Bildungspotenziale in Zeiten digitalen Wandels

UNIVERSITEIT TWENTE

50 JAAR HIGH TECH, HUMAN TOUCH

Promises and challenges of digital technologies for learning

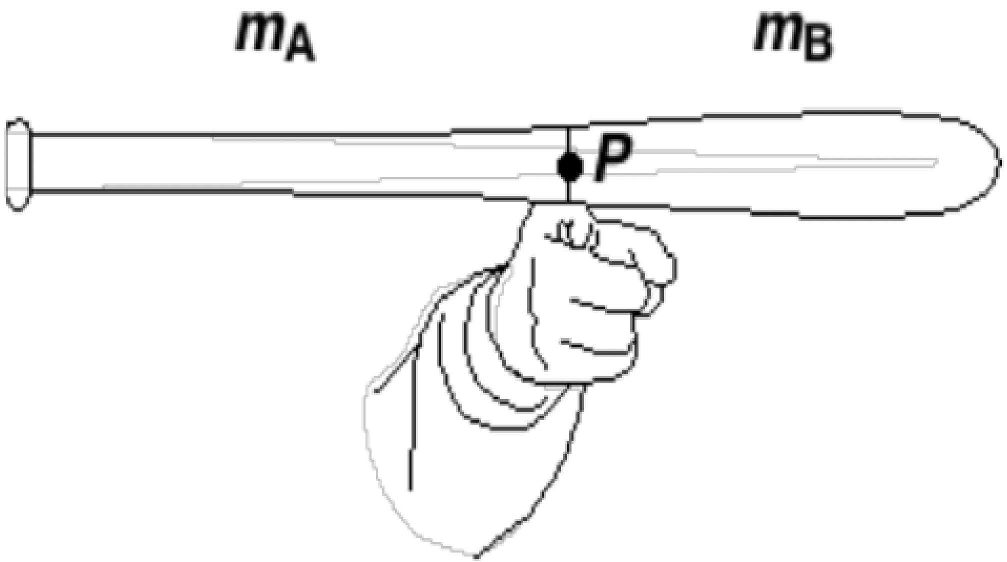
Ton de Jong

University of Twente, the Netherlands

Overview

- How to get advanced technology into the classroom?
- The need for engaging education
- Inquiry learning for science domains/Online laboratories
- Go-Lab/Next-Lab/GO-GA

Baseball bat problem

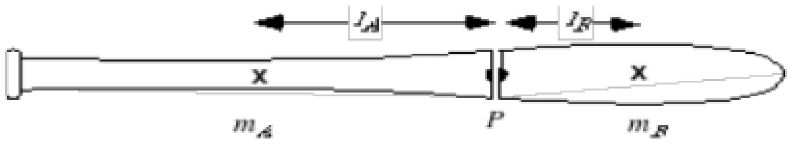


Compare the mass to the left and right of the balance point. Explain.

Ortiz, L. G., Heron, P. R. L., & Shaffer, P. S. (2005). Student understanding of static equilibrium: Predicting and accounting for balancing. *American Journal of Physics*, *73*, 545-553.

Baseball bat problem

- Correct response:



Mass and distance are both factors whose product must be an equal amount on both sides. Thus m_a is less.

- Typical incorrect response:

If the bat is to be balanced, there must be an equal amount of mass to the left and right point of P.

Ortiz, L. G., Heron, P. R. L., & Shaffer, P. S. (2005). Student understanding of static equilibrium: Predicting and accounting for balancing. *American Journal of Physics*, *73*, 545-553.

Correct responses

Study Ortiz: University of Washington first year engineering, physics, math and computer science students with high school physics experience (N = 674)	**20%**
Primary school teachers (N = 582)	**3%**
Lower secondary physics teachers (N = 167)	**6%**
University physics students in introductory calculus-based Mechanics (N => 1000 in 4 different countries)	**14%**
University engineering students in introductory engineering statics (N > 2500 in 4 different countries)	**18%**

From Costas Constantinou. EARLI presidential address 2015. https://www.researchgate.net/publication/282440831_EARLI_2015_Presidential_Address_Presentation_on_Modeling_Based_Learning_in_Science

Many similar results ….

Viennot, L. (1979). Spontaneous reasoning in elementary dynamics. European Journal of Science Education, 1, 205-221.

Trowbridge, D. E., & McDermott, L. C. (1980). Investigation of student understanding of the concept of velocity in one dimension. *American Journal of Physics*, *48*, 1020-1028.

Gunstone, R. F., & White, R. T. (1981). Understanding of gravity. *Science Education*, *65*, 291-299.

Cros, D., Chastrette, M., & Fayol, M. (1988). Conceptions of second year university students of some fundamental notions in chemistry. *International Journal of Science Education*, *10*, 331-336.

Kruger, C. J., Summers, M. K., & Palacio, D. J. (1990). An investigation of some English primary school teachers' understanding of the concepts force and gravity. *British Educational Research Journal*, *16*, 383-397.

Bodner, G. M. (1991). I have found you an argument: The conceptual knowledge of beginning chemistry graduate students. *Journal of Chemical Education*, *68*, 385.

Nakhleh, M. B. (1992). Why some students don't learn chemistry: Chemical misconceptions. *Journal of Chemical Education*, *69*, 191.

Smith, K. J., & Metz, P. A. (1996). Evaluating student understanding of solution chemistry through microscopic representations. *Journal of Chemical Education*, *73*, 233.

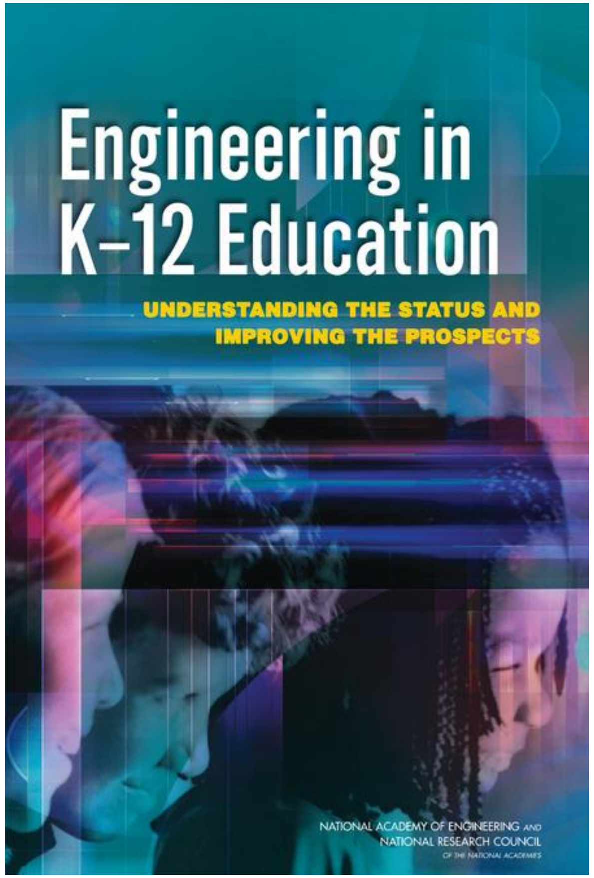
Lin, H., Cheng, H., & Lawrenz, F. (2000). The assessment of students and teachers' understanding of gas laws. *Journal of Chemical Education*, *77*, 235.

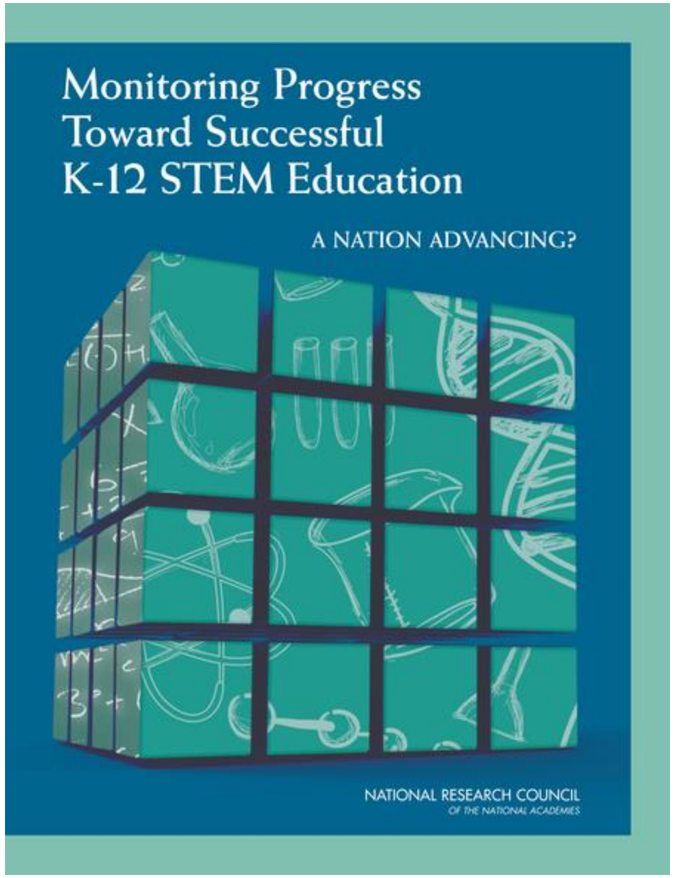
Burgoon, J. N., Heddle, M. L., & Duran, E. (2010). Re-examining the similarities between teacher and student conceptions about physical science. *Journal of Science Teacher Education*, *21*, 859-872

Trouille, L. E., Coble, K., Cochran, G. L., Bailey, J. M., Camarillo, C. T., Nickerson, M. D., & Cominsky, L. R. (2013). Investigating student ideas about cosmology III: Big bang theory, expansion, age, and history of the universe. *Astronomy Education Review*, *12*

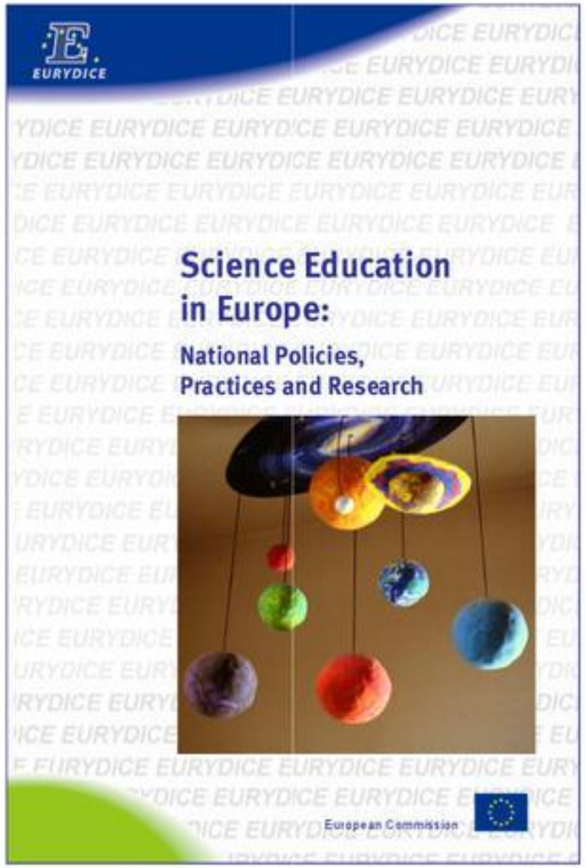
Etc.

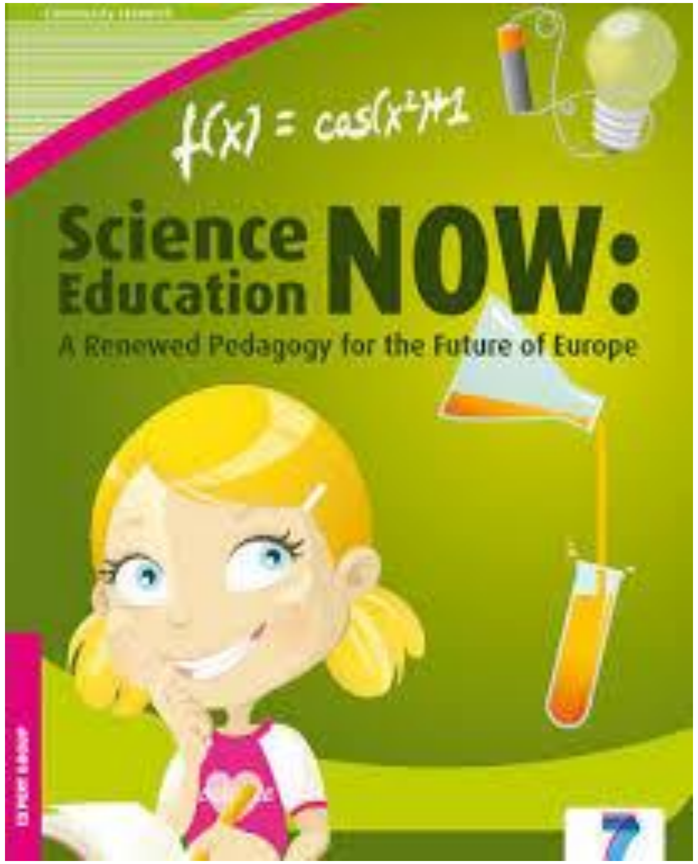
We need engaging (science and engineering) instruction





We need engaging (science and engineering) instruction





Engaged learning

Active learning increases student performance in science, engineering, and mathematics

Scott Freeman[a,1], Sarah L. Eddy[a], Miles McDonough[a], Michelle K. Smith[b], Nnadozie Okoroafor[a], Hannah Jordt[a], and Mary Pat Wenderoth[a]

[a]Department of Biology, University of Washington, Seattle, WA 98195; and [b]School of Biology and Ecology, University of Maine, Orono, ME 04469

Edited* by Bruce Alberts, University of California, San Francisco, CA, and approved April 15, 2014 (received for review October 8, 2013)

To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. The effect sizes indicate that on average, student performance on examinations and concept inventories increased by 0.47 SDs under active learning (n = 158 studies), and that the odds ratio for failing was 1.95 under traditional lecturing (n = 67 studies). These results indicate that average examination scores improved by about 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. Heterogeneity analyses indicated that both results hold across the STEM disciplines, that active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes—although the greatest effects are in small ($n \leq 50$) classes. Trim and fill analyses and fail-safe n calculations suggest that the results are not due to publication bias. The results also appear robust to variation in the methodological rigor of the included studies, based on the quality

225 studies in the published and unpublished literature. The active learning interventions varied widely in intensity and implementation, and included approaches as diverse as occasional group problem-solving, worksheets or tutorials completed during class, use of personal response systems with or without peer instruction, and studio or workshop course designs. We followed guidelines for best practice in quantitative reviews (*SI Materials and Methods*), and evaluated student performance using two outcome variables: (*i*) scores on identical or formally equivalent examinations, concept inventories, or other assessments; or (*ii*) failure rates, usually measured as the percentage of students receiving a D or F grade or withdrawing from the course in question (DFW rate).

The analysis, then, focused on two related questions. Does active learning boost examination scores? Does it lower failure rates?

Results

The overall mean effect size for performance on identical or equivalent examinations, concept inventories, and other assessments was a weighted standardized mean difference of 0.47 (Z = 9.781, P << 0.001)—meaning that on average, student performance increased by just under half a SD with active learning

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*, 8410-8415.

Engaged learning

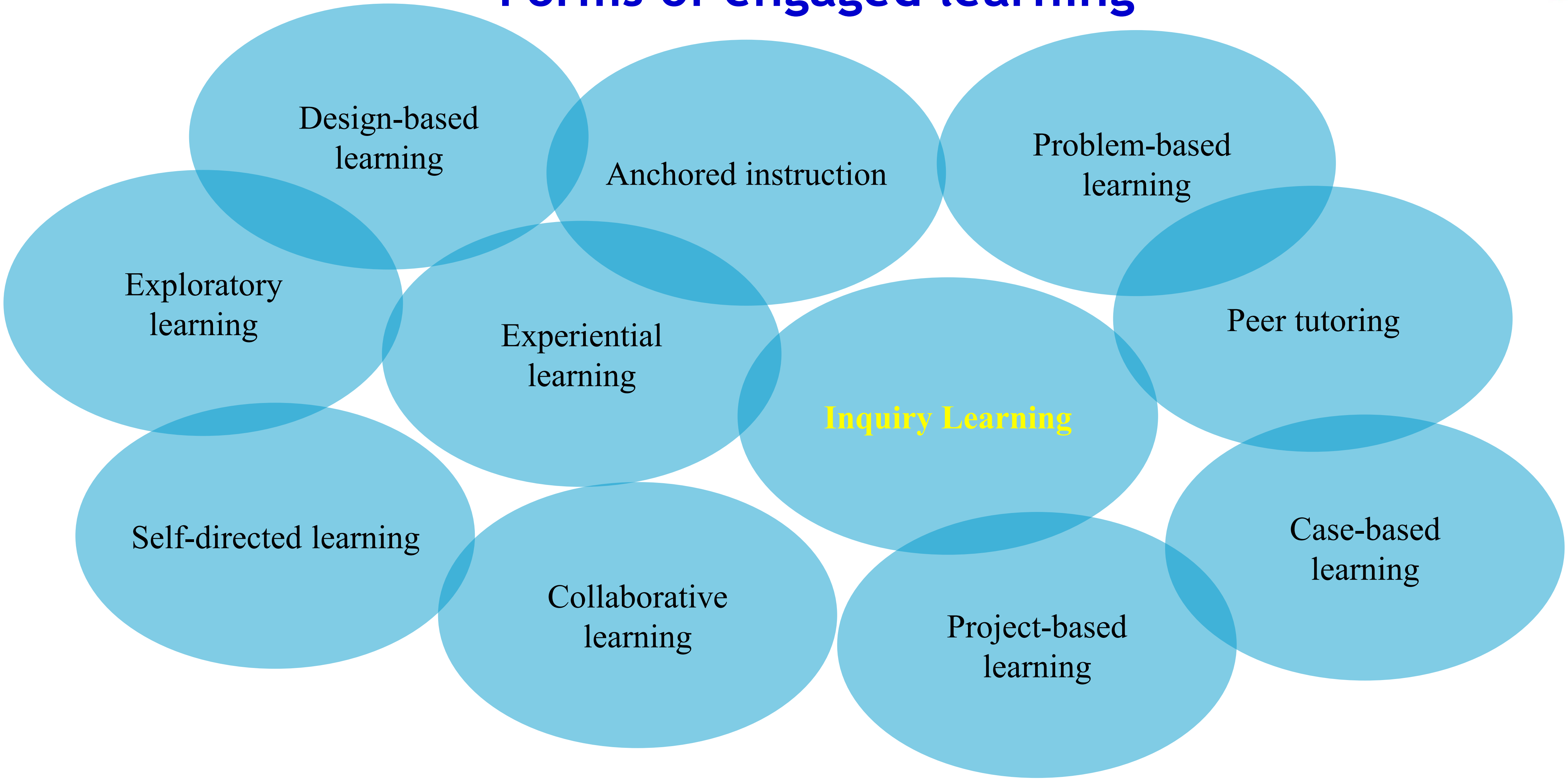
- "The active learning interventions varied widely in intensity and implementation, and included approaches as diverse as occasional group problem-solving, worksheets or tutorials completed during class, use of personal response systems with or without peer instruction, and studio or workshop course designs."(p. 8410)

- Meta-analysis of 225 studies
  - Active learning increases performance by 0.47 SD
  - Students in traditional lectures were 1.5 times more like to fail than students in active learning classes

- "If the experiments analyzed here had been conducted as randomized controlled trials of medical interventions, they may have been stopped for benefit—meaning that enrolling patients in the control condition might be discontinued because the treatment being tested was clearly more beneficial" (p. 8413)

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*, 8410-8415.

Forms of engaged learning



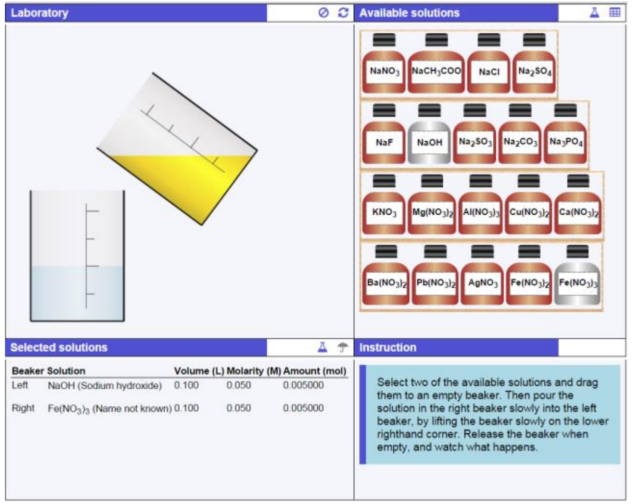
Bill Gates in College Tour

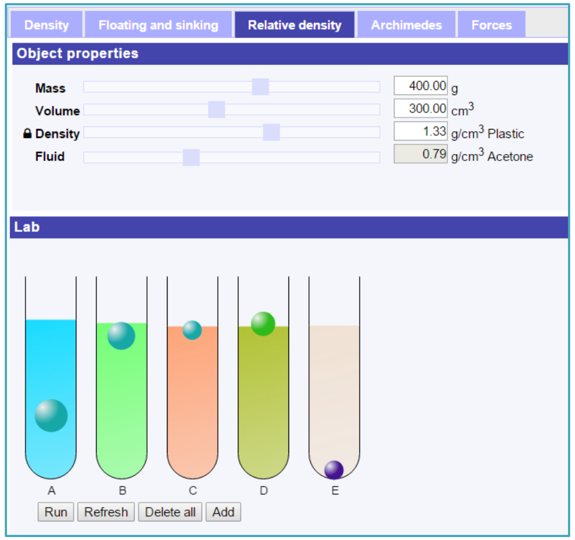
Current status of technology in the classroom

- Popular applications:
  - Drill and practice (spelling, arithmetic)
  - Learning Management Systems (LMS)
  - Whiteboards
  - MOOCs
  - Online (adaptive) testing

- All replace one-on-one traditional methods
  - Alter Wein in neuen Schläuchen

Online labs


Laboratory
Available solutions
NaNO3
NaCH3COO
NaCl
Na2SO4
NaF
NaOH
Na2SO3
Na2CO3
Na3PO4
KNO3
Mg(NO3)2
Al(NO3)3
Cu(NO3)2
Ca(NO3)2
Ba(NO3)2
Pb(NO3)2
AgNO3
Fe(NO3)2
Fe(NO3)3
Selected solutions
Instruction
Beaker Solution Volume (L) Molarity (M) Amount (mol)
Left NaOH (Sodium hydroxide) 0.100 0.050 0.005000
Right Fe(NO3)3 (Name not known) 0.100 0.050 0.005000
Select two of the available solutions and drag them to an empty beaker. Then pour the solution in the right beaker slowly into the left beaker, by lifting the beaker slowly on the lower righthand corner. Release the beaker when empty, and watch what happens.


Density
Floating and sinking
Relative density
Archimedes
Forces
Object properties
Mass 400.00 g
Volume 300.00 cm3
Density 1.33 g/cm3 Plastic
Fluid 0.79 g/cm3 Acetone
Lab
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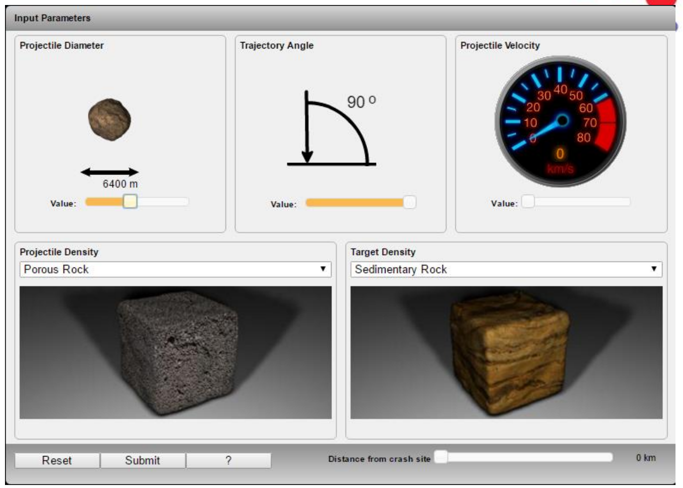
Input Parameters
Projectile Diameter
6400 m
Value:
Trajectory Angle
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Projectile Density
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Submit
?
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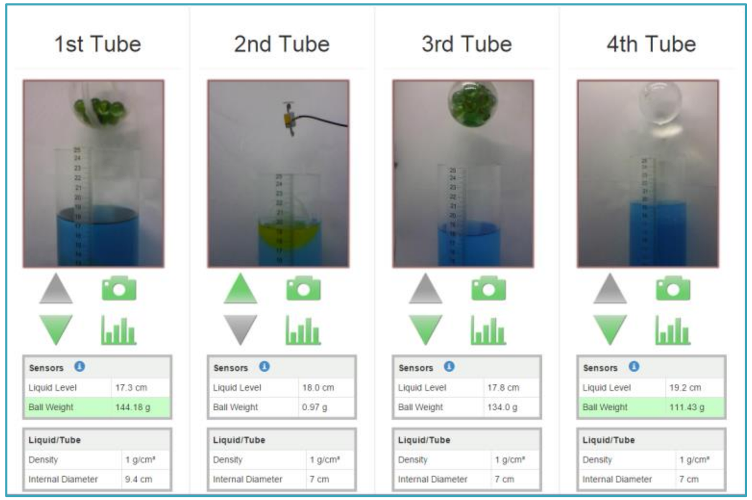
1st Tube
2nd Tube
3rd Tube
4th Tube
Sensors
Liquid Level 17.3 cm
Ball Weight 144.18 g
Liquid/Tube
Density 1 g/cm³
Internal Diameter 9.4 cm
Sensors
Liquid Level 18.0 cm
Ball Weight 0.97 g
Liquid/Tube
Density 1 g/cm³
Internal Diameter 7 cm
Sensors
Liquid Level 17.8 cm
Ball Weight 134.0 g
Liquid/Tube
Density 1 g/cm³
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Sensors
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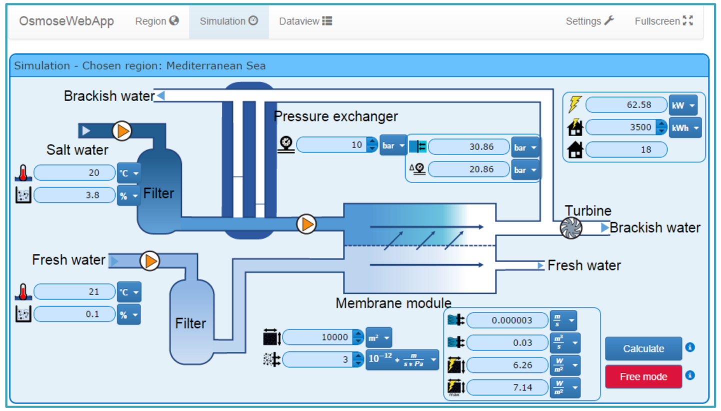
Density 1 g/cm³
Internal Diameter 7 cm


OsmoseWebApp
Region
Simulation
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Fullscreen
Simulation - Chosen region: Mediterranean Sea
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Brackish water
Fresh water
Fresh water
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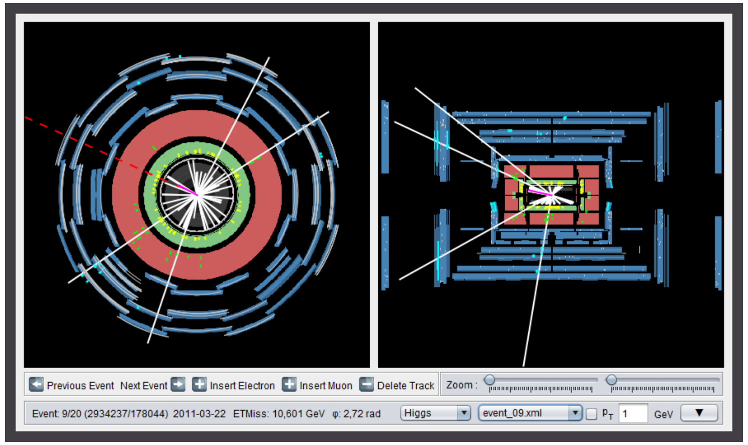
Previous Event
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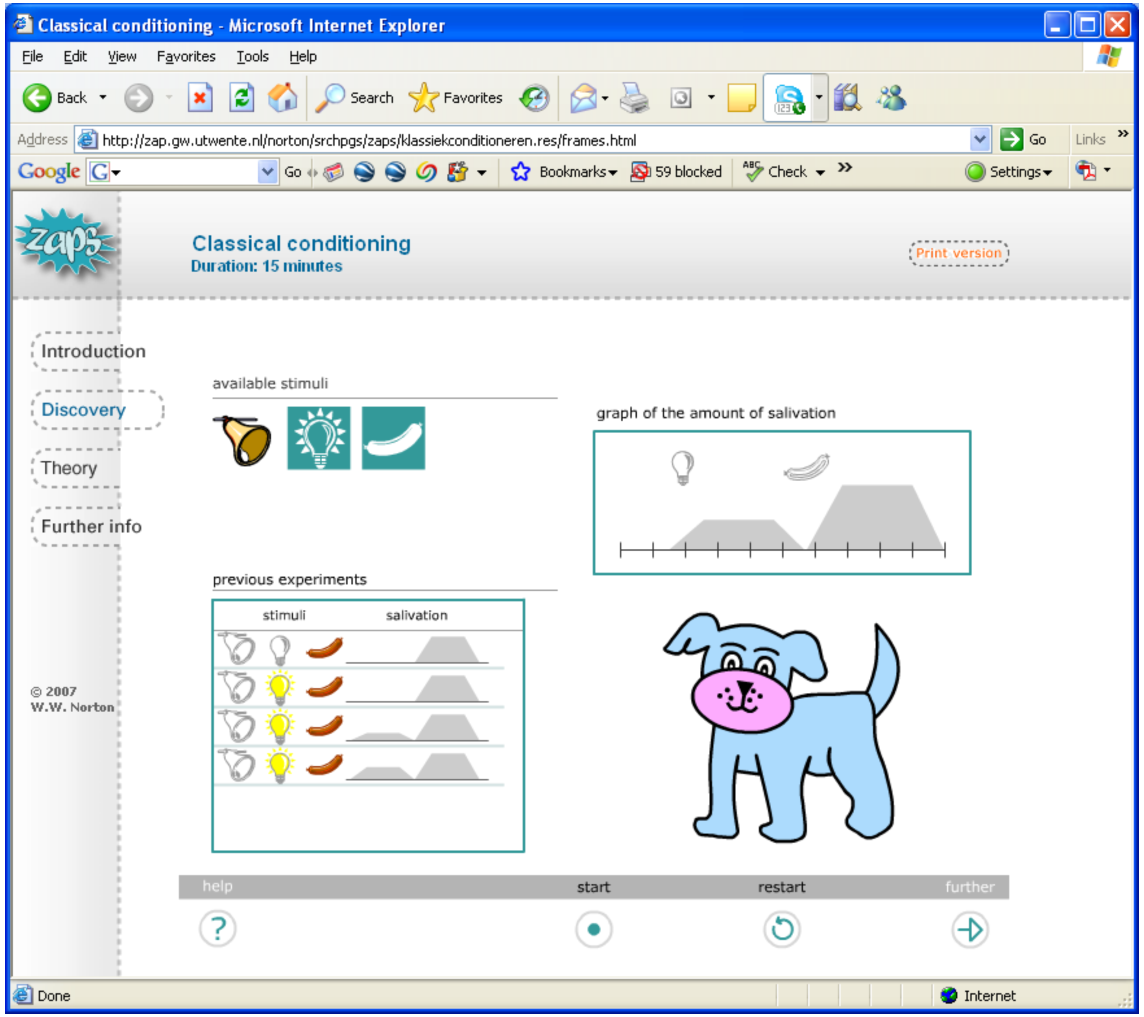
An example from psychology



Inquiry as engaged learning

Expository methods (teaching)	Inquiry methods (learning)
• Teacher explains – students do exercises (ready made science)	• Students do explorations first and design concepts and laws together with their teachers (science-in-the making)
• First: presentation of scientific principles (lecture) • Then: experiment to verify (confirm) the principle (laboratory)	• Students construct (not only confirm) meaning • No clear separation between the lecture and the lab

Schuster, D., Cobern, W. W., Adams, B. A. J., Undreiu, A., & Pleasants, B. (in press). Learning of core disciplinary ideas: Efficacy comparison of two contrasting modes of science instruction. *Research in Science Education*.

Trout, L. Lee, C., Moog, R., Ricky, D. (2008). Inquiry learning: What is it? How do you do it? In: *Chemistry in the National Science Standards, 2nd Edition*, S.L. Bretz (Ed.). Washington, DC: American Chemical Society.

How to make inquiry learning effective?

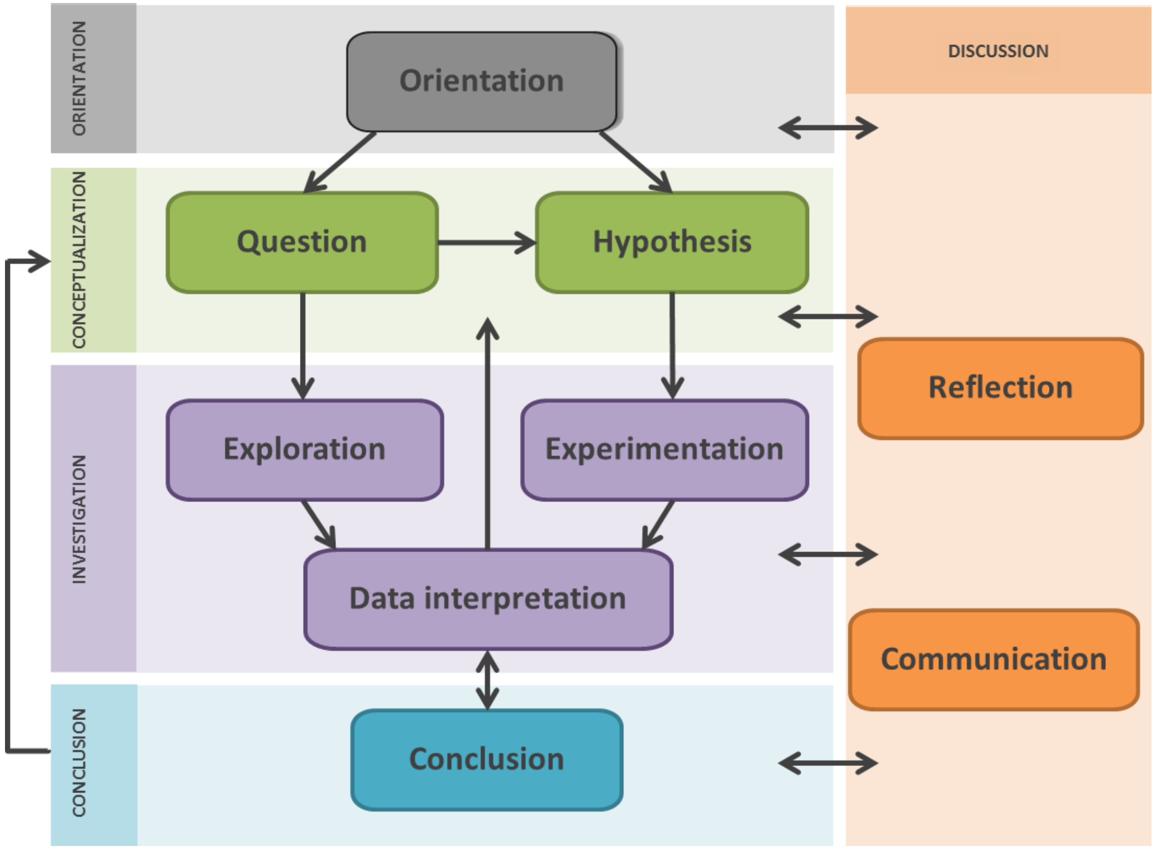
- Open inquiry (discovery) doesn't work

- Students need support:
  - By providing students with an overall strategy (inquiry cycle)
  - By connecting to the right level of prior knowledge
  - By providing students with scaffolds (apps)

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? American Psychologist, 59, 14-19.

Riah, H., & Fraser, B. J. (1998, April). *Chemistry learning environment and its association with students' achievement in chemistry*. In annual meeting of the American Educational Research Association, San Diego, CA.

The Go-Lab inquiry cycle



Pedaste, M. Mäeots, M. Siiman L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: definitions and the inquiry cycle. *Educational Research Review*, *14*, 47-61.

Inquiry needs to be combined with direct instruction

- Programs that promote deep learning (e.g., problem-based learning, inquiry learning) give low effect sizes if they are not preceded by surface learning (Hattie & Donoghue, 2016)

- A moderator analysis shows that simulations are only effective if preceded by instruction of the relevant concepts (Schneider & Preckel, 2017)

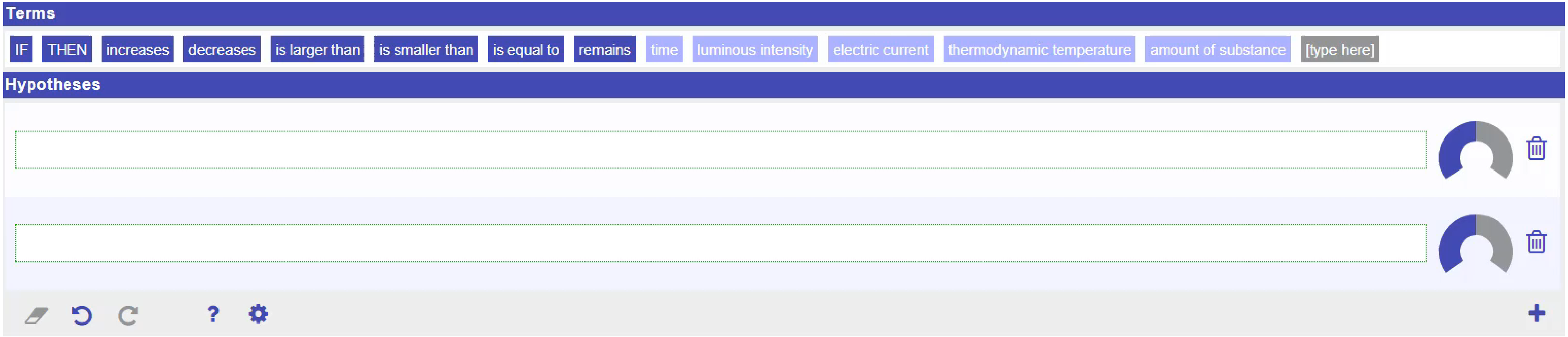
Hattie, J. A. C., & Donoghue, G. M. (2016). Learning strategies: a synthesis and conceptual model. *Npj Science Of Learning*, *1*, 16013.

Schneider, M., & Preckel, F. (2017). Variables associated with achievement in higher education: A systematic review of meta-analyses. *Psychological Bulletin*, *143*, 565-600.

Modern guided inquiry with scaffolds (tools/apps)

- Mixed and dynamic initiative
- Geared towards specific difficulties that students experience
- Possibility of fading

An example: the hypothesis scratchpad



Based on: van Joolingen, W. R. & de Jong, T. (1991). Supporting hypothesis generation by learners exploring an interactive computer simulation. *Instructional Science*, *20*, 389-404.

Is inquiry learning with online labs effective?

- Inquiry-based learning with online labs (and simulations) shows an advantage over expository instruction
- Students in online labs gain the same level of knowledge or a more advanced level of knowledge than students who learn in a real laboratory
- Inquiry learning with online labs is only effective when well structured and designed, this is guidance, e.g., scaffolds included

de Jong, T. (2006). Computer simulations - Technological advances in inquiry learning. *Science*, *312*, 532-533.

de Jong, T., Linn, M.C., & Zacharia, Z.C. (2013). Physical and virtual laboratories in science and engineering education. *Science*, *340*, 305-308

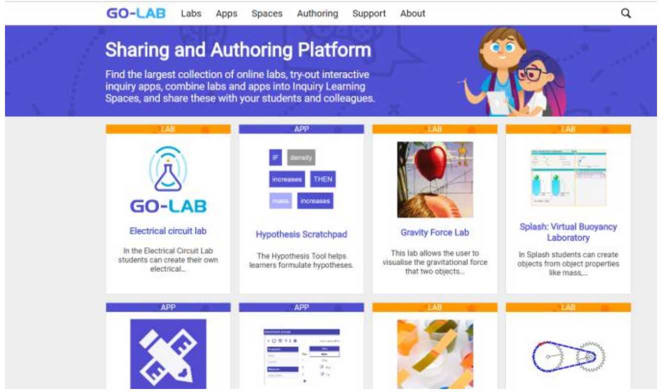
How to upscale the use of online lab?

- One simple portal (one stop shop)
- A system that is flexible and that has different levels of usage
- Teachers should be able to adjust content to local circumstances (including language)
- An extensive support system to train teachers
- Support for teachers to monitor their students (individually and through learning analytics)

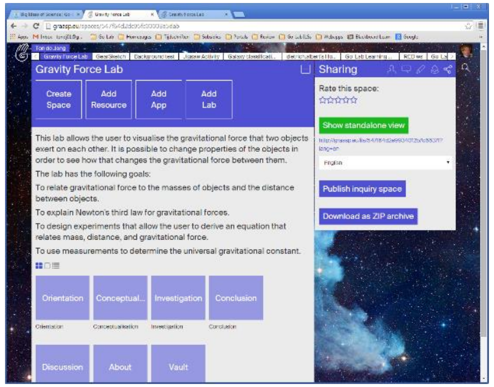
The Go-Lab project

- 7th Framework EU project
- 19 partners
- Budget 13,5 million Euros
- 4 years (2014-2017)
- UT coordinator
- 2013-2016
- Final evaluation: excellent

The Go-Lab ecosystem (www.golabz.eu)



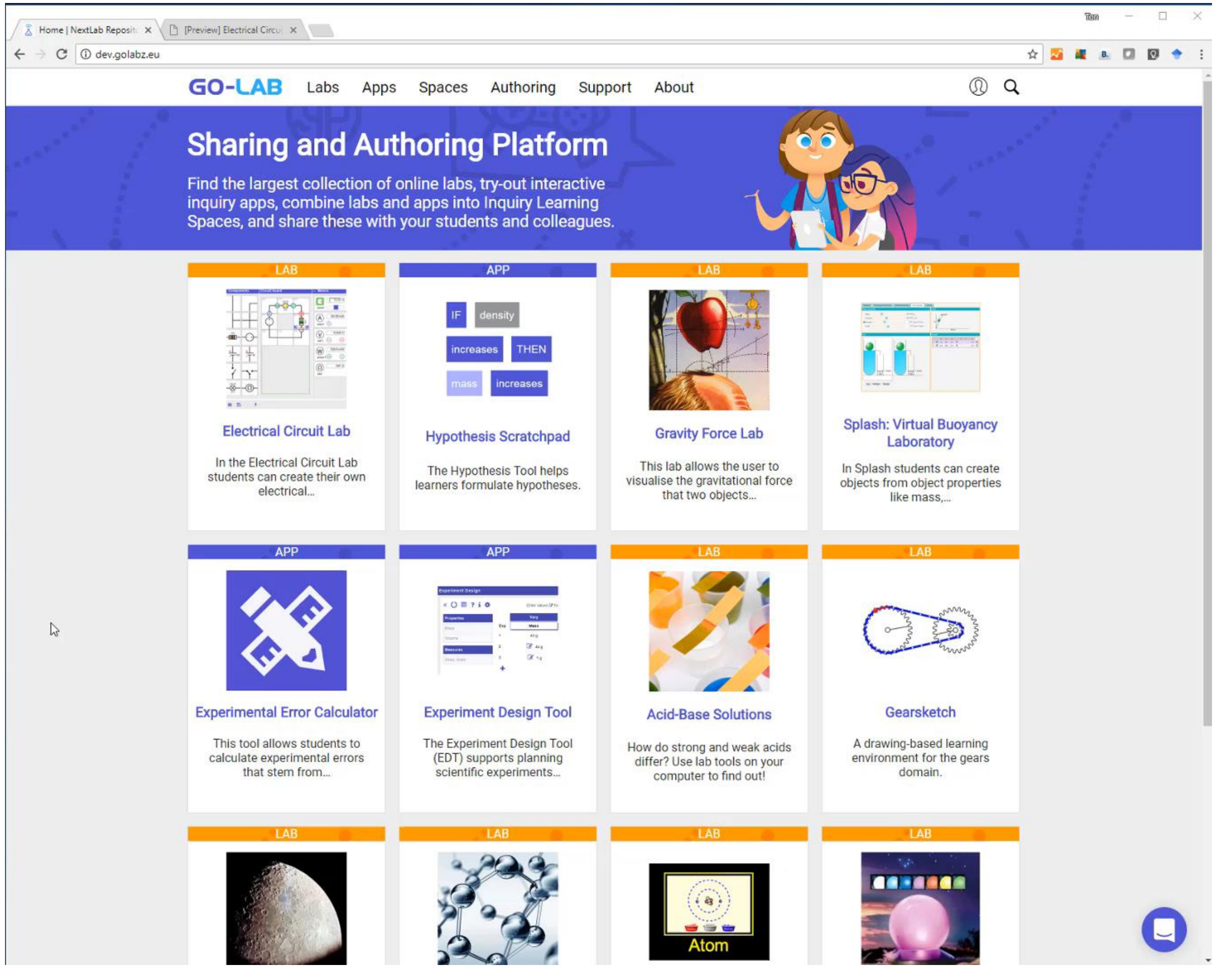
Sharing platform



Authoring platform

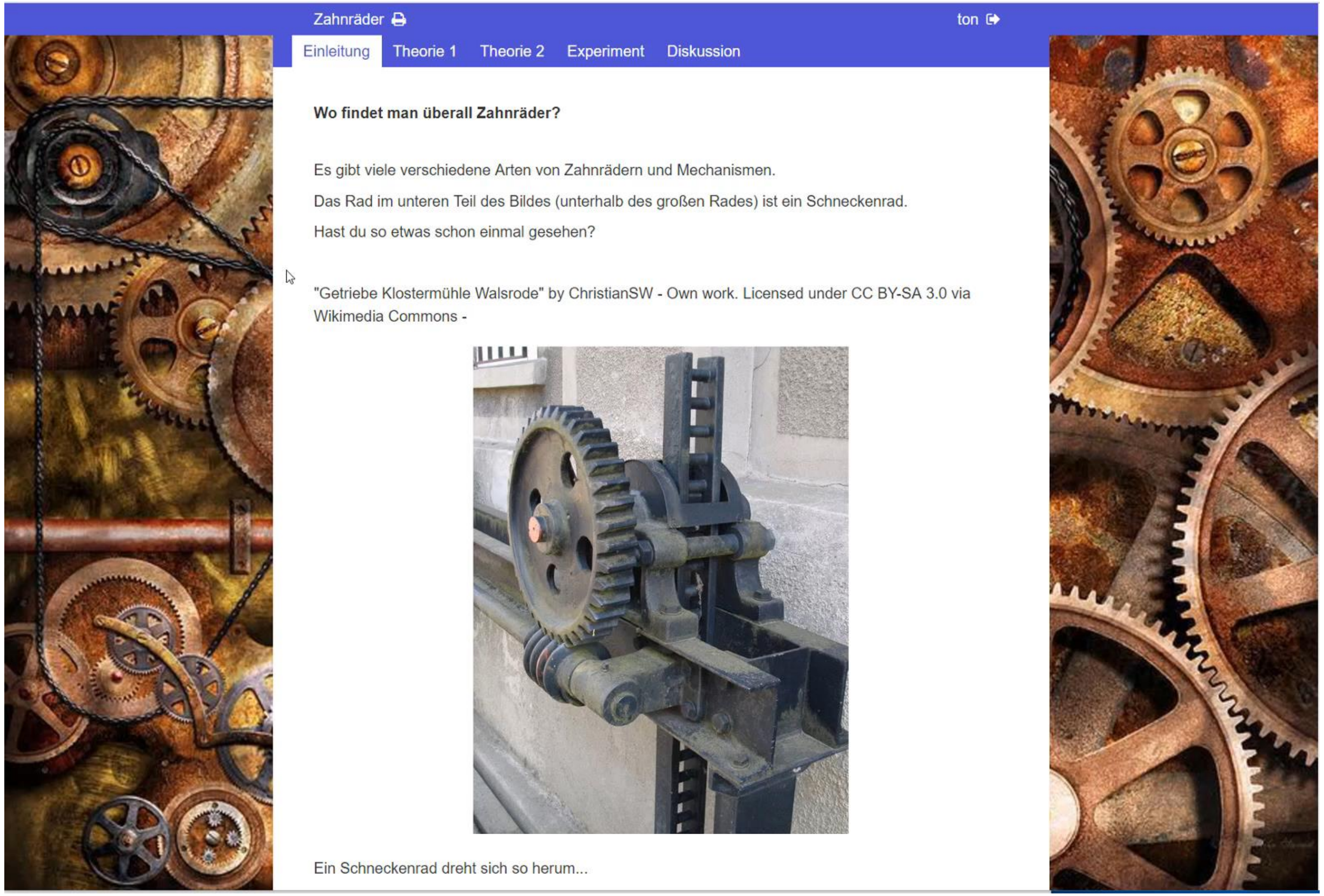
Support platform

The sharing platform

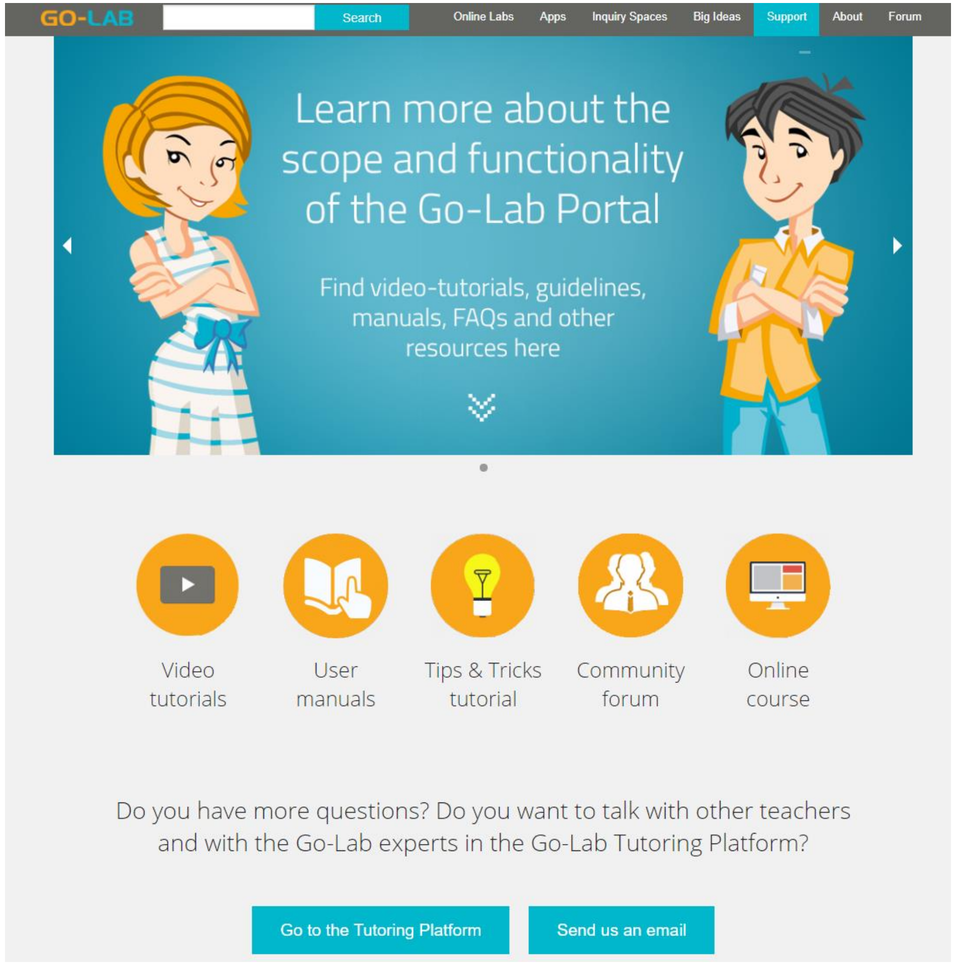


The authoring platform

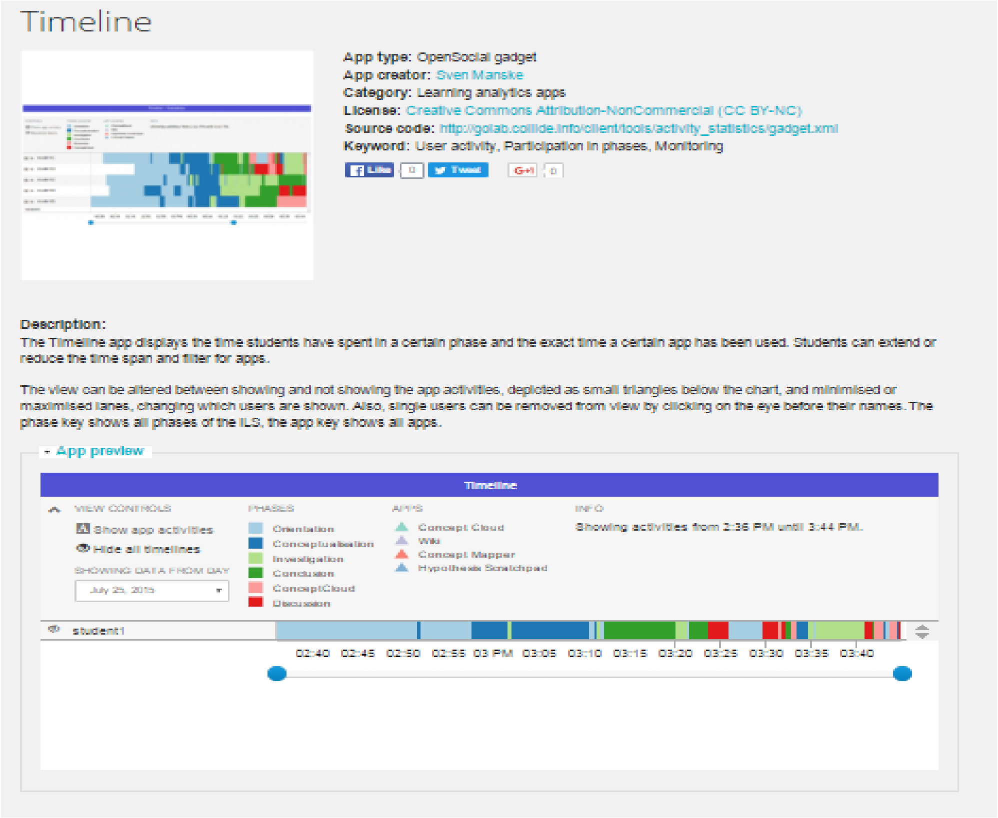
Go-Lab Inquiry Learning Spaces

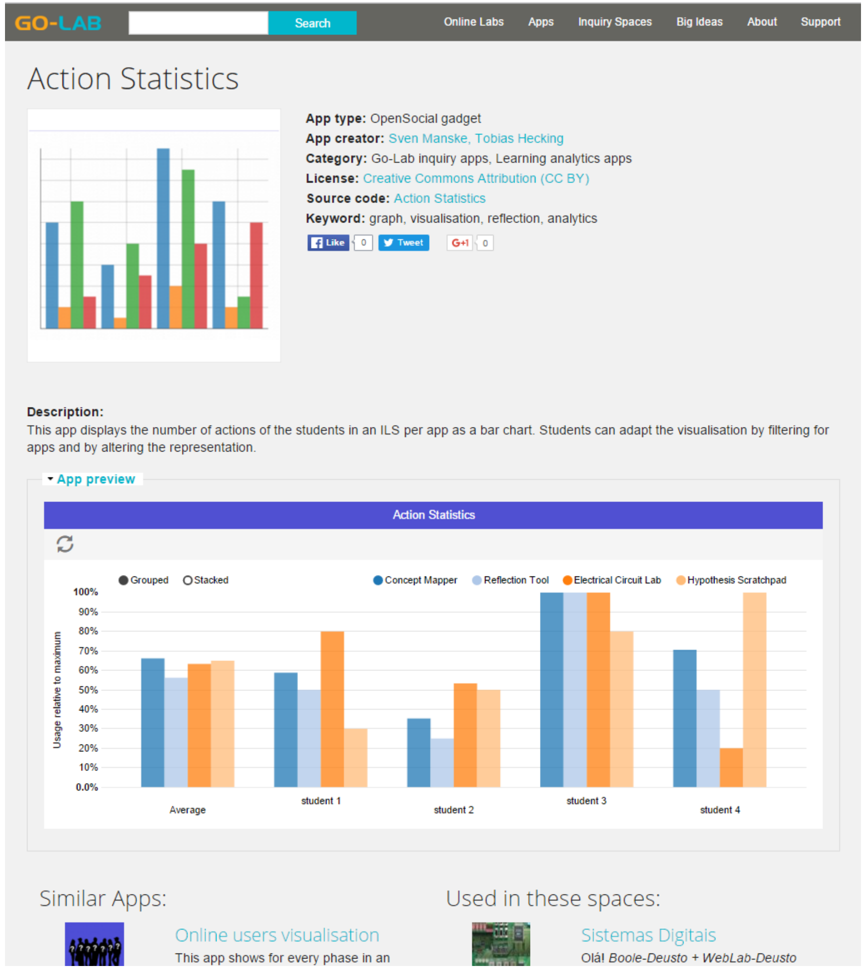


The support platform



Some learning analytics features





nextlab

- H2020 EU project
- 12 partners
- Budget 7,2 million Euros
- 3 years (2017-2020)
- UT coordinator
- Innovation action

- Extended in the H2020 GO-GA project

- Bring Go-Lab to primary education
- Include support for 21st century skills

Collaboration: Electricity transport lab

Chat

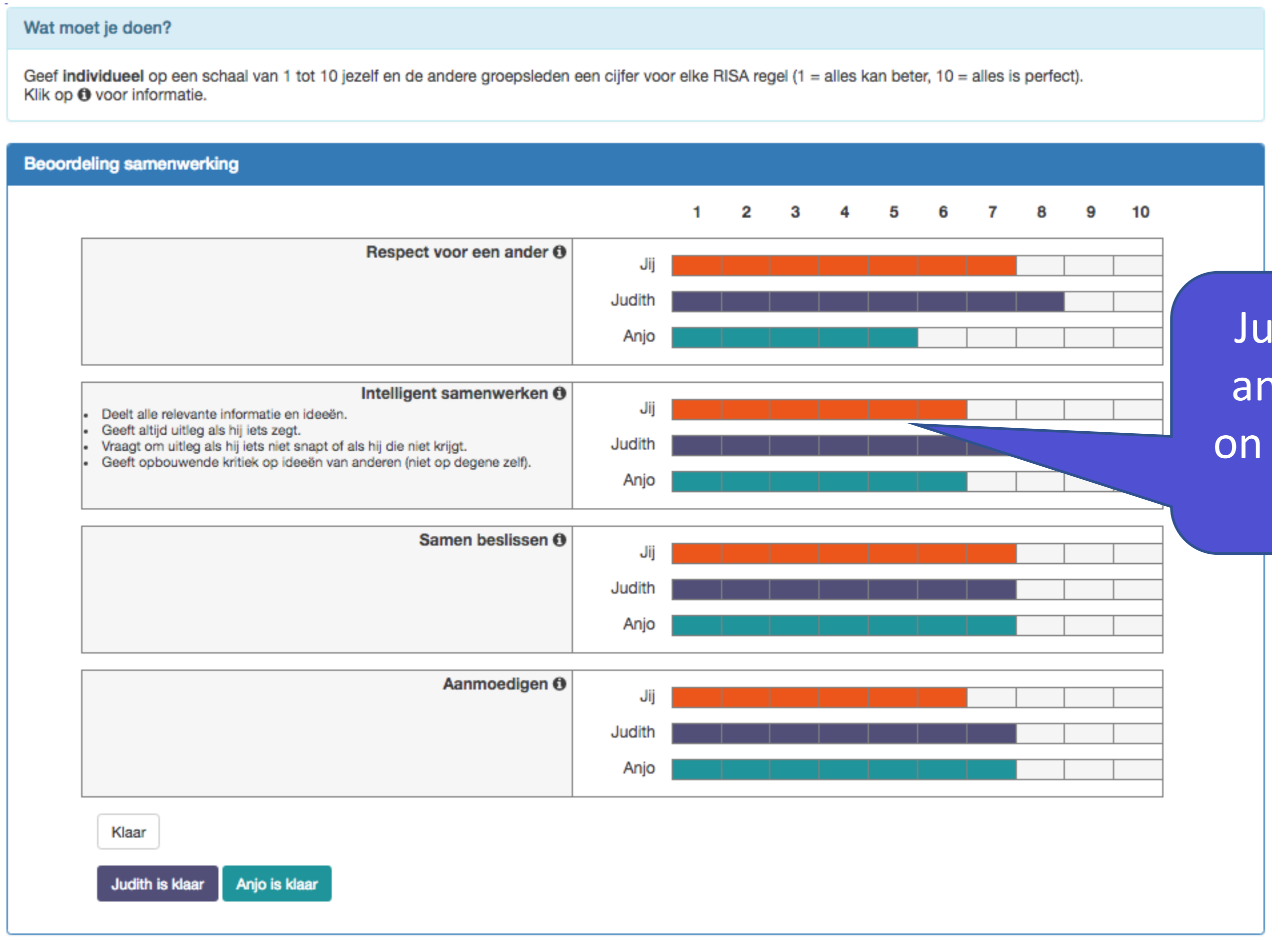
Collaboration: the RIDE rules

RIDE Rule	Sub-rules
(R) Respect	Everyone will have a chance to contribute
	Everyone's ideas will be thoroughly considered
(I) Intelligent collaboration	Sharing all relevant information and suggestions
	Clarify the information given
	Explain the answers given
	Give criticism
(D) Deciding together	Explicit and joint agreement will precede decisions and actions
	Accepting that the group (rather than an individual member) is responsible for decisions and actions
(E) Encouraging	Ask for explanations
	Ask till you understand
	Give positive feedback

From: Saab, N., van Joolingen, W., & van Hout-Wolters, B. (2012). Support of the collaborative inquiry learning process: influence of support on task and team regulation. *Metacognition and Learning*, *7*, 7-23. (p. 13)

twist education
Twenty-first century Skills for Technical Education

Assessing the collaboration



Judge yourself and the others on the four RIDE rules

Visualizing the collaboration

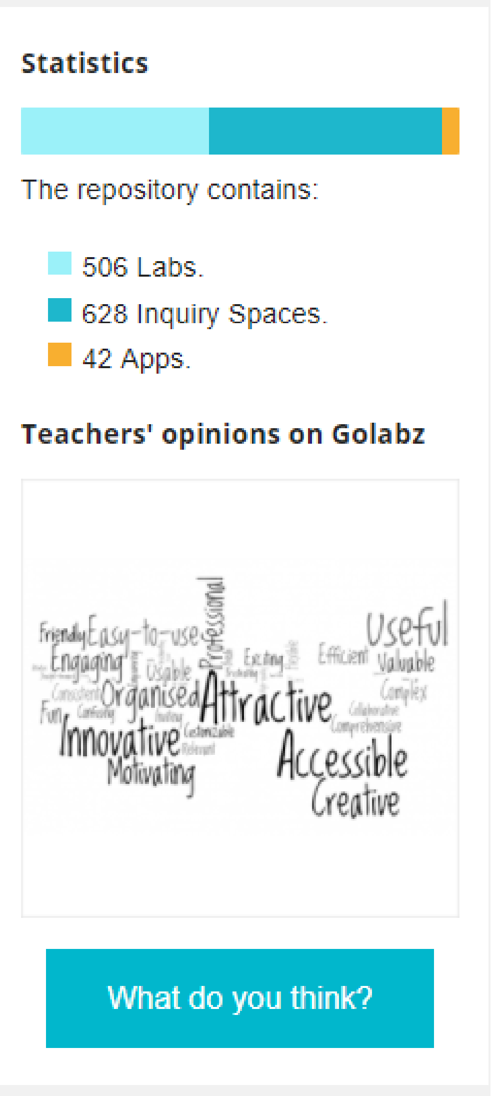
Overview per member of their own score and the average score by others about them, for each RIDE rule

Is Go-Lab a success?

- Go-Lab sharing platform unique users:
  - 2014: 10,718 users
  - 2015: 15,152 users
  - 2016: 78,384 users
  - 2017: 67.877 users (until October)
  - 2017: 90.500 users (extrapolated)

  - Overall: 193.000 users

- 13:000 visits per month: USA, Spain, UK, Greece, Portugal, the Netherlands, Germany, Italy, Turkey, Estonia, Switzerland, …



Obstacles for innovative software

- New technology for the teacher
- A change in pedagogy for the teacher
- No training facilities for teachers

- Fixed curricula (some countries yes, others no)
- Policies by schools that are hard to change

- Software needs to be ready for large scale usage

Next-Lab actions to reach out

- Large set of courses/MOOC/promotional material/summer – winter schools
- Network of ambassadors
- Being part of teacher training institutes curricula

www.golabz.eu