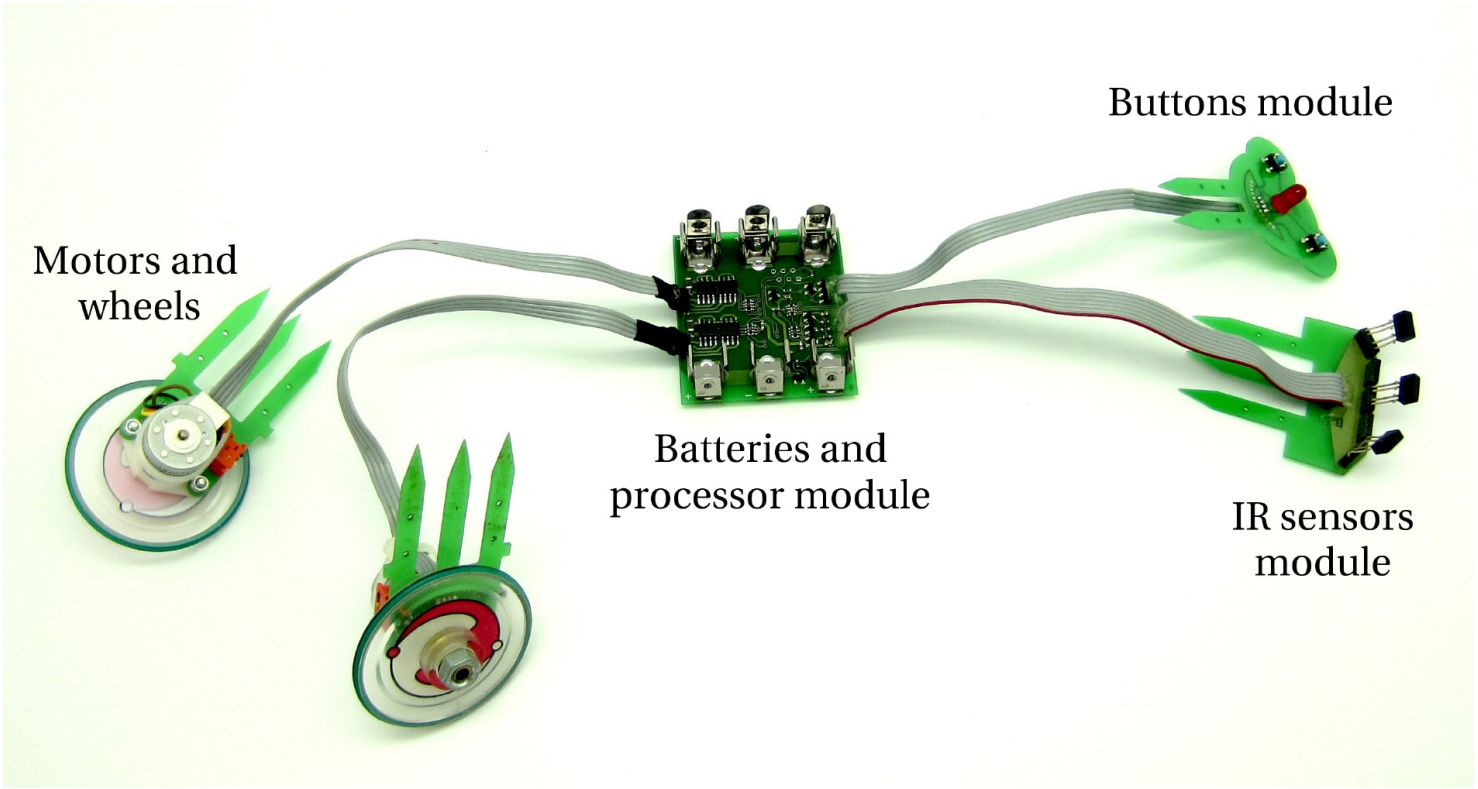
thymio

Thymio robot

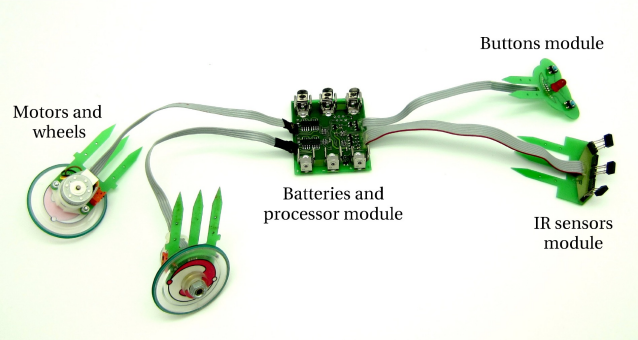


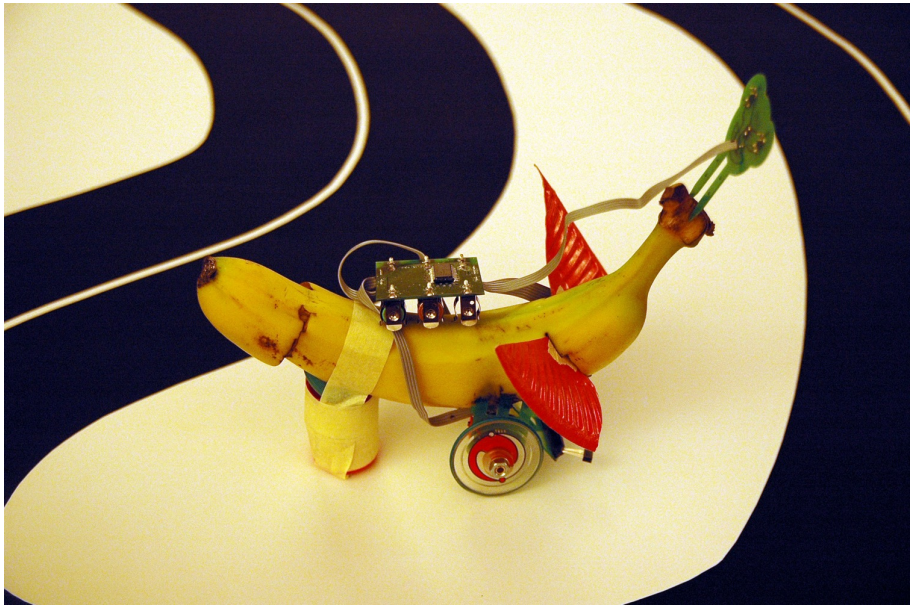
Julien Ayer & Nicolas Le Moigne, ECAL

Thymio 0 robot

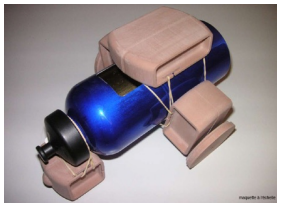


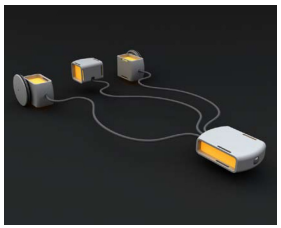
Fanny Riedo, “Thymio: a holistic approach to designing accessible educational robots”, PhD thesis 6557, EPFL, (2015)

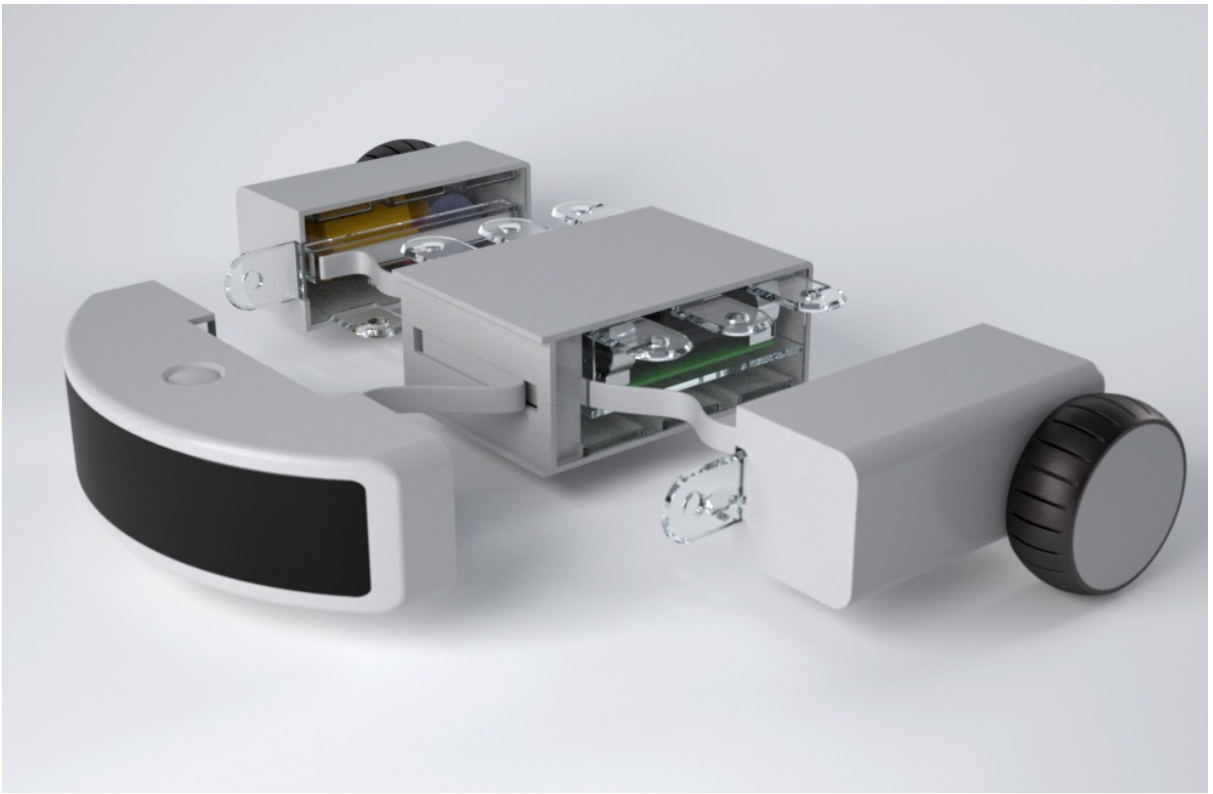

Buttons module
Motors and wheels
Batteries and processor module
IR sensors module



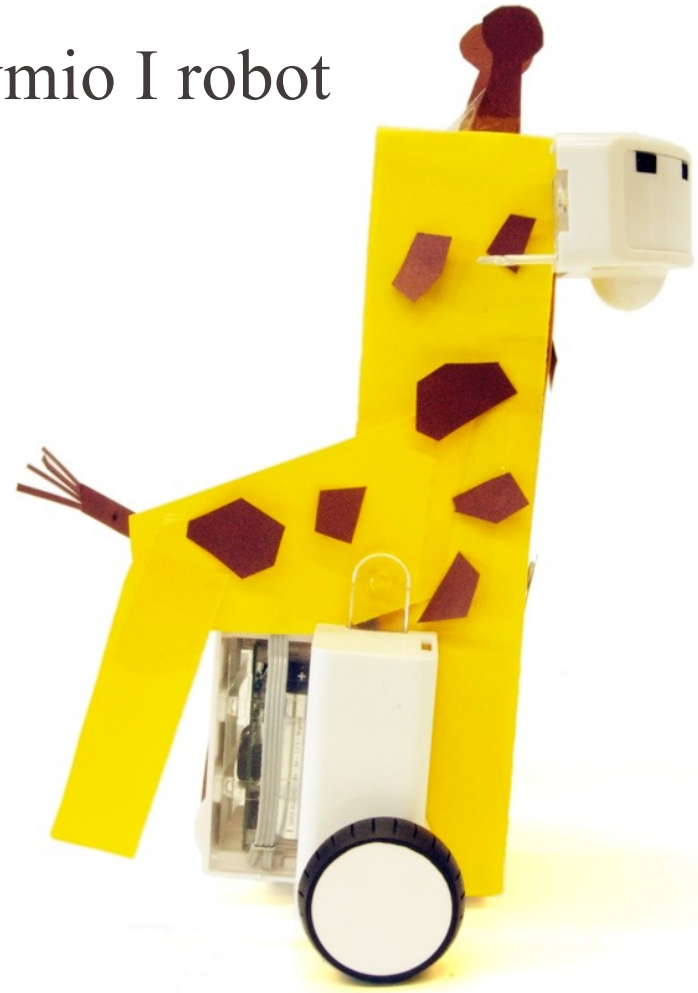
Thymio I robot

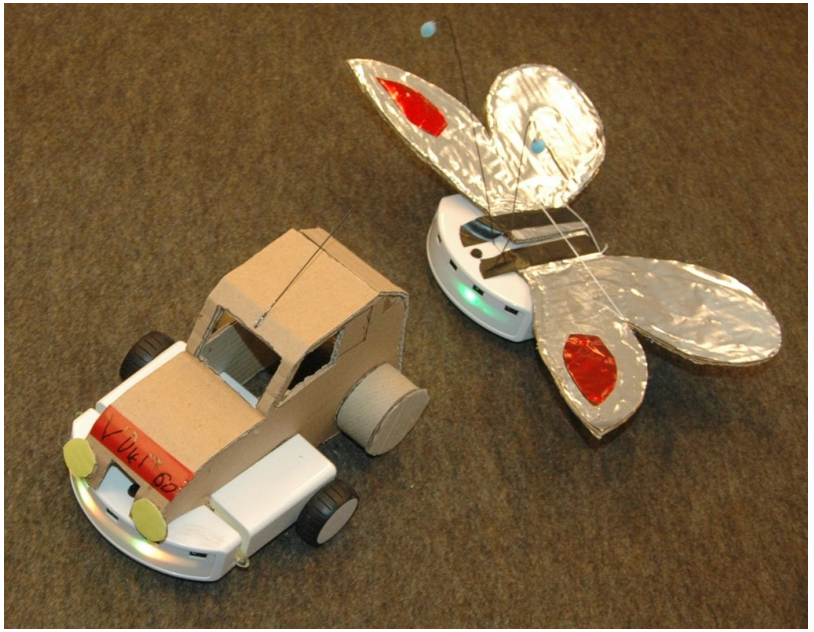






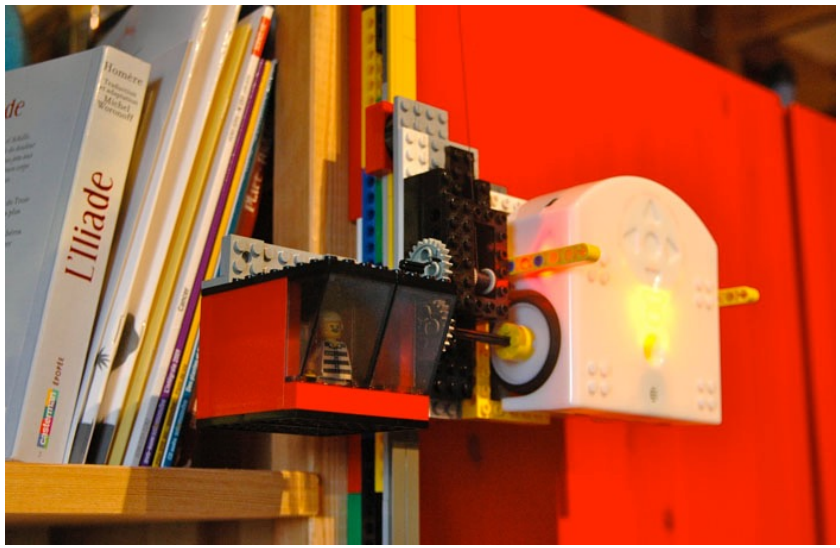
Thymio I robot

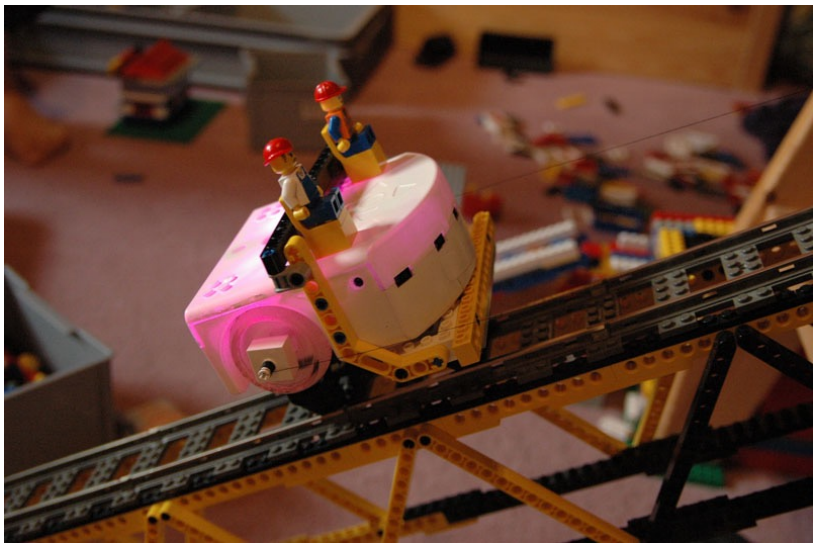


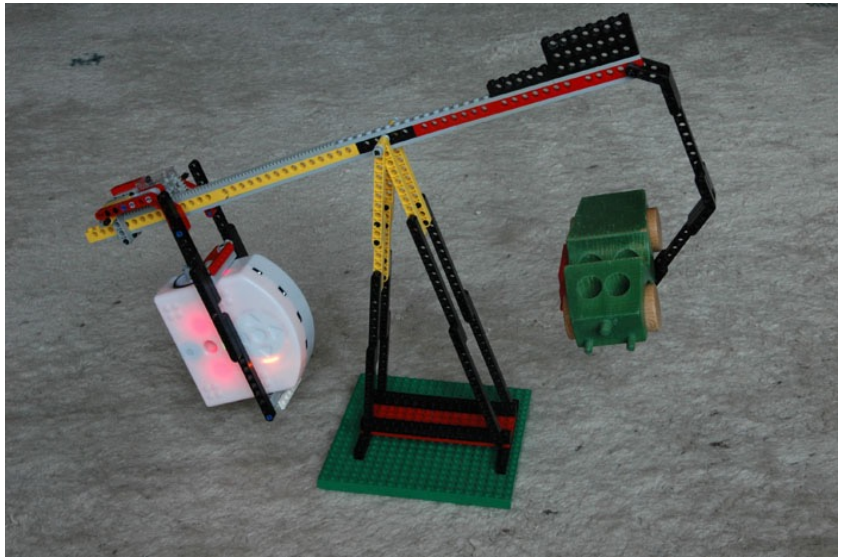


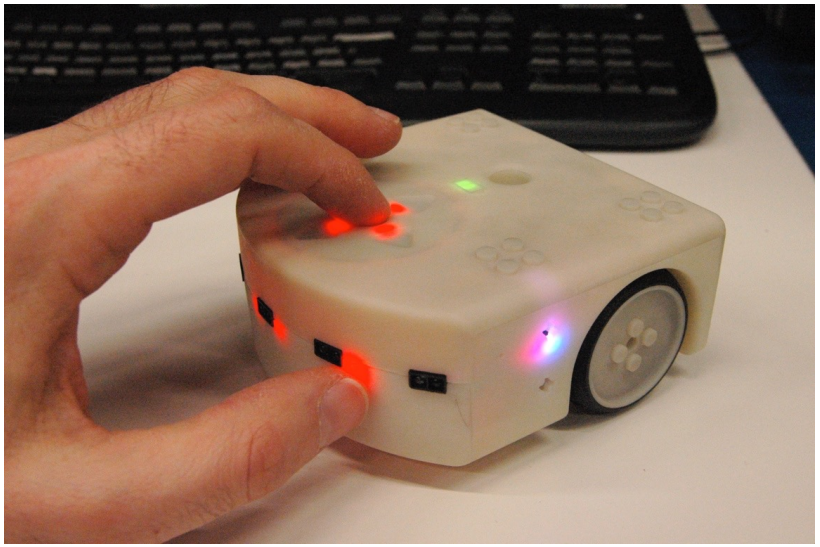
Thymio II robot

Thymio II

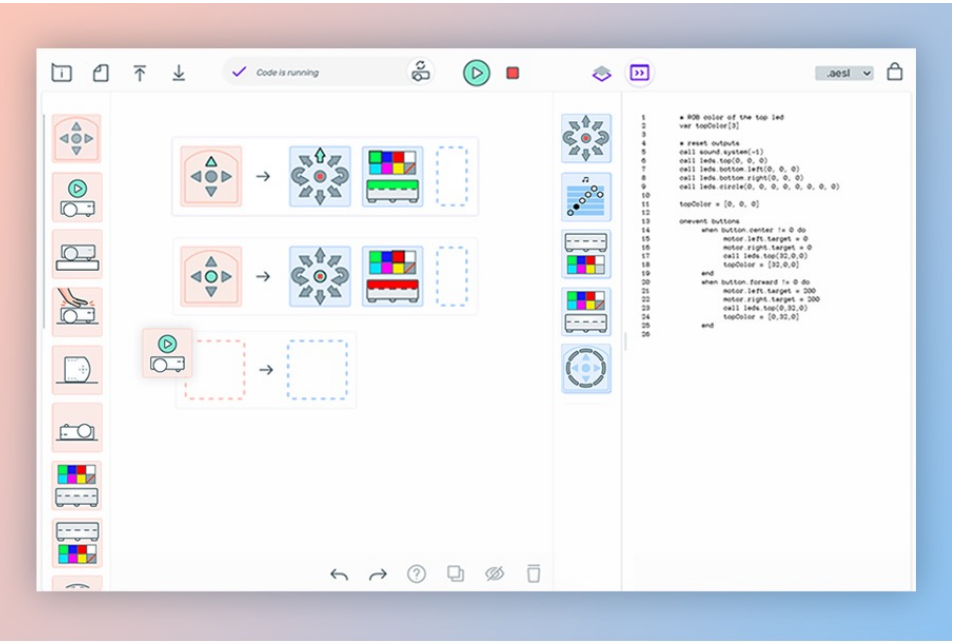








Thymio, educational robot supporting translational research



79

Thymio II robot

Impact:

- Sold >100’000 units mainly to schools
- Convinced teachers, institutions, governments
- New interaction features
- Innovative programming concept and environment
- Excellent base for user studies

Thymio II robot

The customer?

- Us for promotion of technology
- Our bosses
- Colleagues in promotion of science
- Children, teachers, schools, cantons, countries

Thymio II robot

Specifications: where are they?

- Based on a lot of user feedback combined with some innovative ideas

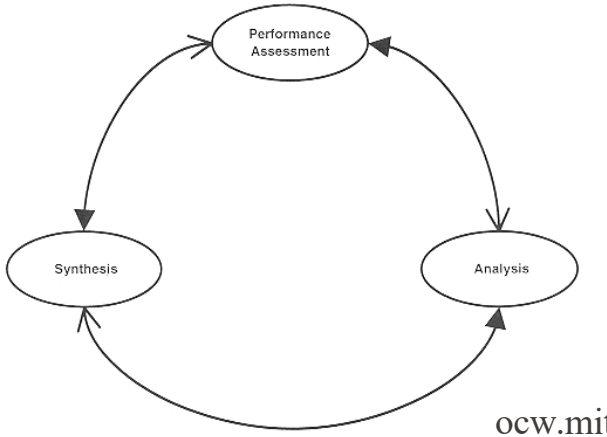
- Based on our own needs
- Based on our design experience
- Refined during three years of project
- Fitting mass-production needs

Thymio II robot

Methodology

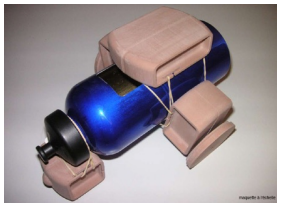
Design process / milestones

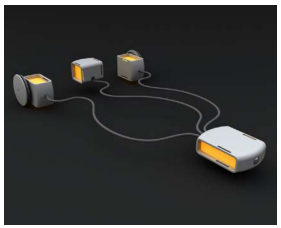
- Classical approach, lot of constraints for low price
- Design by iterations, no real time pressure

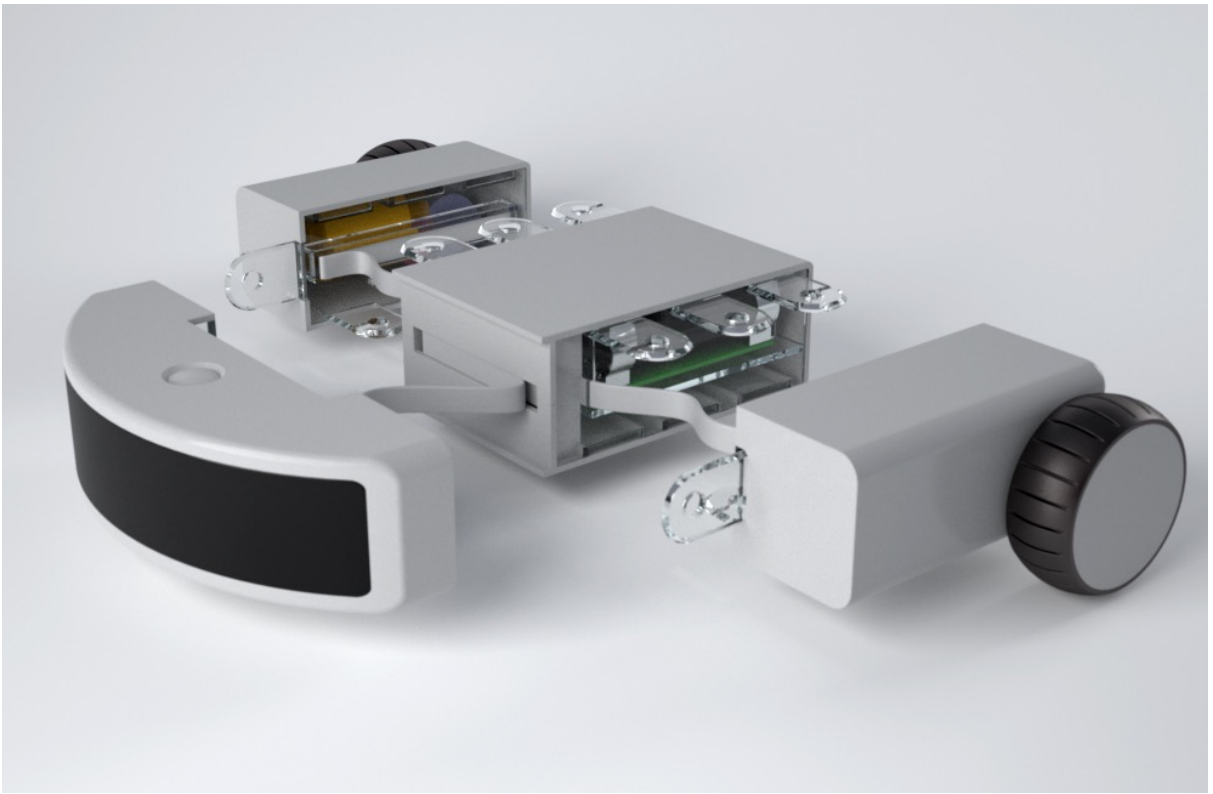


ocw.mit.edu/

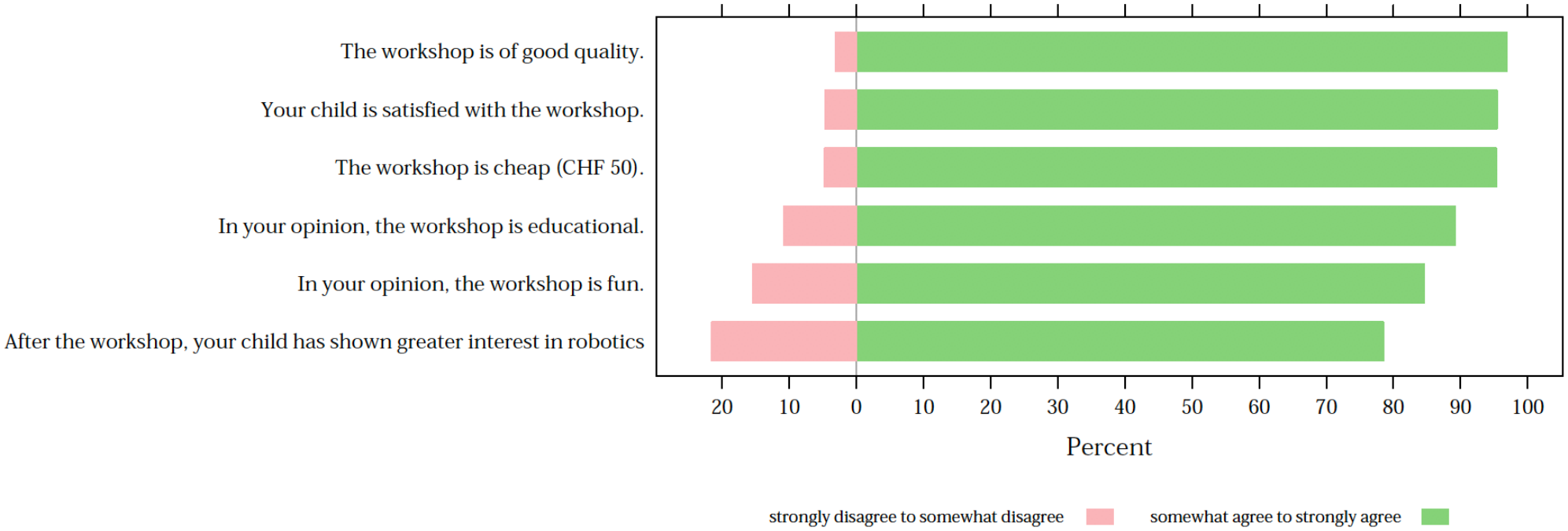
Starting from the Thymio I robot made for our workshops





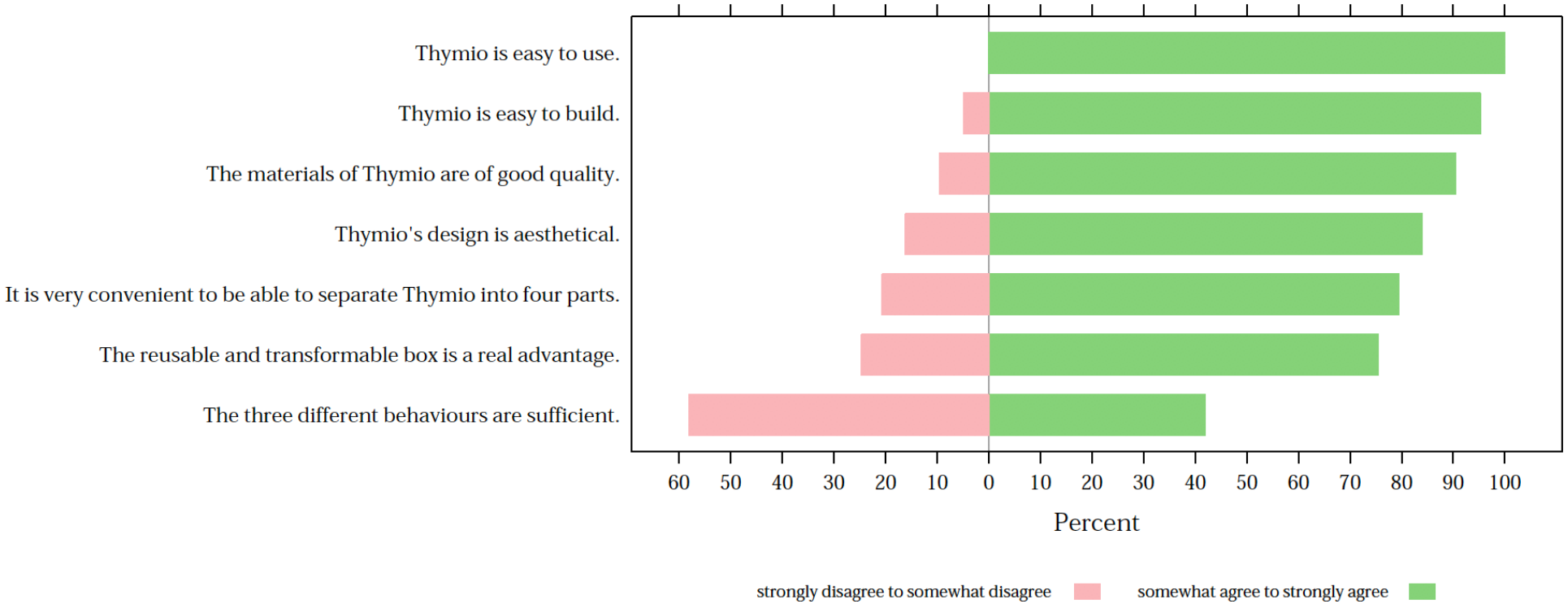


Market Study with HEIG-VD
Parents feedback on workshops at EPFL



Fanny Riedo, “Thymio: a holistic approach to designing accessible educational robots”, PhD thesis 6557, EPFL, (2015)

Parents feedback on Thymio I, n=65



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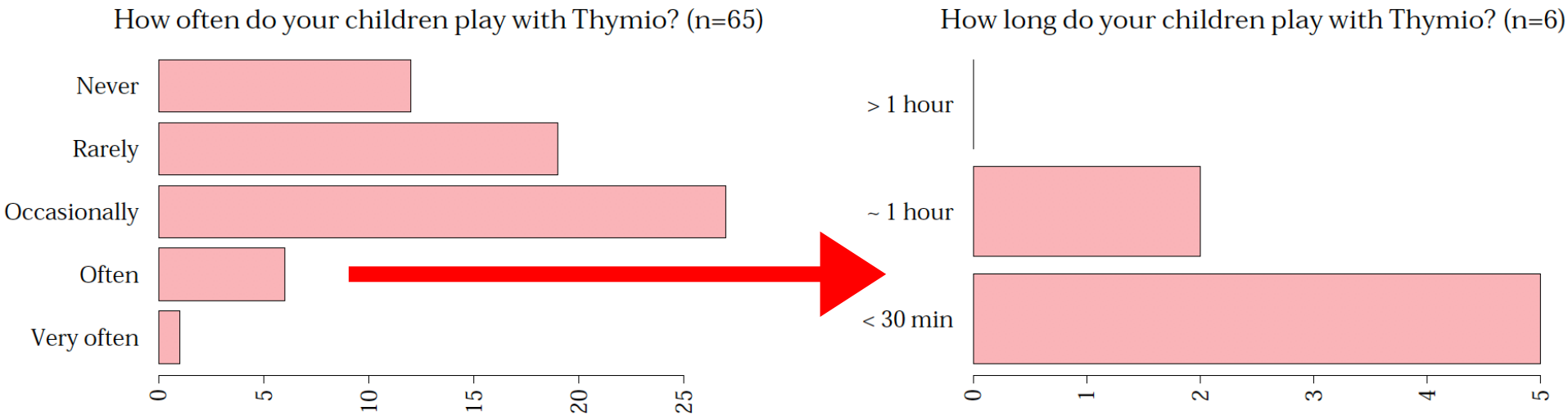
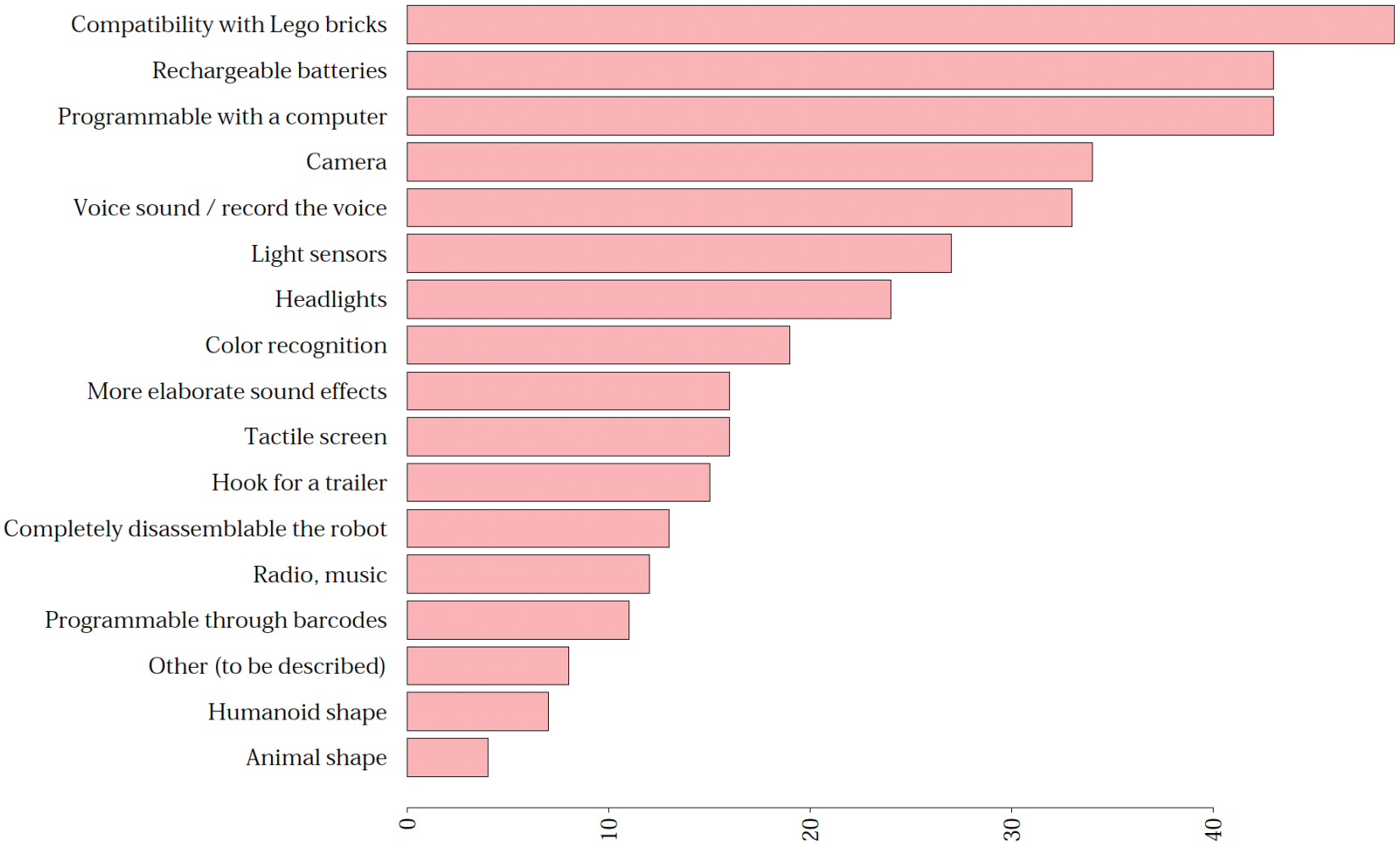


Which features would you like to add? (n=65)



Fanny Riedo, “Thymio: a holistic approach to designing accessible educational robots”, PhD thesis 6557, EPFL, (2015)

Thymio II robot

Open / proprietary IP

- Open
  schematics, implementation and code, TOWARD environmental impact
- Manufacturing by a non-profit association
- Main result for EPFL: image, not $$$!

Thymio II robot

Selling the idea:

- based on the robotic festival, and contacts
- answering to strong needs
- corresponding to a trend (digitalization)
- low cost

Thymio II robot in the school curriculum: Teachers following a training

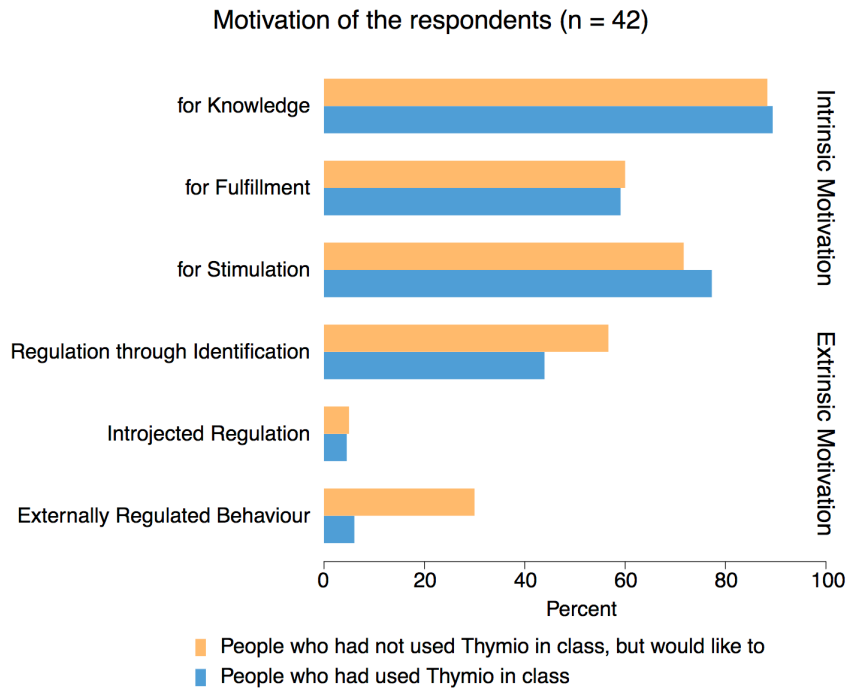
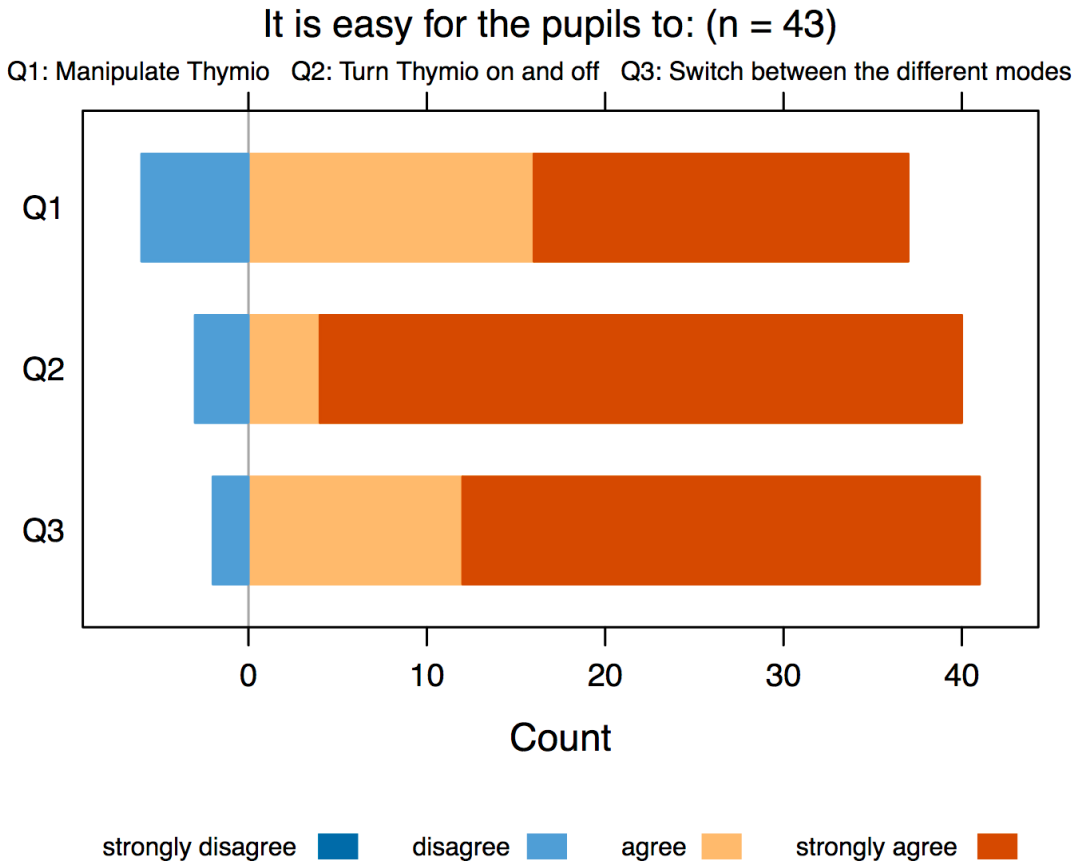


Fig. 5: Motivation of teachers: each type of motivation was measured by three different questions. Amotivation is not considered because this study covers only teachers who had decided to act, by attending at least one training session.

Chevalier, Morgane, Fanny Riedo, and Francesco Mondada. "Pedagogical Uses of Thymio II: How Do Teachers Perceive Educational Robots in Formal Education?." *IEEE Robotics & Automation Magazine* 23, no. 2 (2016): 16-23.

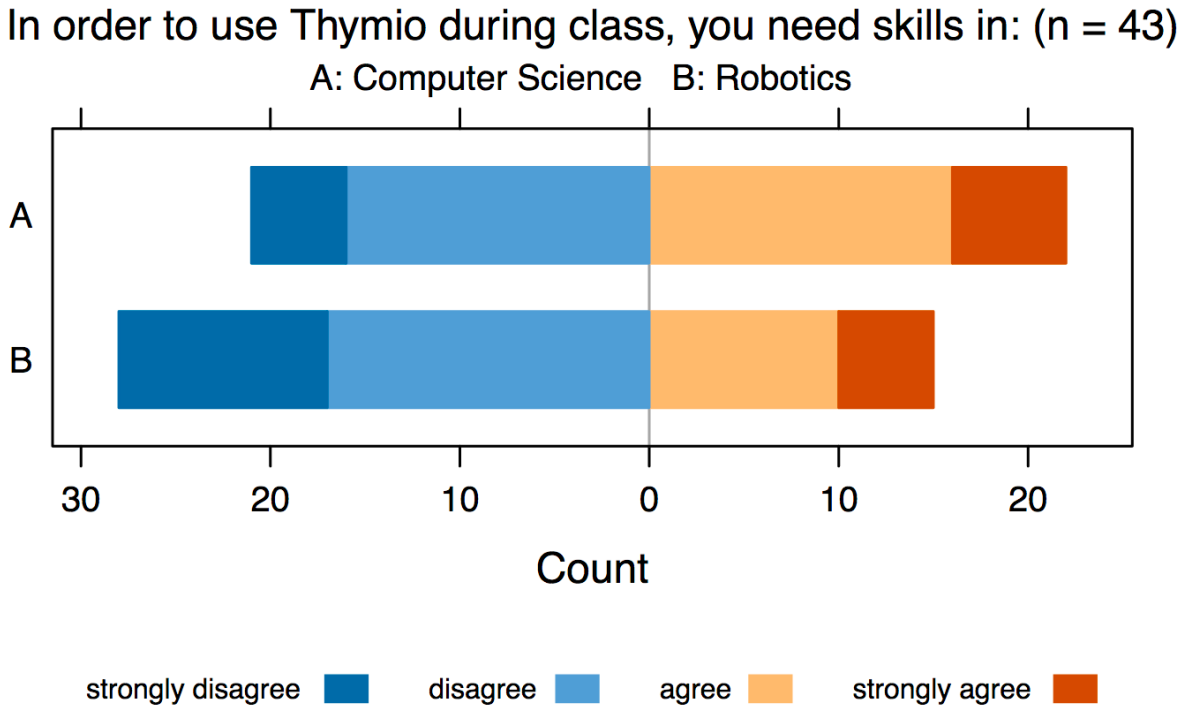
Thymio II robot in the school curriculum: Teachers following a training



(b) Teachers' opinions on Thymio's usability by pupils.

Chevalier, Morgane, Fanny Riedo, and Francesco Mondada. "Pedagogical Uses of Thymio II: How Do Teachers Perceive Educational Robots in Formal Education?." *IEEE Robotics & Automation Magazine* 23, no. 2 (2016): 16-23.

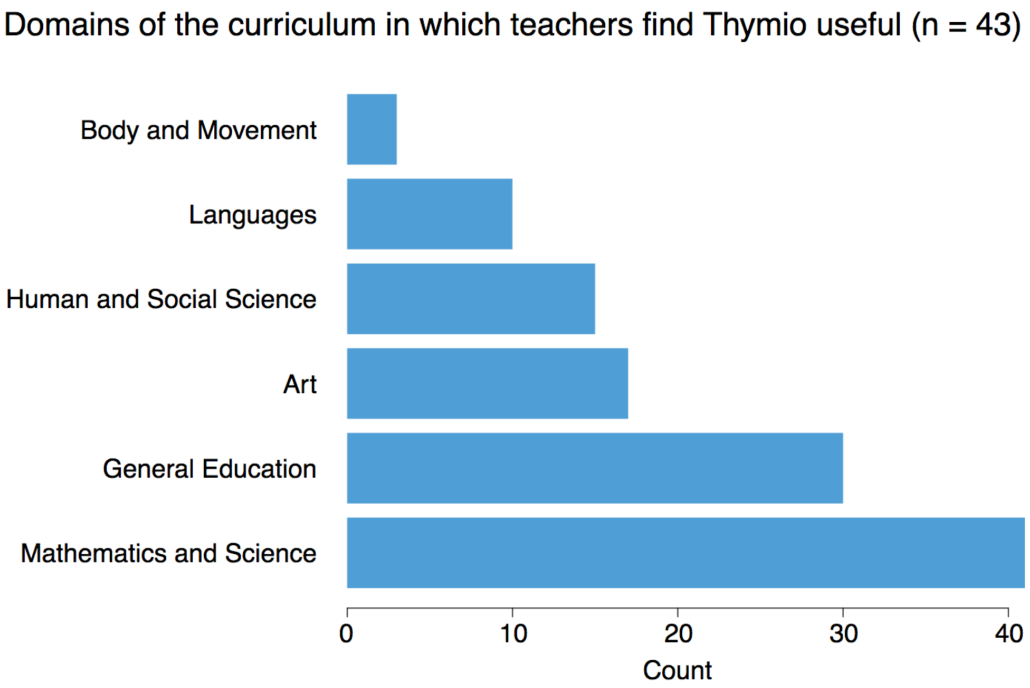
Thymio II robot in the school curriculum: Teachers following a training



(a) Professional skills teachers consider necessary in order to use Thymio with their class.

Chevalier, Morgane, Fanny Riedo, and Francesco Mondada. "Pedagogical Uses of Thymio II: How Do Teachers Perceive Educational Robots in Formal Education?." *IEEE Robotics & Automation Magazine* 23, no. 2 (2016): 16-23.

What is Thymio good for?



(a) Domains of the Swiss curriculum (PER)

Chevalier, Morgane, Fanny Riedo, and Francesco Mondada. "Pedagogical Uses of Thymio II: How Do Teachers Perceive Educational Robots in Formal Education?." IEEE Robotics & Automation Magazine 23, no. 2 (2016): 16-23.

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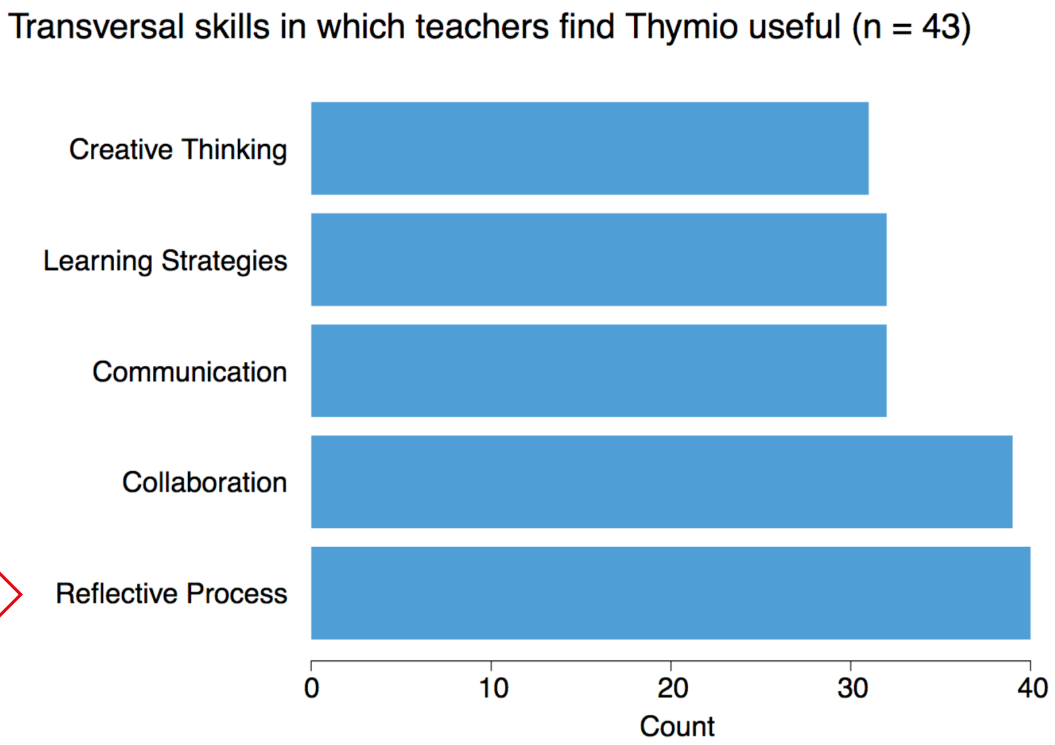
What is Thymio good for?



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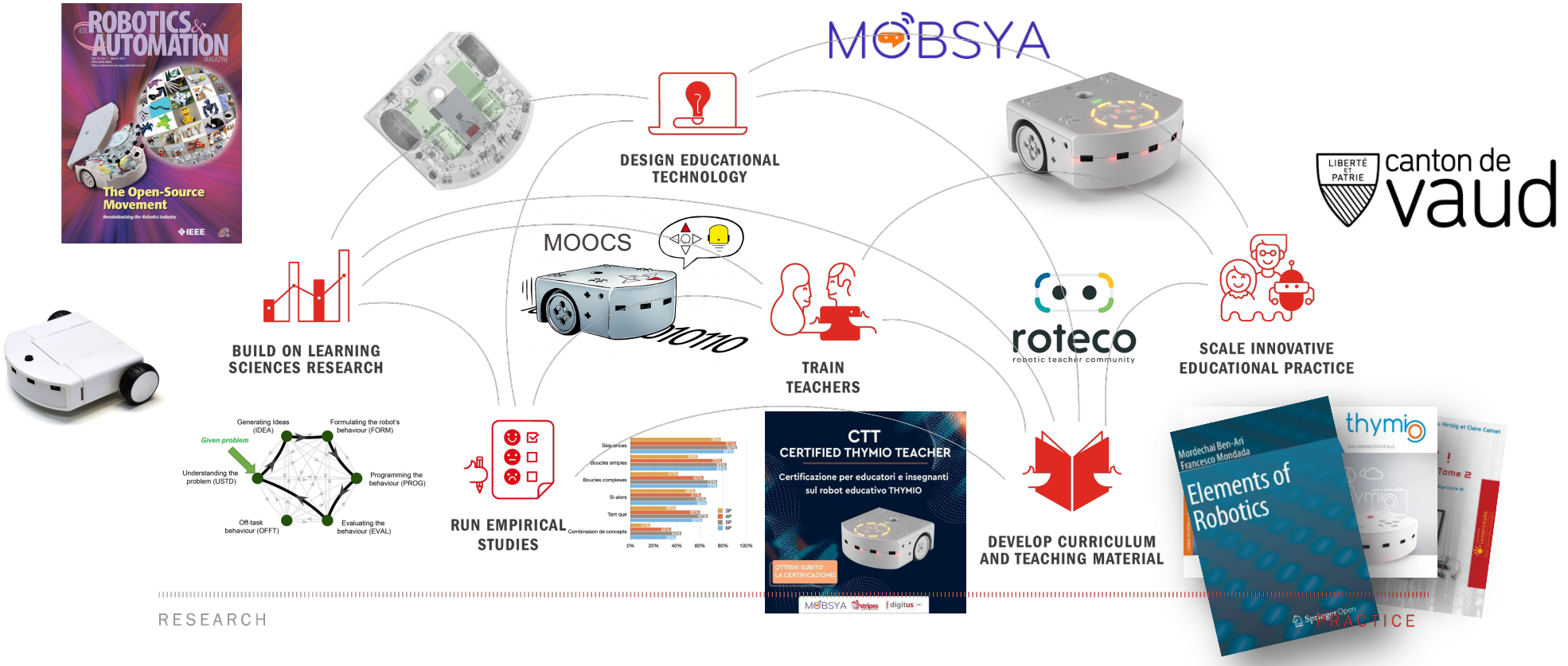
Thymio II robot

Research topics:

- Robot mechatronics for education
- Interaction for education
- User studies
- Acceptance in schools, by teachers
- AI concepts
- Robotics as an interdisciplinary tool

- Translational research

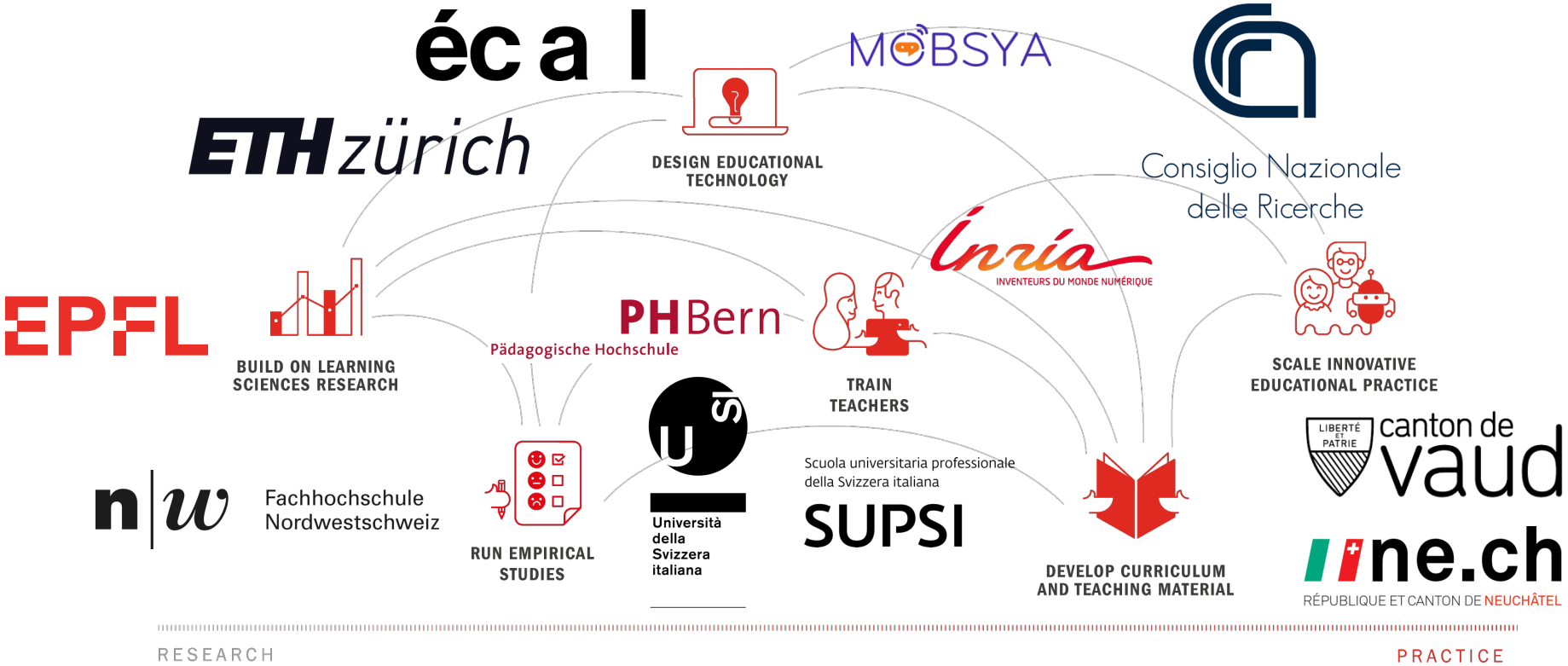
A translational approach to computational thinking



Mondada, F., Bonani, M., Riedo, F., Briod, M., Pereyre, L., Rétornaz, P., & Magnenat, S. (2017). Bringing robotics to formal education: The thymio open-source hardware robot. *IEEE Robotics & Automation Magazine*, *24*(1), 77-85.

97

A strong translational ecosystem



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Why robotics (in elementary school) ?

Background

- Political awareness for digital education (and STEM?)
- Resistance, among others from teachers
- Negative image of computer science (119/154 teachers in our Vaud project).

Pros

- Motivation
- THE STEM object
- Immediate feedback
- "Class dynamics remixer"

Cons

- Cost
- New learning content, no curriculum
- Immediate feedback

Kradolfer, S., Dubois, S., Riedo, F., Mondada, F., & Fassa, F. (2014, October). A sociological contribution to understanding the use of robots in schools: the thymio robot. In International Conference on Social Robotics (pp. 217-228). Springer, Cham.

99

Are kids really thinking when they program?

Not sure….

100

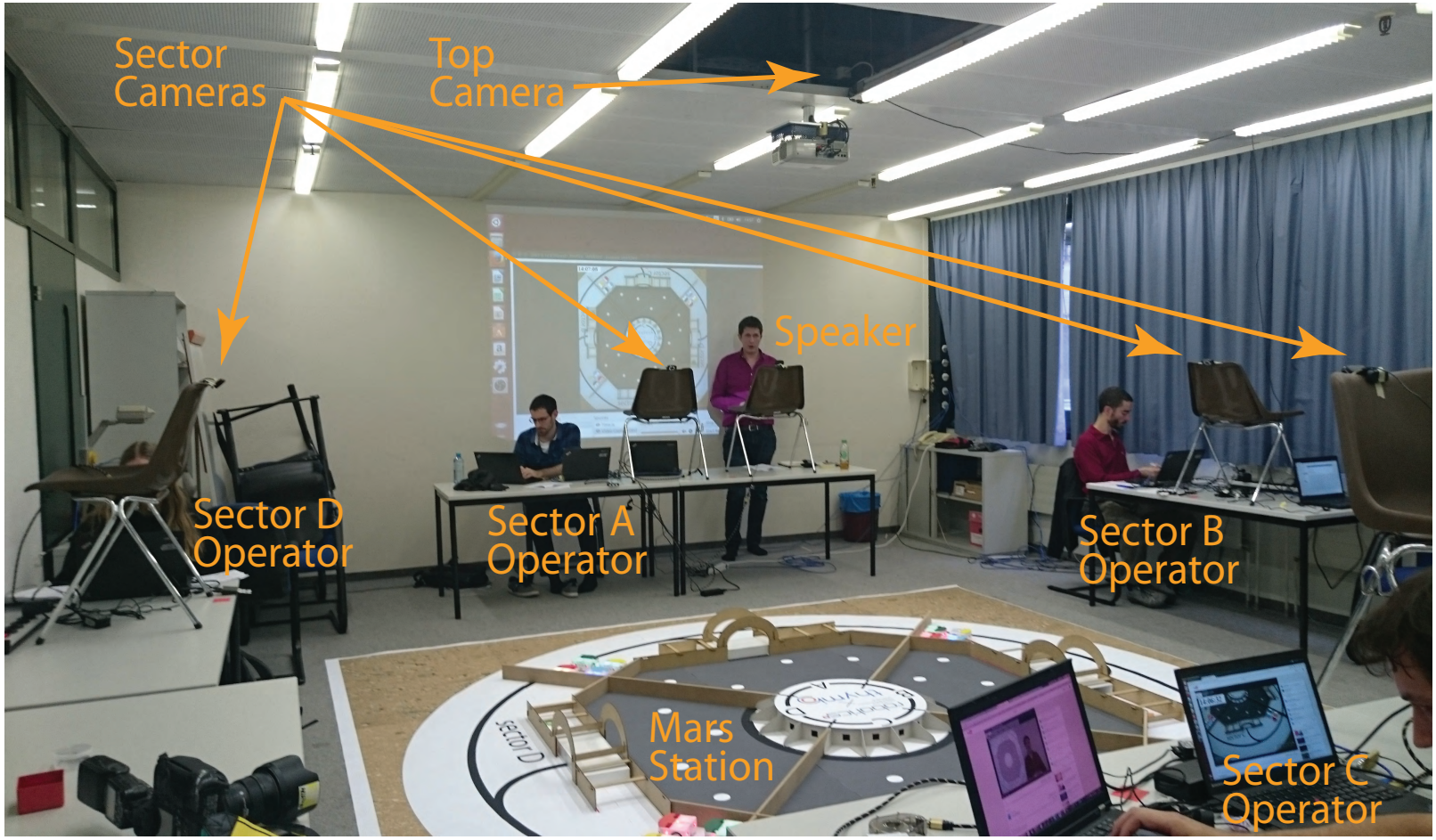
R^2T_2: REMOTE Rescue by Thymio2

101

R^2T_2: REMOTE Rescue by Thymio2

102

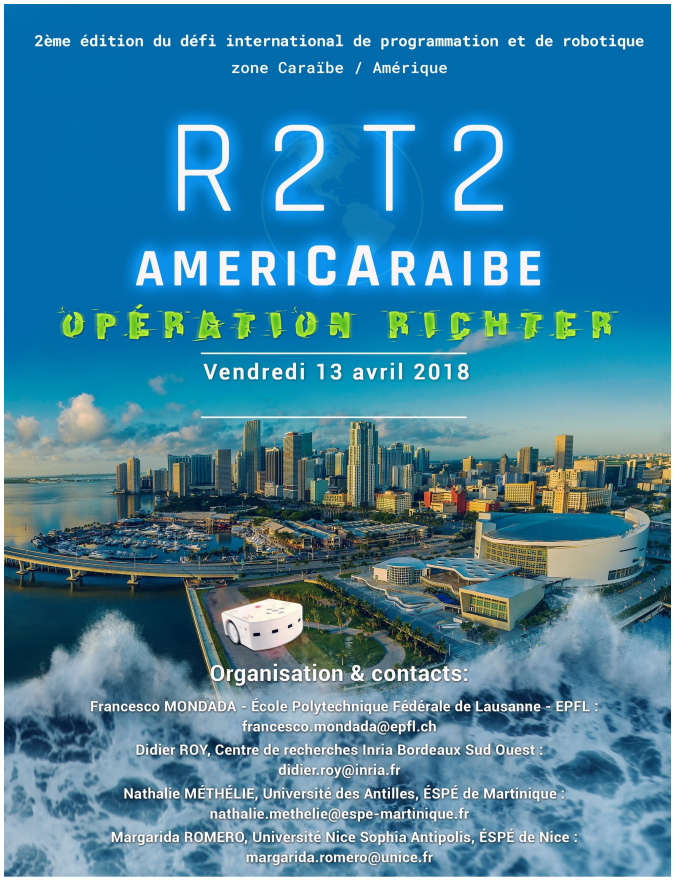
R^2T_2: REMOTE Rescue by Thymio2



R^2T_2: REMOTE Rescue by Thymio2

104

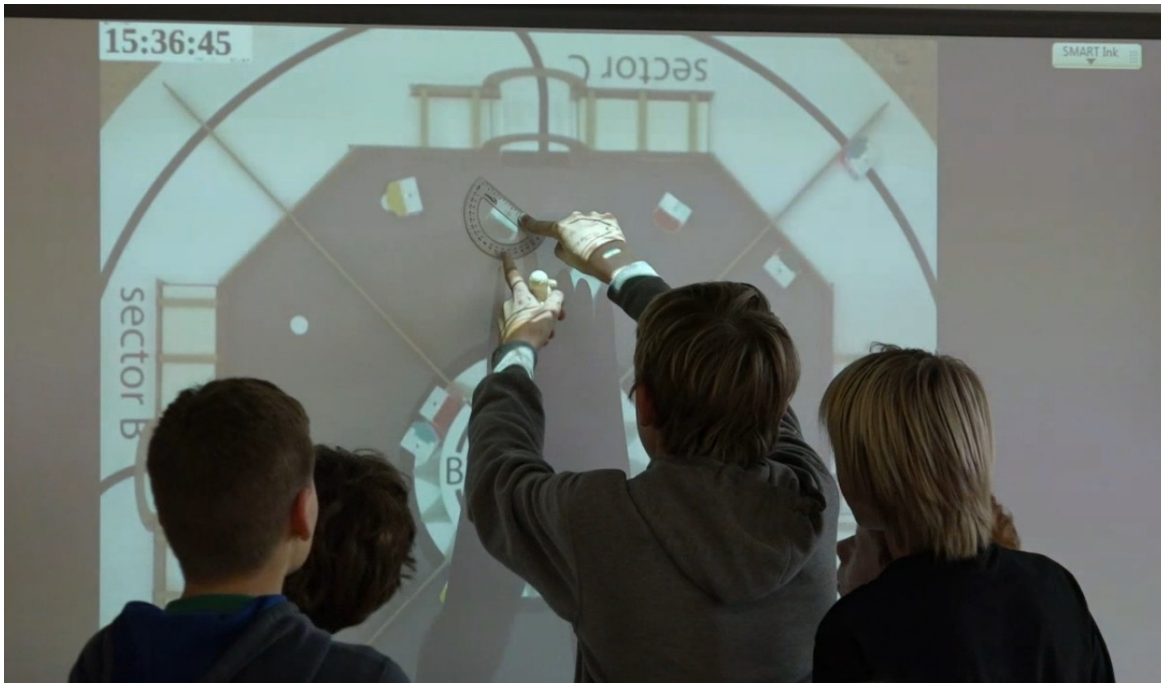
R^2T_2: REMOTE Rescue by Thymio2



Are kids really thinking when they program?

Yesssss

But why?



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R^2T_2: need to think

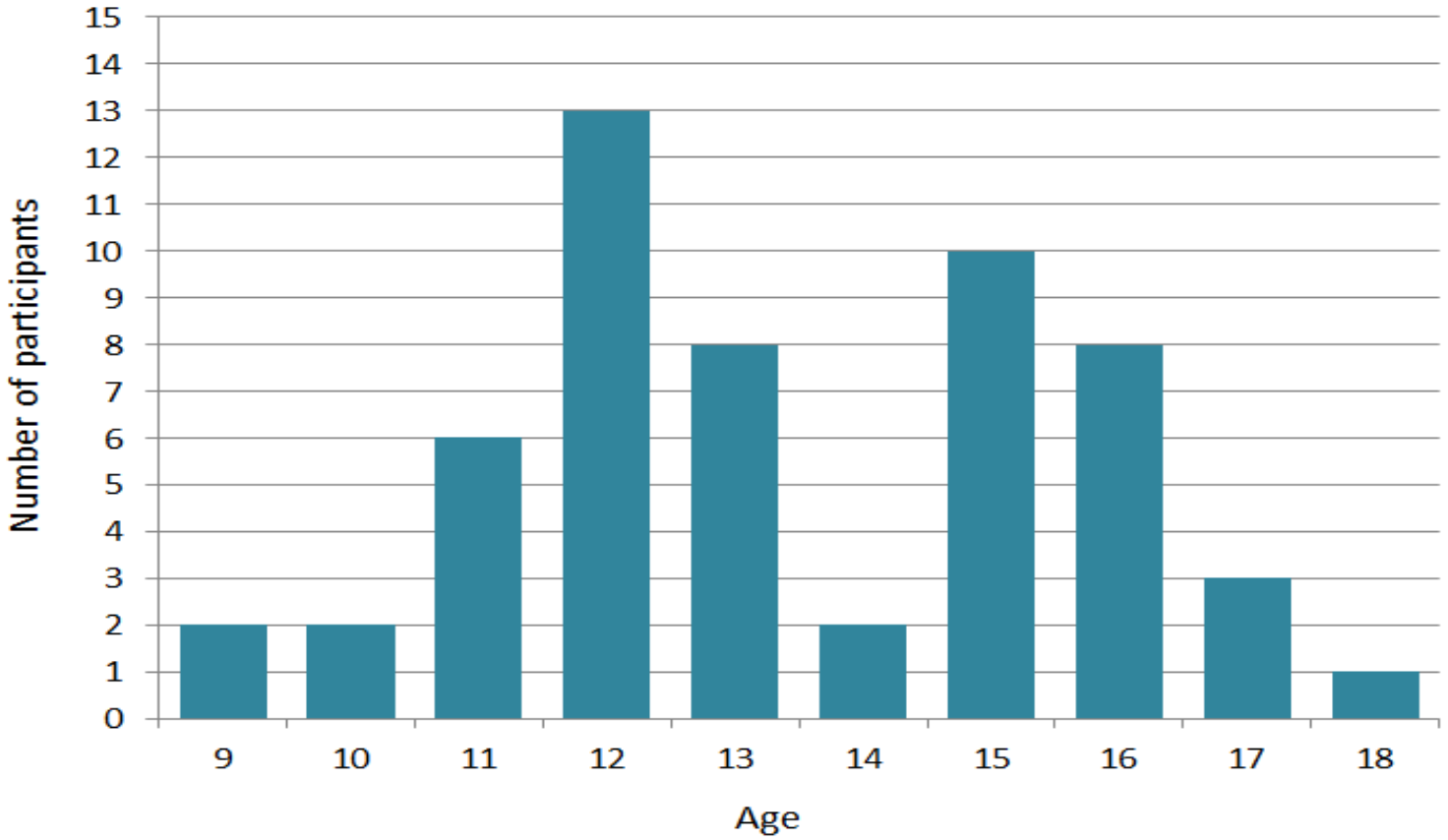
Because of the delay of transmission to Mars (of YouTube ☺)

You cannot remotely operate the robot, you need to program the task to be executed by the robot

When you start the program on Mars, it has to work!

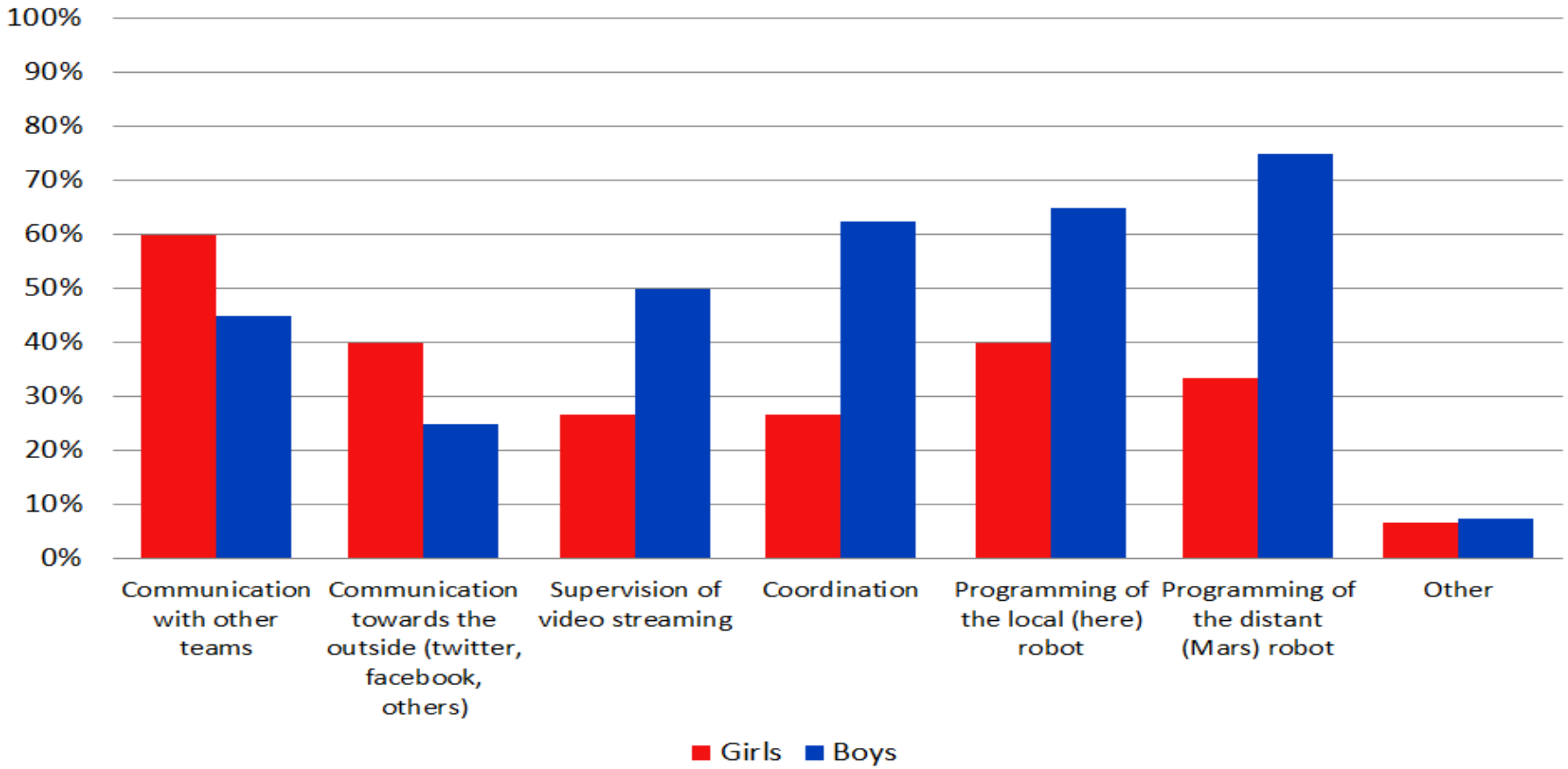
- You have to wait 30-45 second until it starts (stress)
- If something goes wrong, you see it 30-45 seconds after
- If you stop, you see the damages during 30-45 seconds
- In a group mission you can create big damages

Age profile



Mondada, F., Bonnet, E., Davrajh, S., Johal, W., & Stopforth, R. (2016). R2T2: Robotics to integrate educational efforts in South Africa and Europe. International Journal of Advanced Robotic Systems, 13(5), 1729881416658165.

Role in the team & gender



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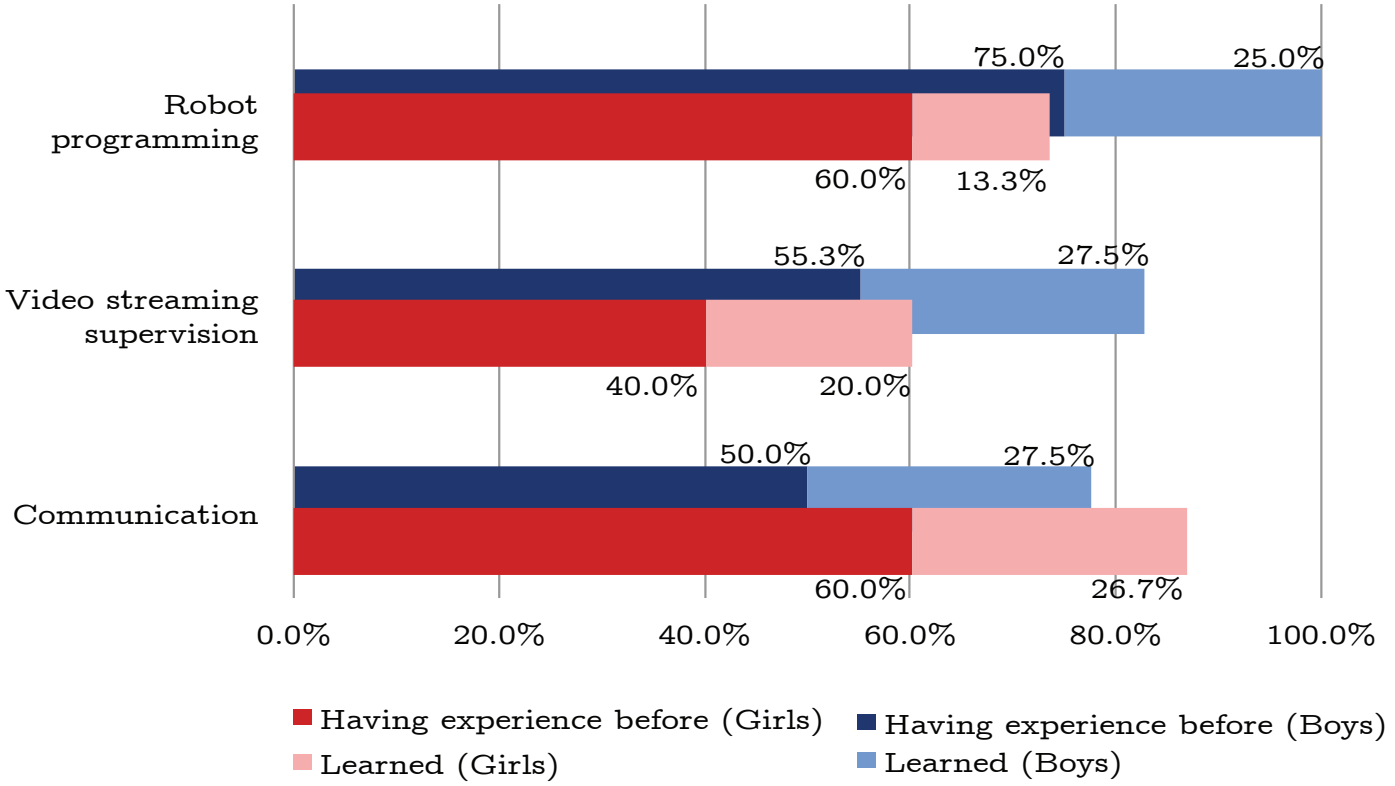
How much I progressed in which area (self-evaluation)



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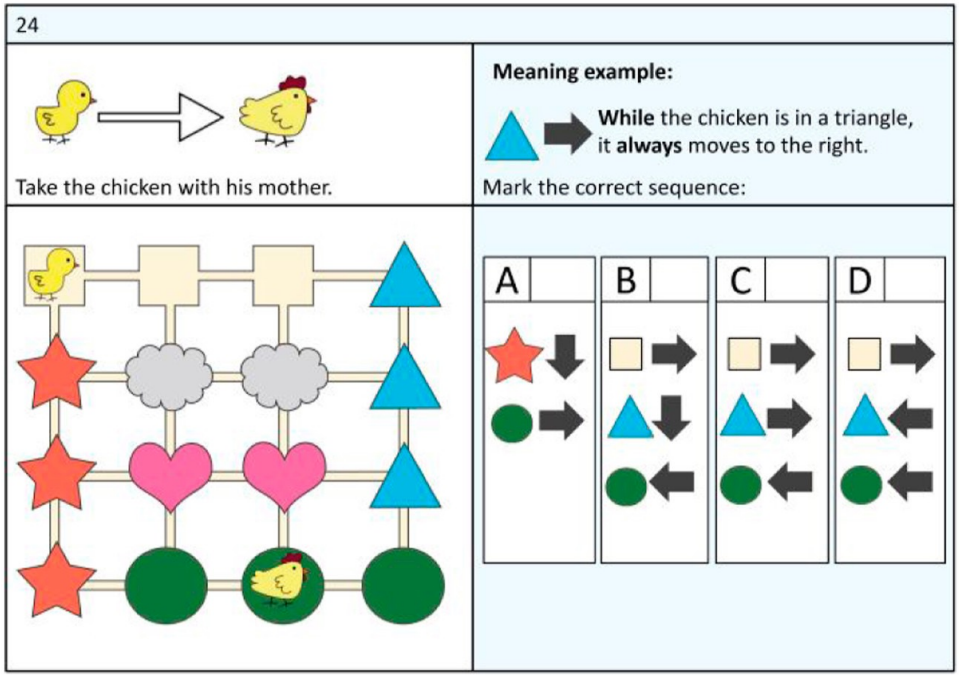
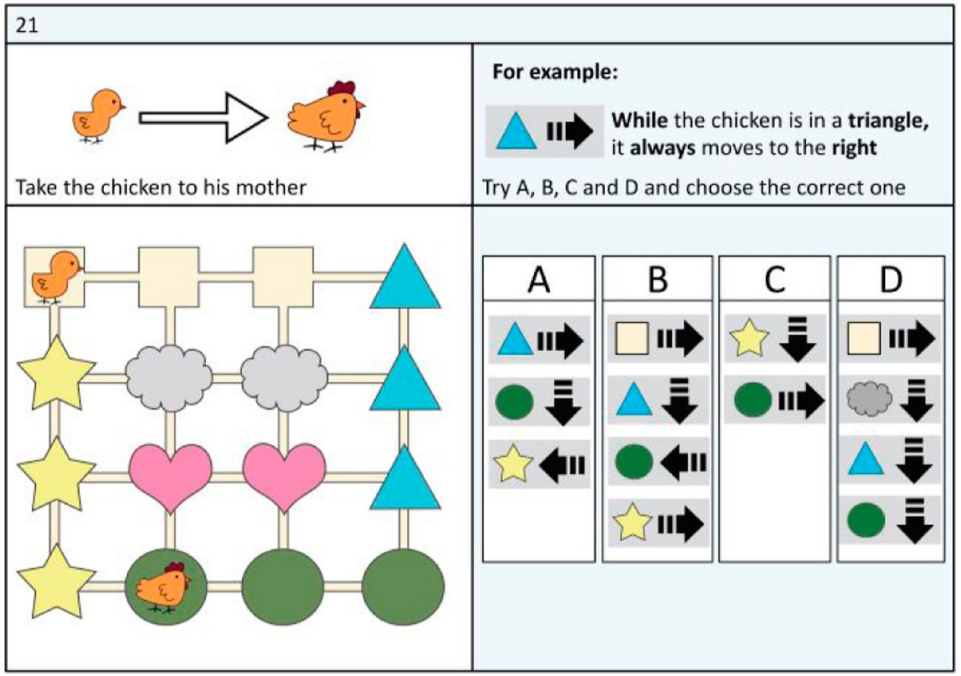
Testing CT skills?





El-Hamamsy, L., Zapata-Cáceres, M., Barroso, E. M., Mondada, F., Zufferey, J. D., & Bruno, B. (2022). The competent computational thinking test: Development and validation of an unplugged computational thinking test for upper primary school. Journal of Educational Computing Research, 60(7), 1818-1866.

CCPS creative computational problem solving Model

Model the process to:

- *Understanding the process*
- *Measure the process*
- *Give guidance to improve the process*

of Computational Thinking

Chevalier, M., El-Hamamsy, L., Giang, C., Bruno, B., & Mondada, F. (2021, April). Teachers' perspective on fostering computational thinking through educational robotics. In *International Conference on Robotics in Education (RiE)* (pp. 177-185). Springer, Cham.

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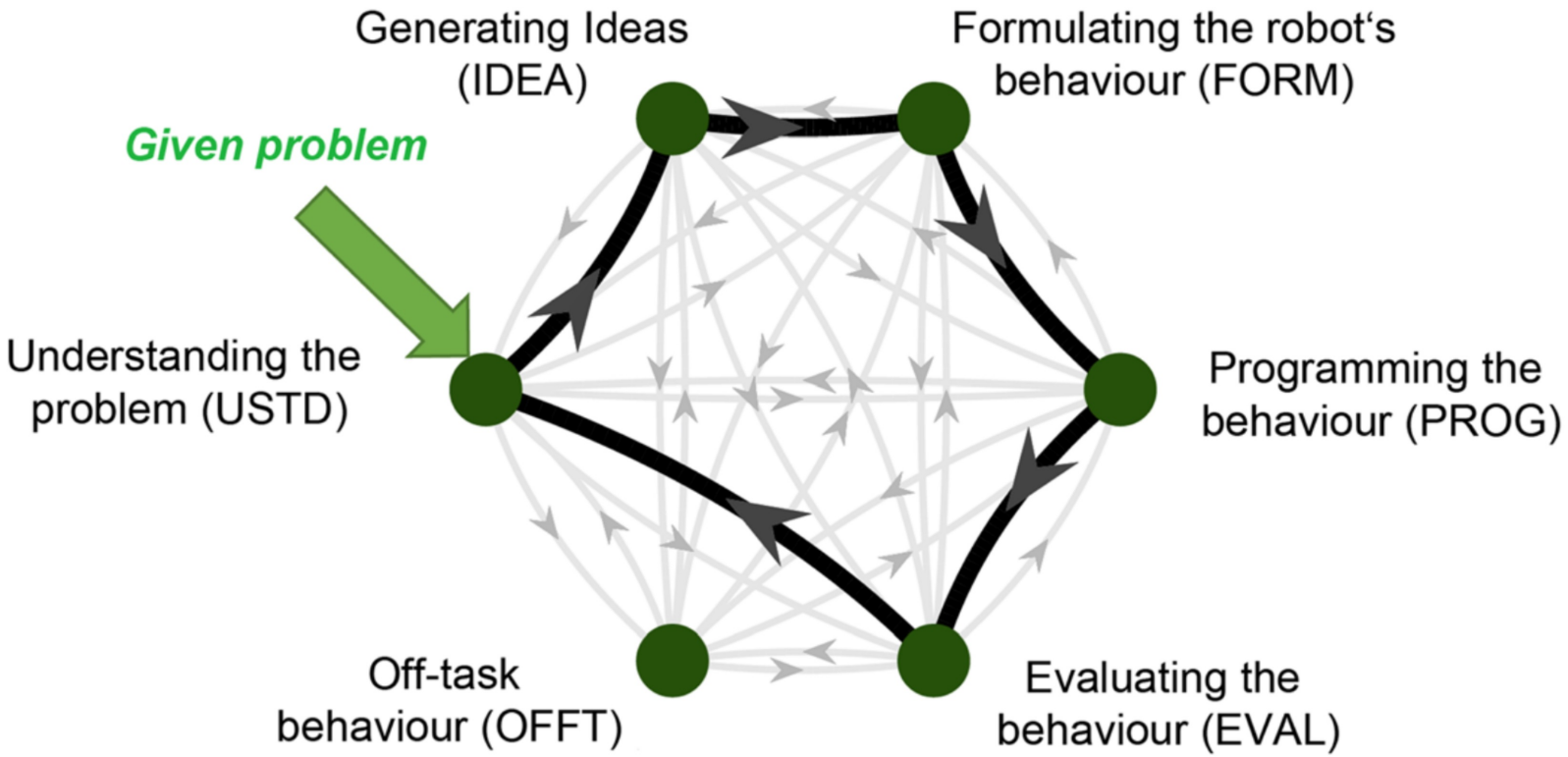
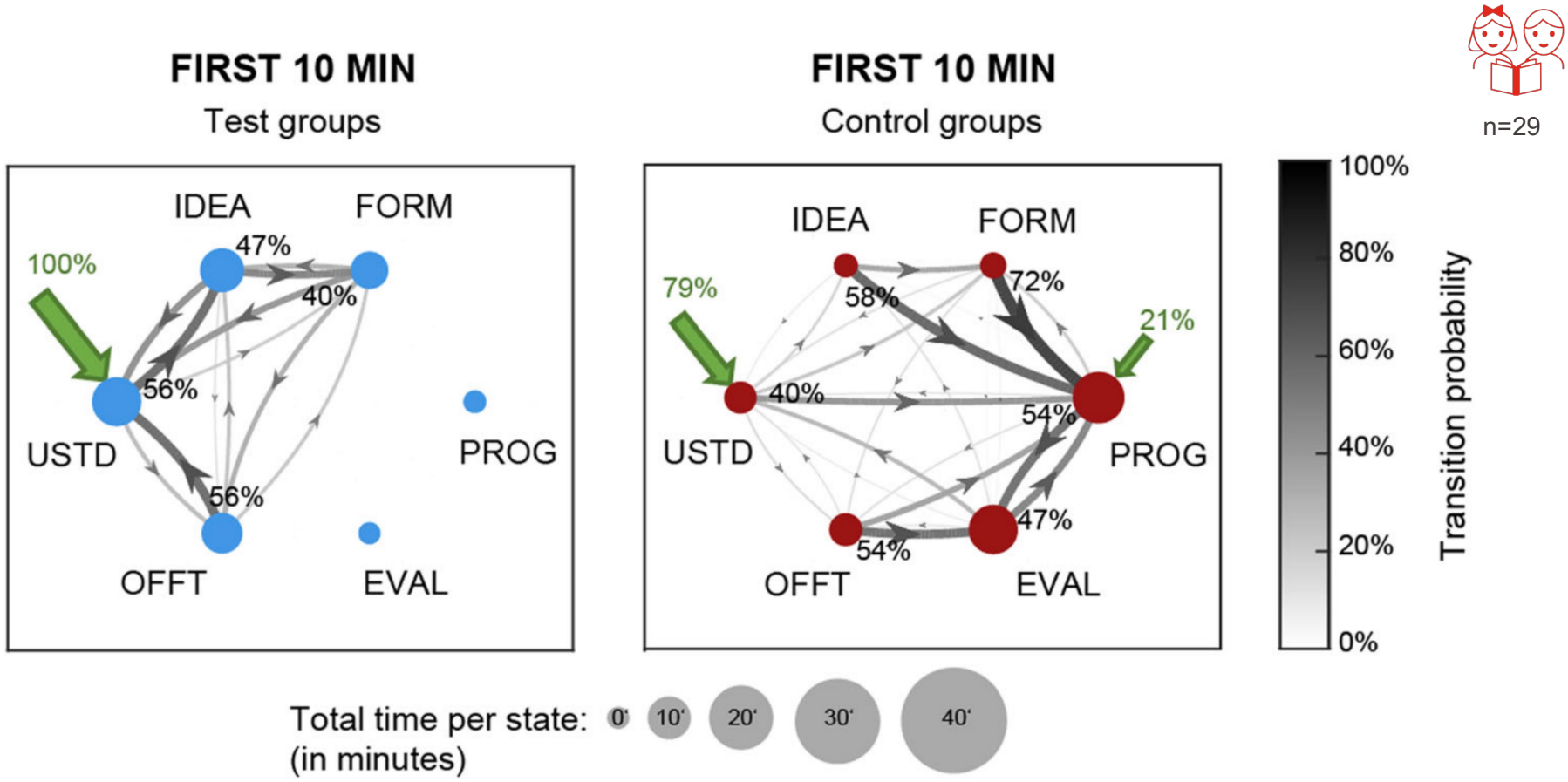
CCPS creative computational problem solving Model



Chevalier, M., Giang, C., Piatti, A., & Mondada, F. (2020). Fostering computational thinking through educational robotics: a model for creative computational problem solving. International Journal of STEM Education, 7(1), 1-18.

113

CCPS creative computational problem solving Model



Chevalier, M., Giang, C., Piatti, A., & Mondada, F. (2020). Fostering computational thinking through educational robotics: a model for creative computational problem solving. International Journal of STEM Education, 7(1), 1-18.

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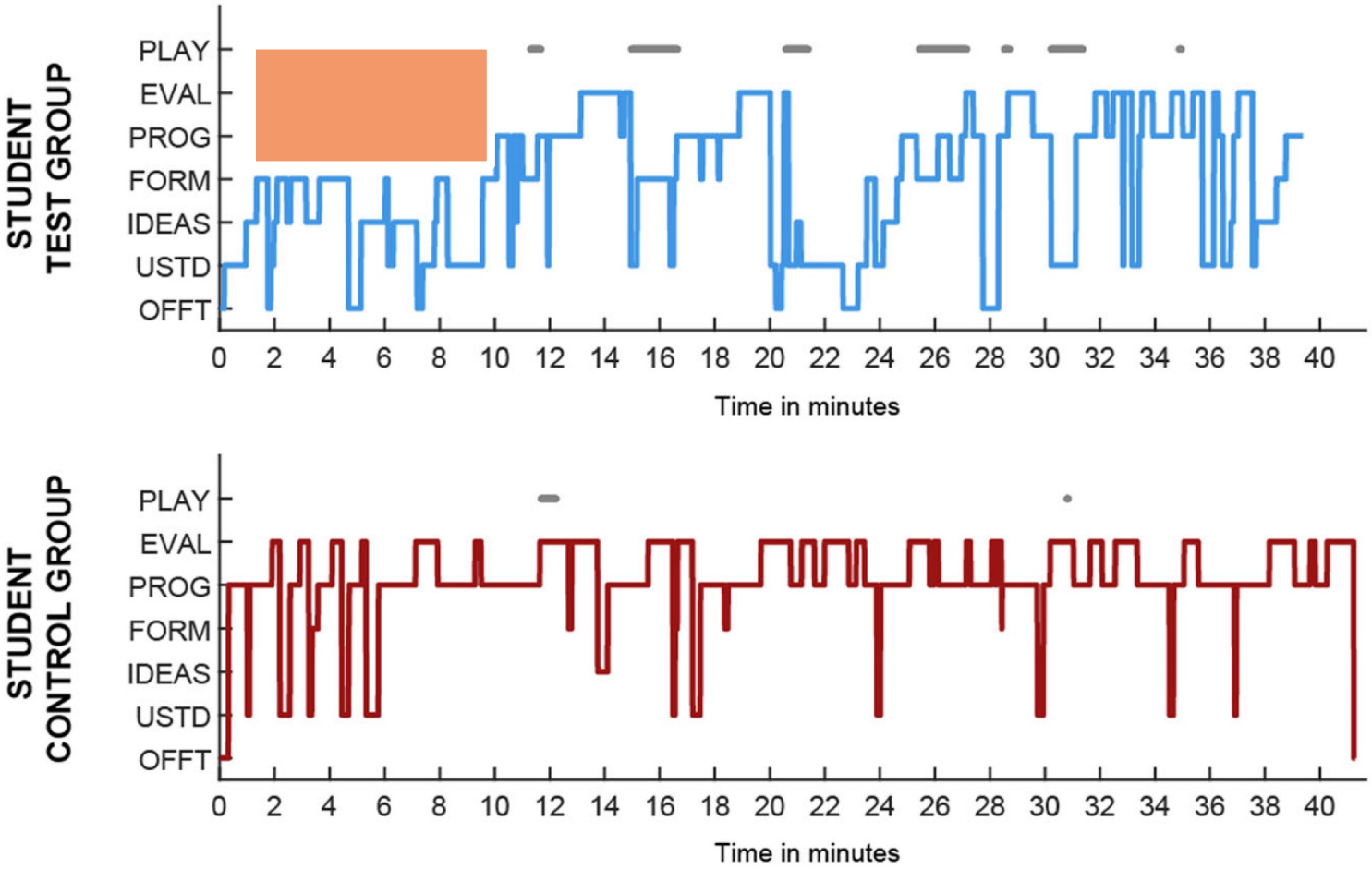

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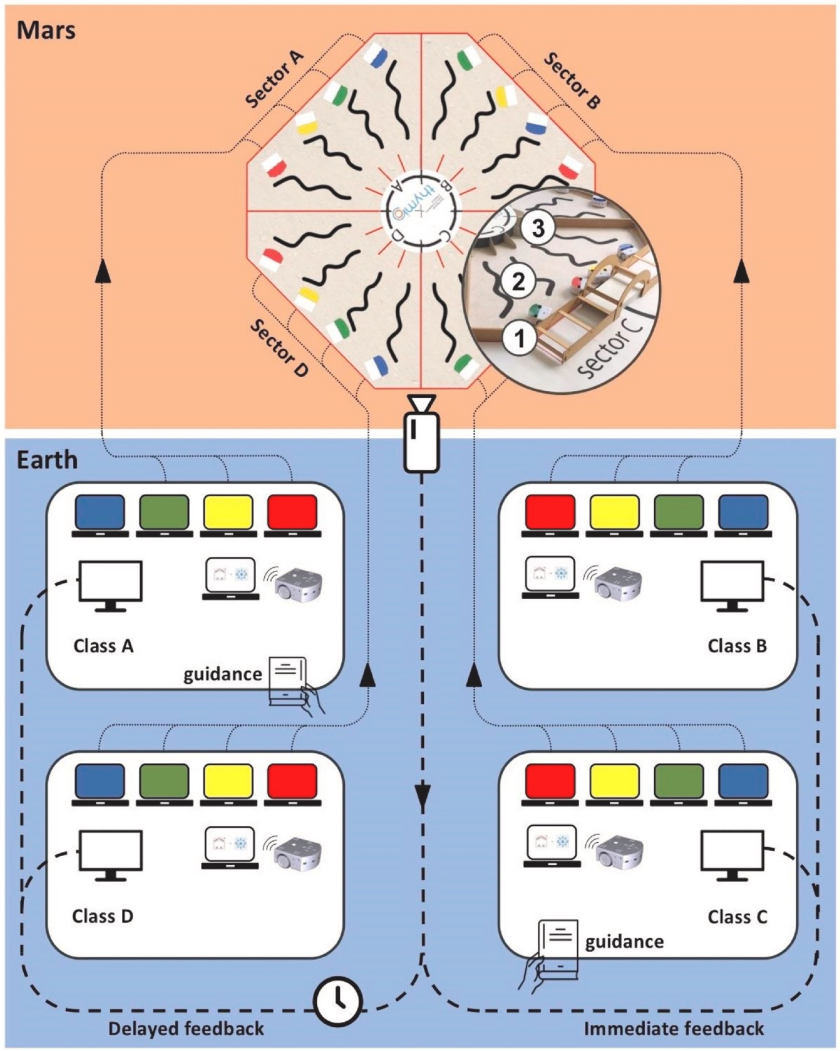

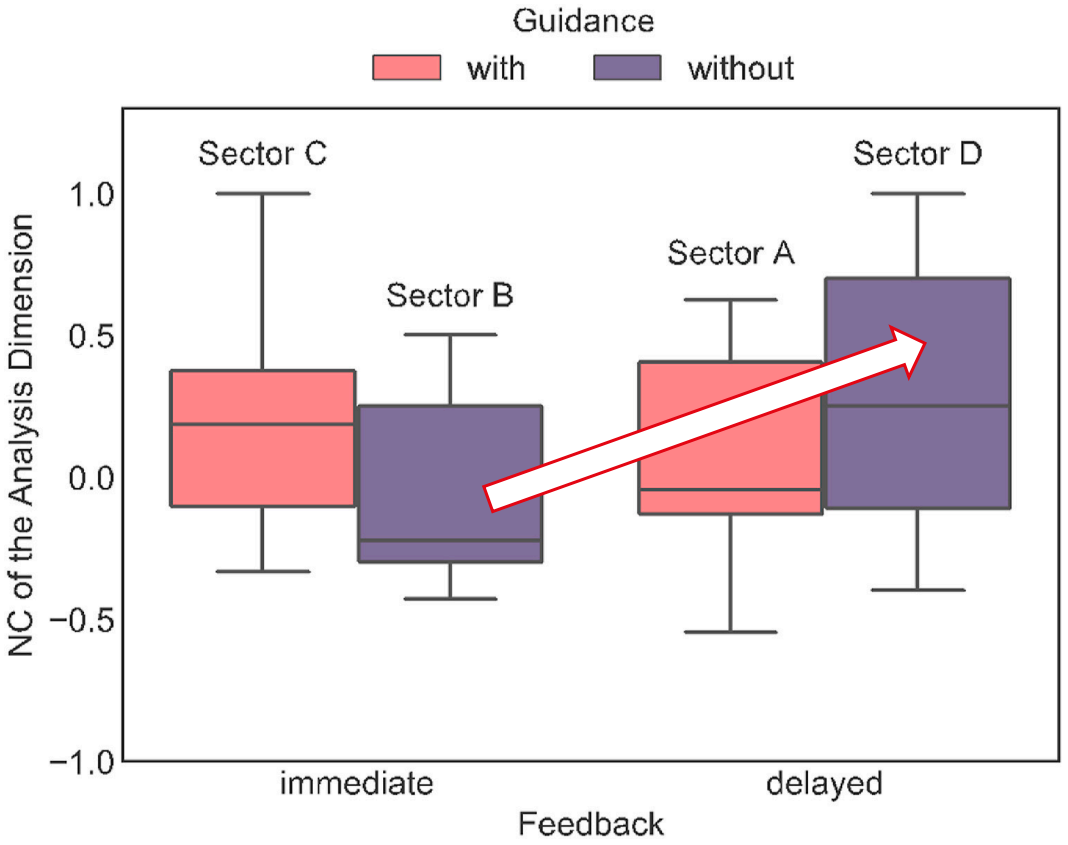

Chevalier, M., Giang, C., El-Hamamsy, L., Bonnet, E., Papaspyros, V., Pellet, J. P., ... & Mondada, F. (2022). The role of feedback and guidance as intervention methods to foster computational thinking in educational robotics learning activities for primary school. Computers & Education, 180, 104431.

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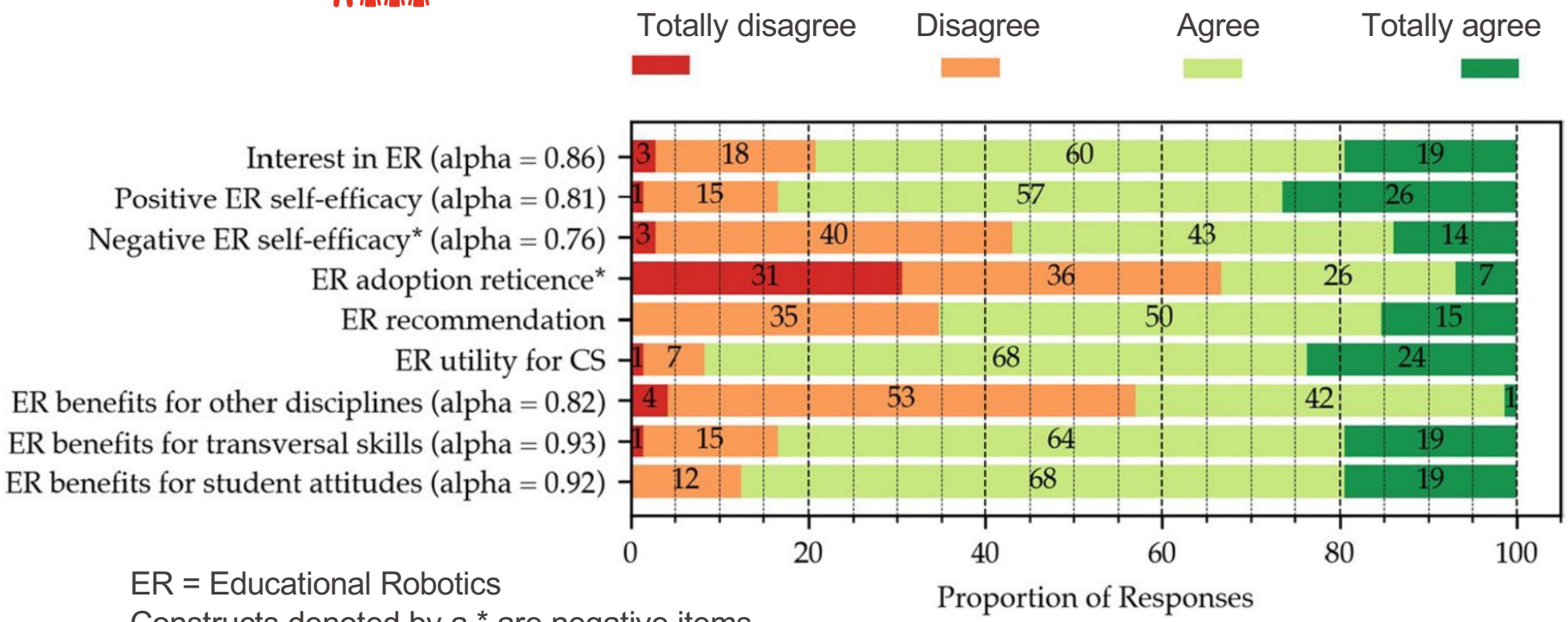
Implementation in Vaud (12 schools)

canton de vaud

n=69



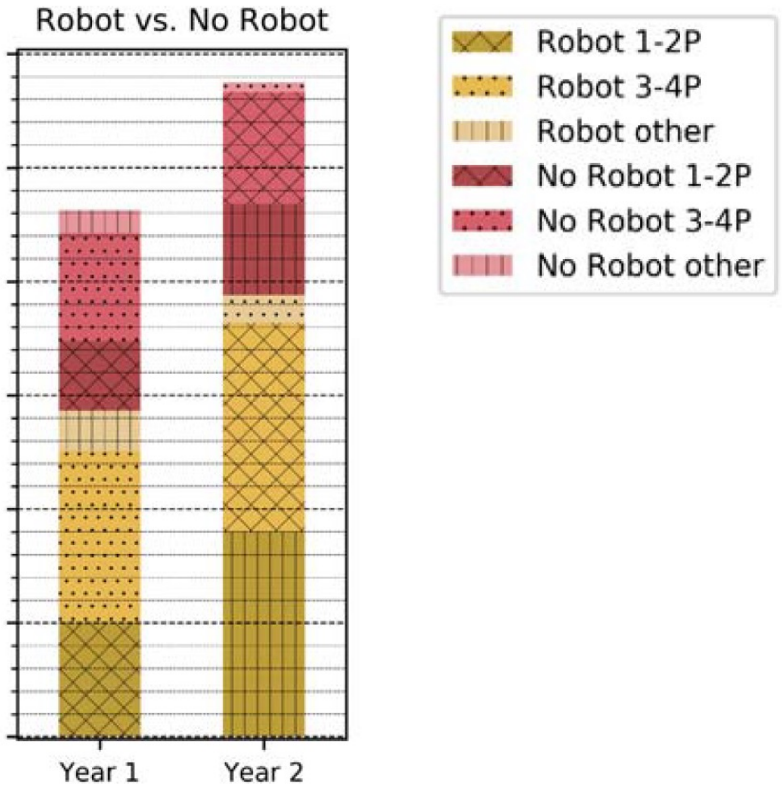
ER = Educational Robotics

Constructs denoted by a * are negative items

El-Hamamsy, L., Bruno, B., Chessel-Lazzarotto, F., Chevalier, M., … & Mondada, F. (2021) The symbiotic relationship between educational robotics and computer science in formal education. Education and Information Technologies, 26, 5077–5107.

Implementation in Vaud (12 schools)

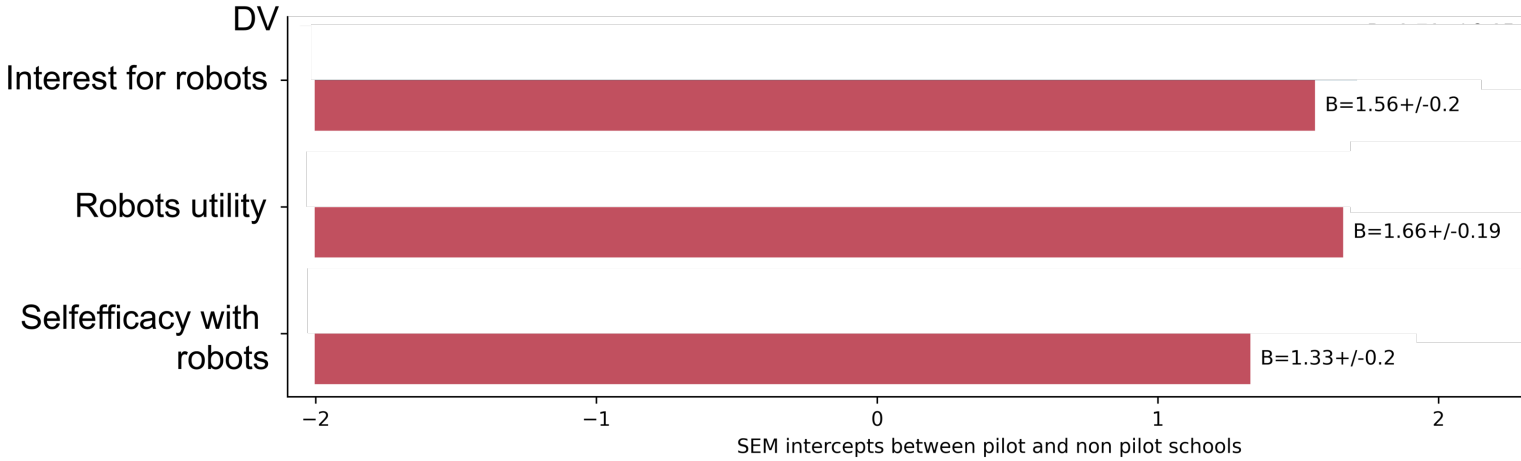
- In-service training in 12 schools, 350 teachers
- 1 professional development day on robotics in year 1, out of a total of 8 days in two years.
- Voluntary implementation in the classroom
- Measurement of implementation based on number of lessons with or without robots



El-Hamamsy, L., Chessel-Lazzarotto, F., Bruno, B., Roy, D., Cahlikova, T., Chevalier, M., ... & Mondada, F. (2020). A computer science and robotics integration model for primary school: evaluation of a large-scale in-service K-4 teacher-training program. Education and Information Technologies, 1-31.

Impact on the perception of computer science - robotics?

n=1644



canton de vaud

El-Hamamsy, L., Bruno, B., Audrin, C., Chevalier, M., Avry, S., Zufferey, J. D., & Mondada, F. (2023). How are primary school computer science curricular reforms contributing to equity? Impact on student learning, perception of the discipline, and gender gaps. International Journal of STEM Education, 10(1), 60.

Impact on the perception of computer science - robotics?

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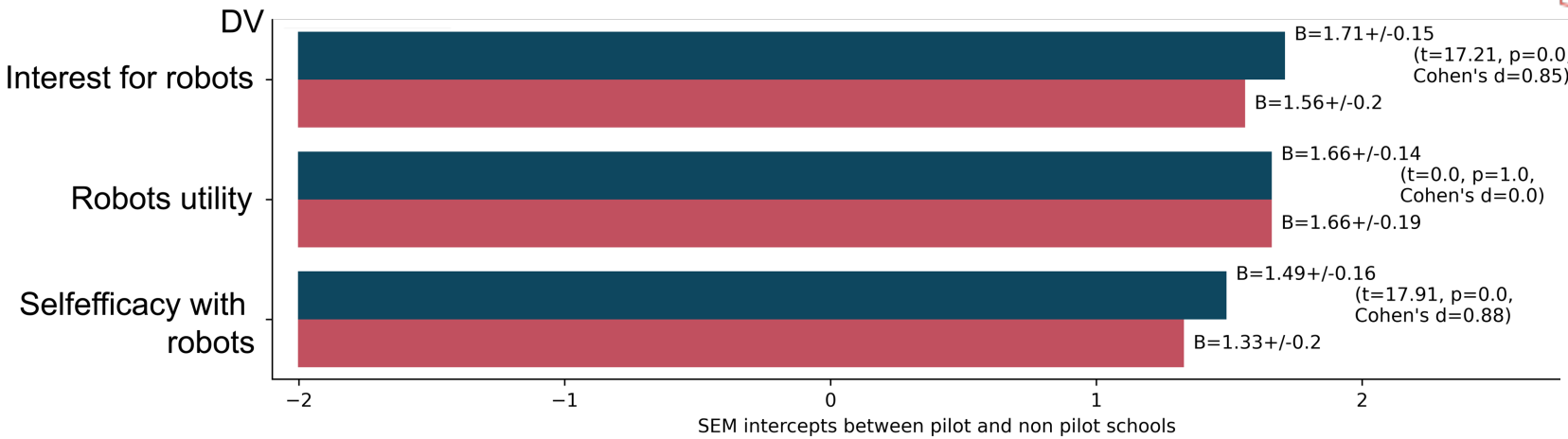

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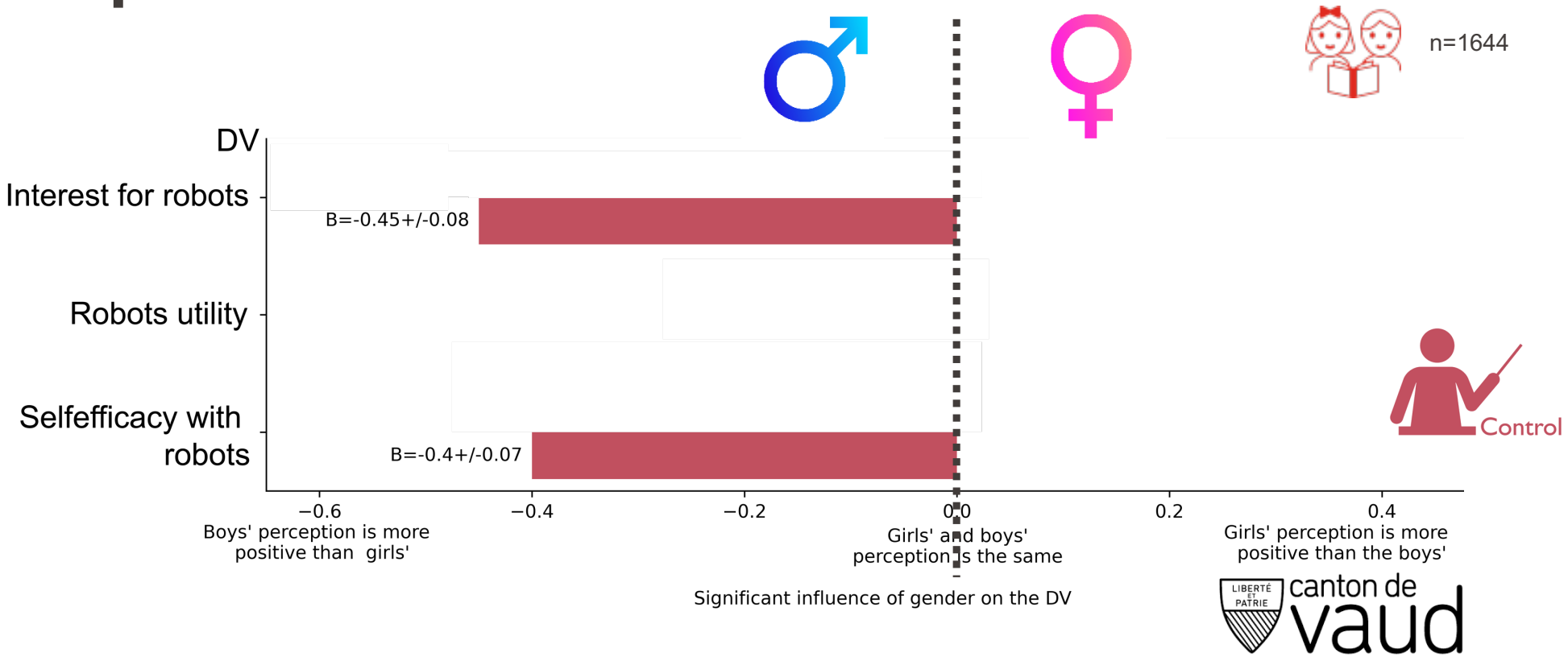

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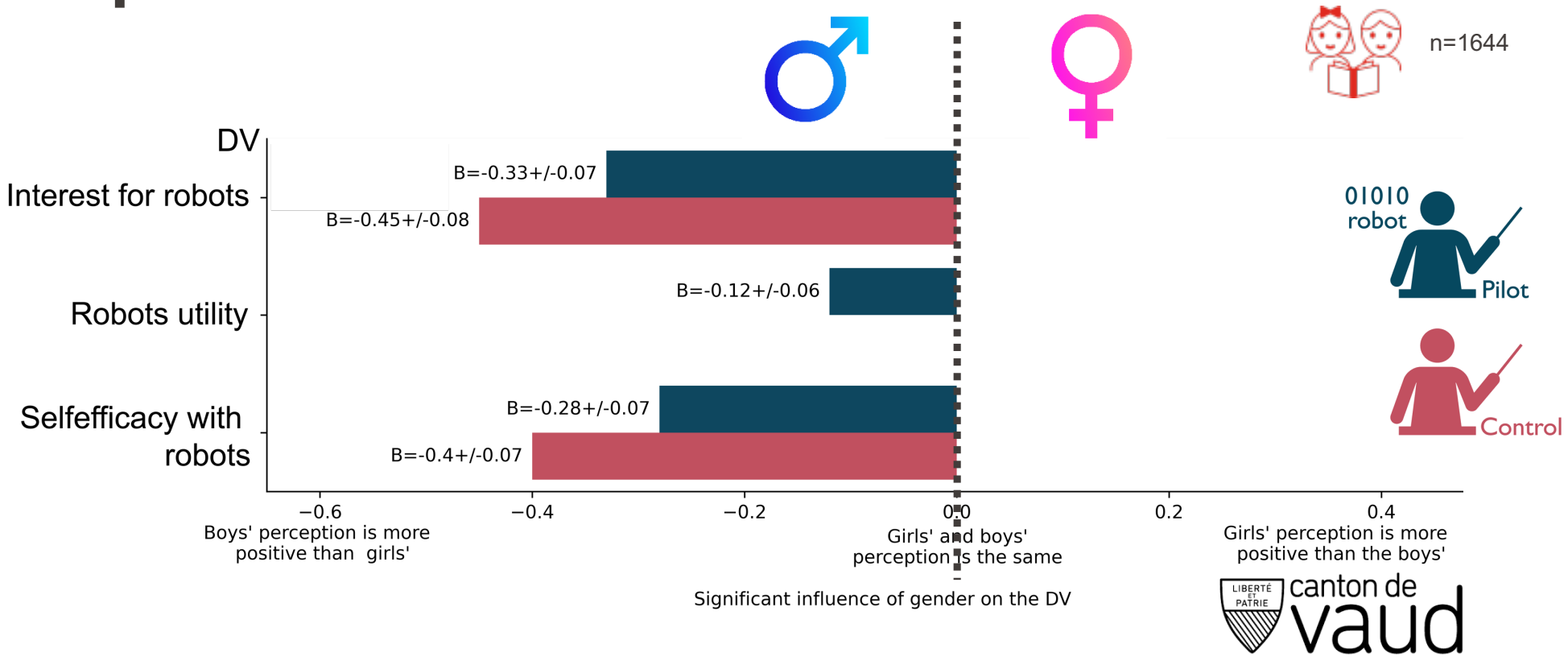

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Environmental impact

Life Cycle Analysis

- Considering the impact of the whole life of a product
- Impact of production is massive
- Do not simplify to CO2 production (climate)

www.greenyoureveryday.com

Environmental impact

Thymio

- Considering the impact of the whole life of a product
- Impact of production is massive
- Do not simplify to CO2 production (climate)

indicator	unit	value	Detail
CTUe	CTUe	2.325165e+03	Ecotoxicity. freshwater (CTUe)
TPE	MJ	2.912730e+02	Total Primary Energy (MJ)
ADPf	MJ	2.491409e+02	Resource use. fossils (MJ)
LU	sans dimensions	8.950800e+01	Land use (dimensionless)
GWP	kg CO2 eq.	1.950440e+01	Climate change (kg CO2 eq.)
GWPf	kg CO2 eq.	1.928338e+01	Climate change - Fossil (kg CO2 eq.)
WU	m3 eq.	7.109953e+00	Water use (m3 eq.)
IR	kBq U235 eq.	2.344374e+00	Ionising radiation. human health (kg U235 eq.)
Ept	mol N eq.	2.950739e-01	Eutrophication. terrestrial (mol N eq.)
GWPb	kg CO2 eq.	1.915871e-01	Climate change - Biogenic (kg CO2 eq.)
AP	mol H+ eq.	1.425274e-01	Acidification (mol H+ eq.)
POCP	kg NMVOC eq.	7.696151e-02	Photochemical ozone formation (kg NMVOC eq.)
GWPlu	kg CO2 eq.	3.231070e-02	Climate change - Land use and land use change ...
Epm	kg N eq.	2.760584e-02	Eutrophication. marine (kg N eq.)
Epf	kg P eq.	2.691432e-02	Eutrophication. freshwater (kg P eq.)
ADPe	kg Sb eq.	7.636741e-03	Resource use. minerals and metals
ODP	kg CFC-11 eq.	1.698000e-06	Ozone depletion (kg CFC-11 eq.)
PM	occurrences de maladies	1.031100e-06	Particulate matter (disease occurrences)
CTUh-nc	CTUh	8.519000e-07	Human toxicity. non-cancer (CTUh)
CTUh-c	CTUh	1.850000e-08	Human toxicity. cancer (CTUh)

Environmental impact

Thymio

- Considering the impact of the whole life of a product
- Impact of production is massive
- Do not simplify to CO2 production (climate)

Climate change

ADPe = Resource use. Minerals and metals

% of planet boundaries pro capita (for one year)

Table 6. Planetary Boundaries as adapted for their app[illegible] in the LCIA context, according to the impact categories available in the EF method.

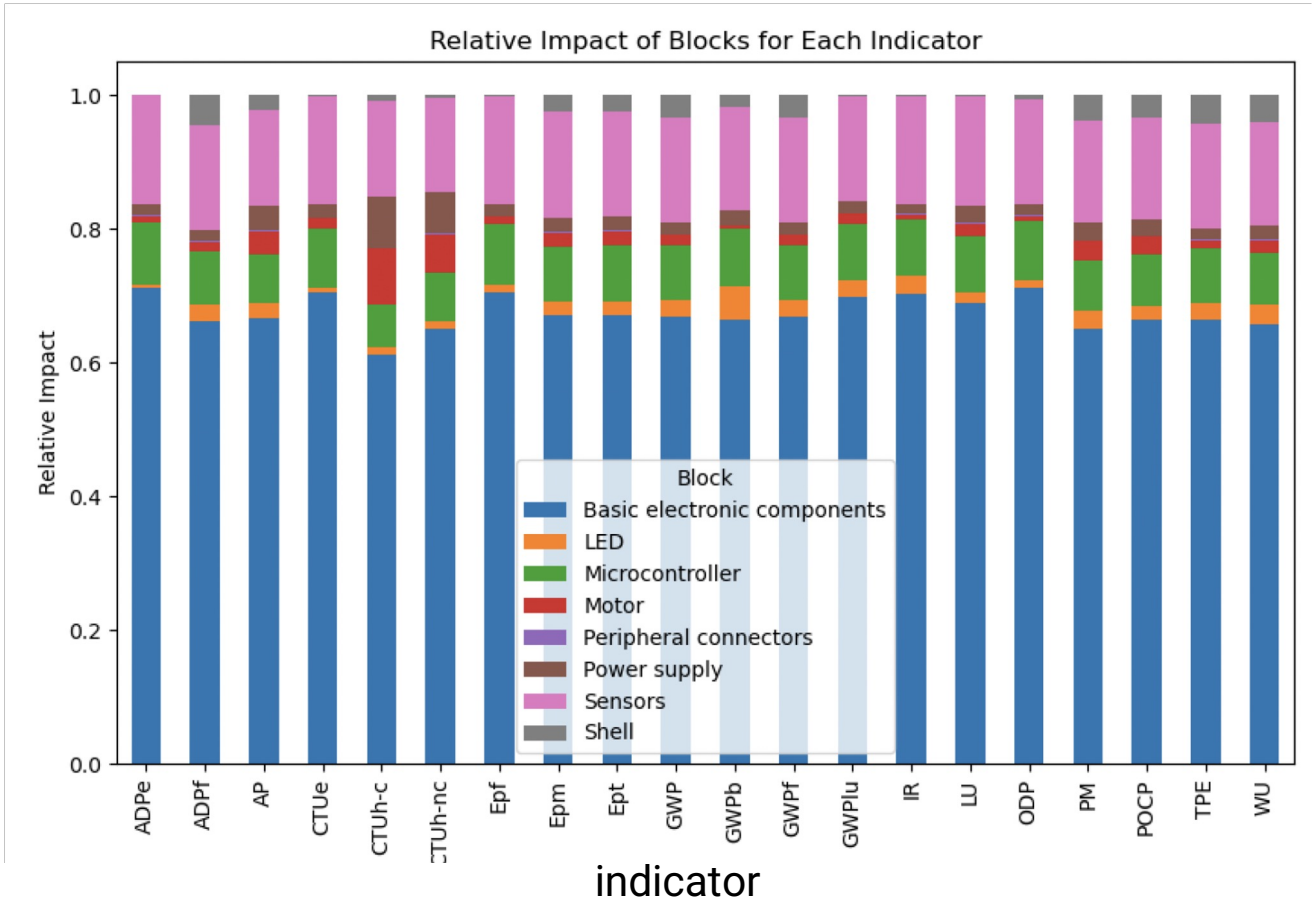
Impact category	Abbreviation	Unit	PB	PB capita*	[illegible]rces
Climate change	CC	kg CO_2 eq	6.81E+12	9.85E+02	Bjørn & Hau[illegible]ld (2015)
Ozone depletion	ODP	kg CFC-11 eq	5.39E+08	7.80E-02	Bjørn & Hauschild (201[illegible]
Eutrophication, marine	MEU	kg N eq	2.01E+11	2.90E+01	Bjørn & Hauschild (2015)
Eutrophication, freshwater	FEU	kg P eq	5.81E+09	8.40E-01	Bjørn & Hauschild (2015)
Eutrophication, terrestrial	TEU	molc N eq	6.13E+12	8.87E+02	recalculated by Bjørn (personal communication)
Acidification	AC	molc H^+ eq	1.00E+12	1.45E+02	recalculated by Bjørn (personal communication)
Land use	LU	kg soil loss	1.27E+13	1.84E+03	Bjørn & Hauschild (2015)
Water use	WU	m^3 world eq	1.82E+14	2.63E+04	based on recalculation by Bjørn (personal communication)
Particulate matter	PM	Disease incidence	5.16E+05	7.47E-05	based on Vargas-Gonzalez et al. (2019)
Photochemical ozone formation, human health	POF	kg NMVOC eq	4.07E+11	5.88E+01	recalculated by Bjørn (personal communication)
Human toxicity, cancer	HTOX_c	CTUh	9.62E+05	1.39E-04	based on Vargas-Gonzalez et al. (2019)
Human toxicity, non-cancer	HTOX_nc	CTUh	4.10E+06	5.93E-04	based on Vargas-Gonzalez et al. (2019)
Ecotoxicity, freshwater	ECOTOX	CTUe	1.31E+14	1.90E+04	Bjørn & Hauschild (2015)
Ionising radiation, human health	IR	kBq U^{235} eq	5.27E+14	7.62E+04	based on Vargas-Gonzalez et al. (2019)
Resource use, fossils	FRD	MJ	2.24E+14	3.24E+04	JRC calculation based on factor 2 concept (Bringezu, 2015; Buczko et al., 2016)
Resource use, mineral and metals	MRD	kg Sb eq	2.19E+08	3.18E-02	JRC calculation based on factor 2 concept (Bringezu, 2015; Buczko et al., 2016)

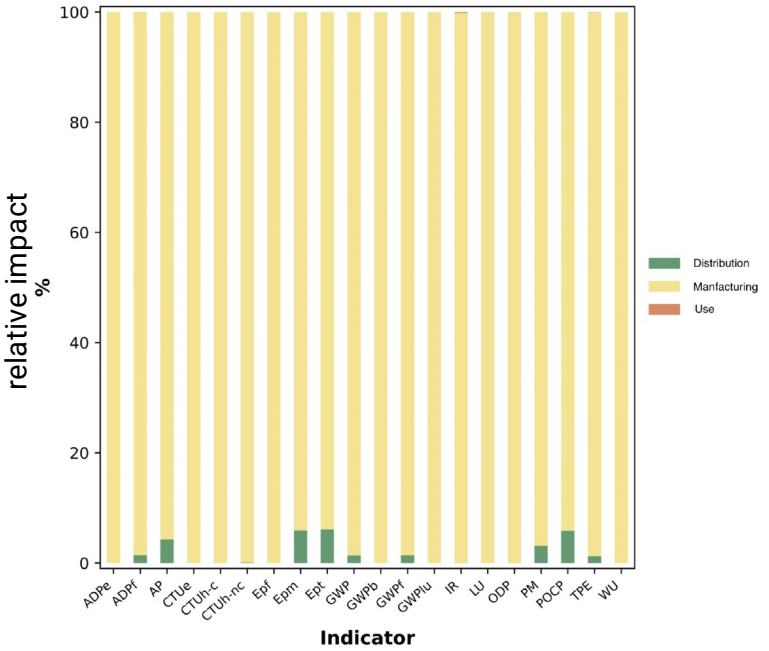
*Global population in 2010: 6,916,183,482, as from Bjørn & Hauschild (2015). Planetary Boundaries order presented in accordance with Table 5.

indicator	
ADPe	0.240149
CTUe	0.122377
LU	0.048646
Epf	0.032041
GWP	0.019801
PM	0.013804
ADPf	0.007690
CTUh-nc	0.001437
POCP	0.001309
AP	0.000983
Epm	0.000952
Ept	0.000333
CTUh-c	0.000133
IR	0.000031
ODP	0.000022

Sala, S., Benini, L., Beylot, A., Castellani, V., Cerutti, A., Corrado, S., Crenna, E., Diaconu, E., Sanye Mengual, E., Secchi, M., Sinkko, T. and Pant, R., Consumption and Consumer Footprint: methodology and results, EUR 29441 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-79-97256-0, doi:10.2760/98570, JRC113607.

Environmental impact



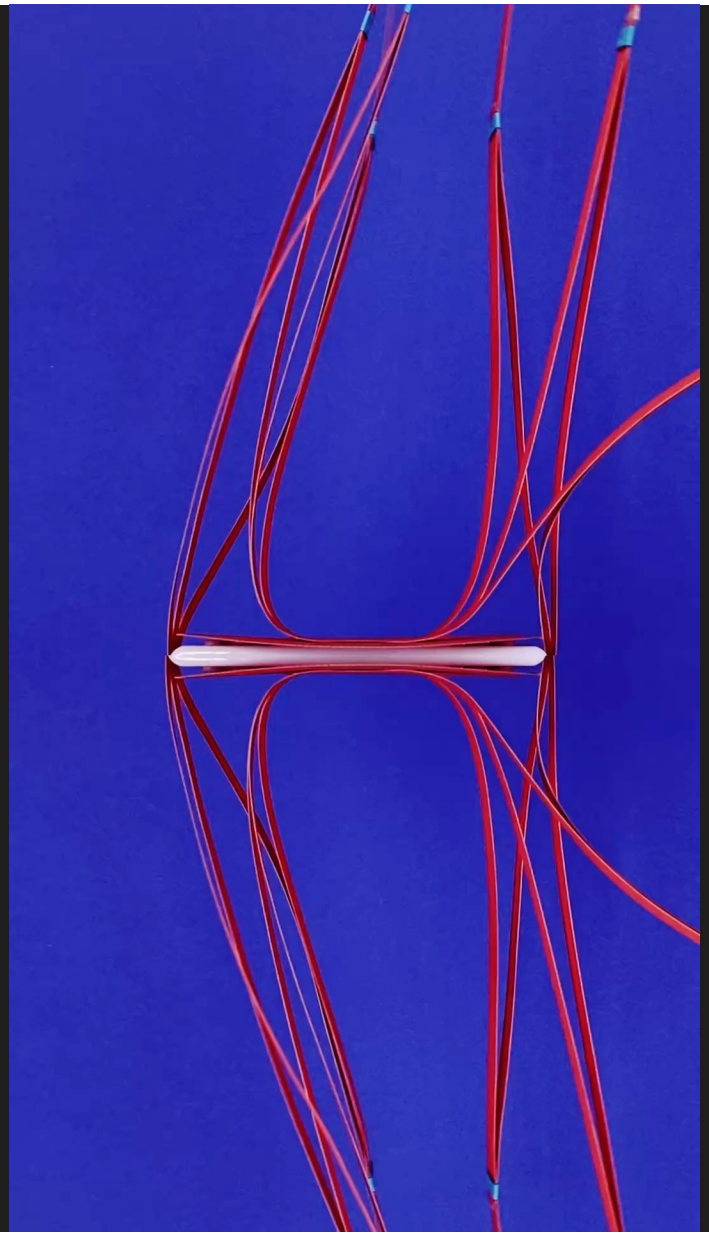


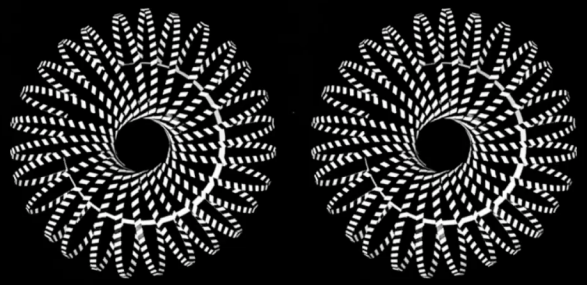
The Beauty and the Machine

To what extent does the combination of robotics with aesthetics influence preservice teachers' motivation to integrate educational robots in their future lessons?

What role does preservice teachers' gender play regarding the potential effects of combining robotics with aesthetics?

EPFL

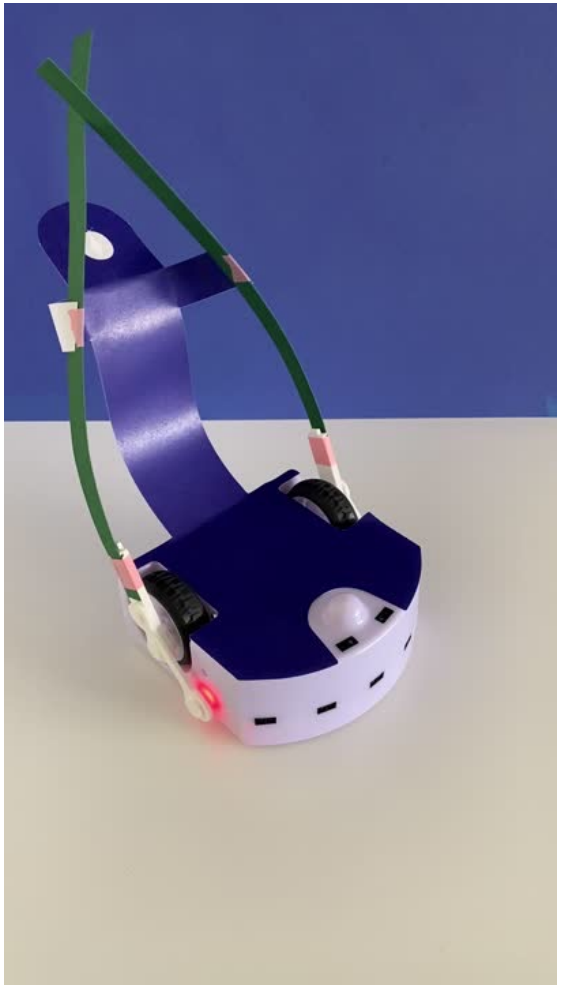




The Beauty and the Machine

Studies have repeatedly shown that aesthetics can lead to positive emotions which have a huge potential to increase the integration of educational robots in schools.

Research gap: Research has not yet investigated the potentials of combining robotics and aesthetics, and the power of positive emotions for pre- and in-service teachers' change in motivation and skills.

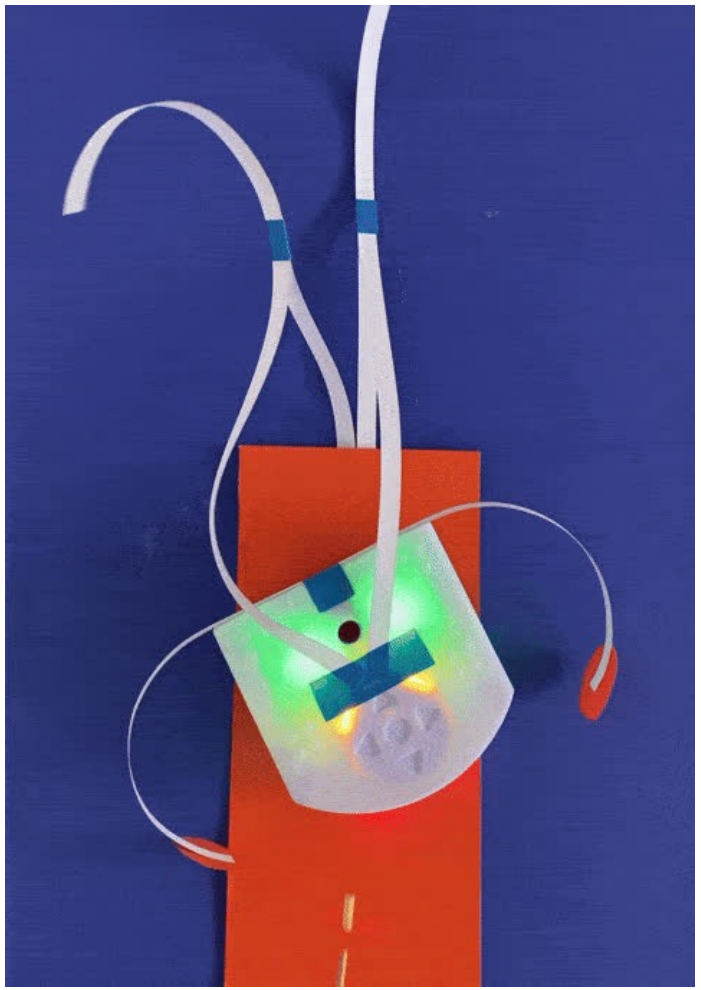


The Beauty and the Machine

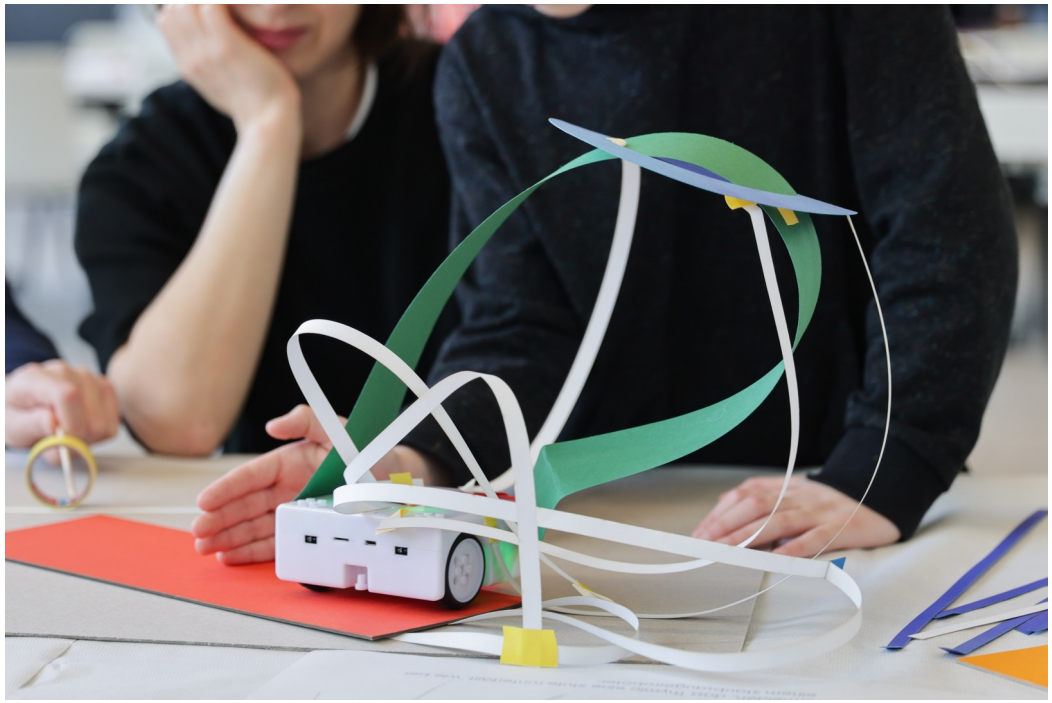
Goals:

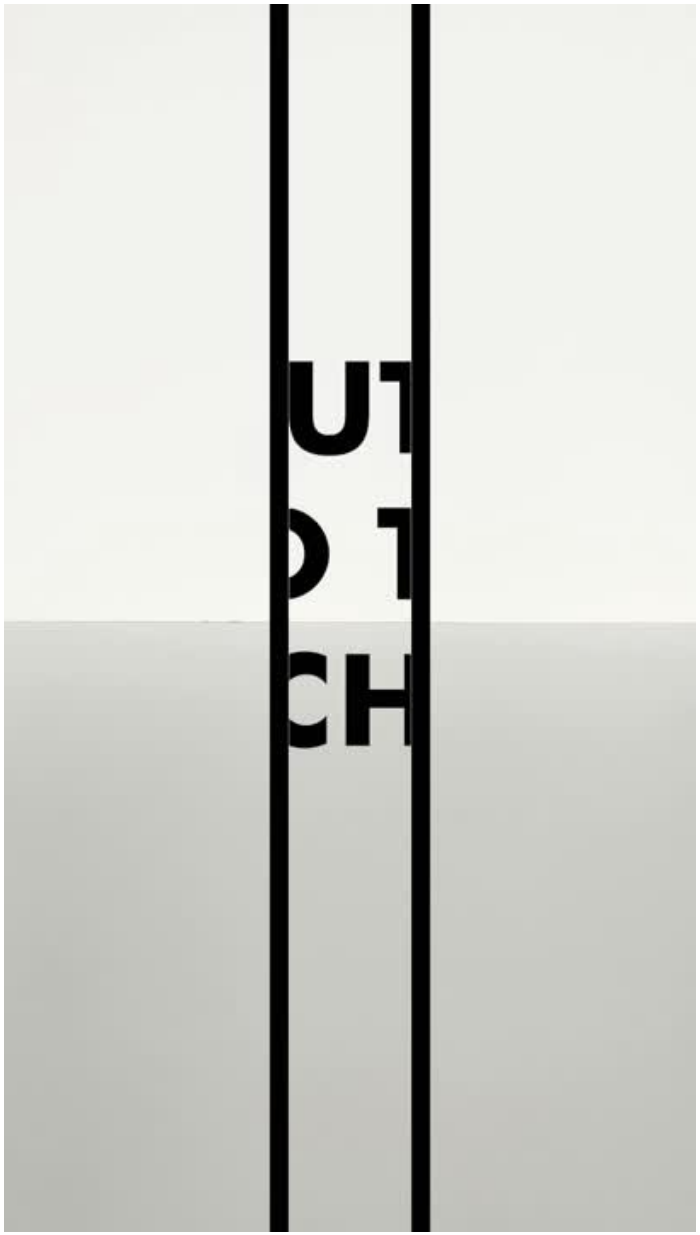
Develop evidence-based teacher education course material that helps to foster digital motivation and skills. The material builds on our scientific findings which hold information about the specific factors that increase motivation and skills.

The course material adopts the benefits of combining aesthetics and robotics (e.g., more positive emotions) which foster pre- and in-service teachers' motivation to integrate educational robots in their future lessons.



The Beauty and the Machine





Sthymuli Robot

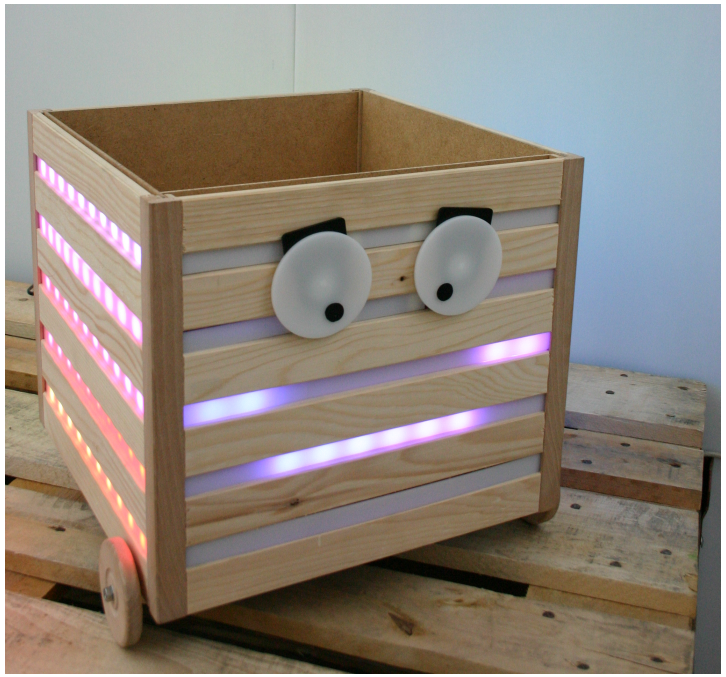
Mobility in class is an issue

Why not exploring aesthetics with a static robot?

Same hardware than Thymio

Bernal-Lecina, M., Hernández, A., Pannatier, A., Pereyre, L., & Mondada, F. (2025). Sthymuli: a Static Educational Robot. Leveraging the Thymio II Platform. arXiv preprint arXiv:2501.07013.

Ranger



Ranger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Projects:

1. Environmental impact of electronic devices (example of robot)
2. …?