

Promises and challenges of digital technologies for learning

Ton de Jong

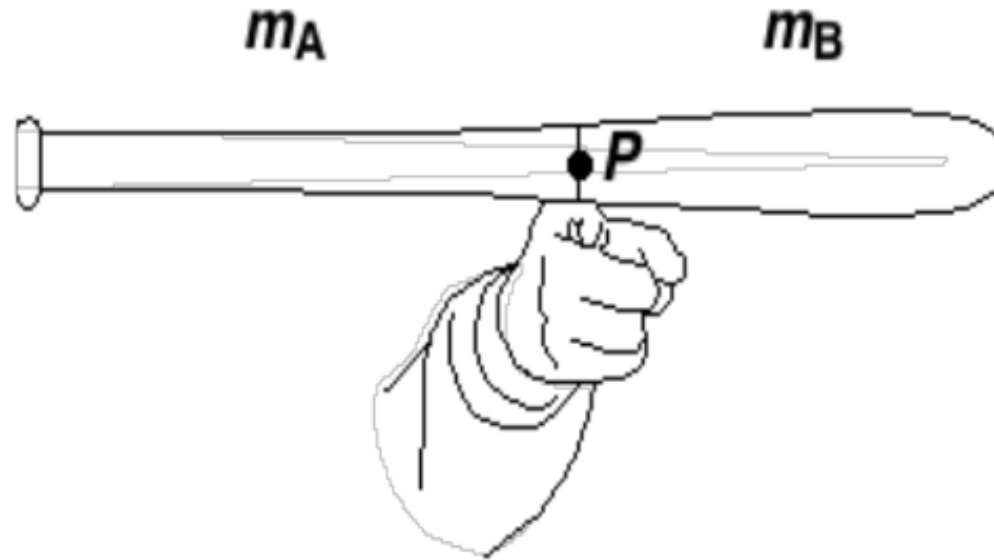
University of Twente, the Netherlands



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.

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.

Correct responses



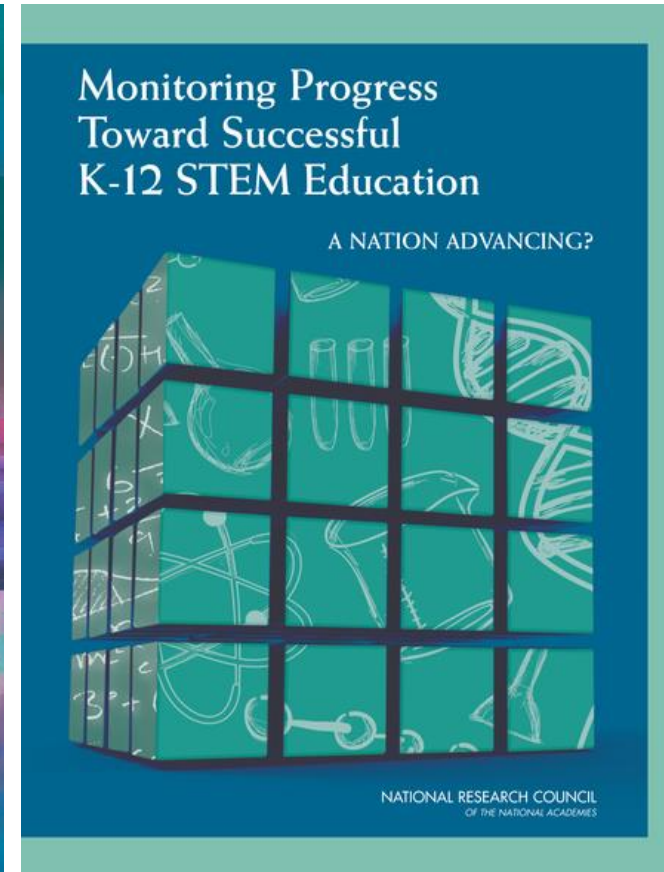
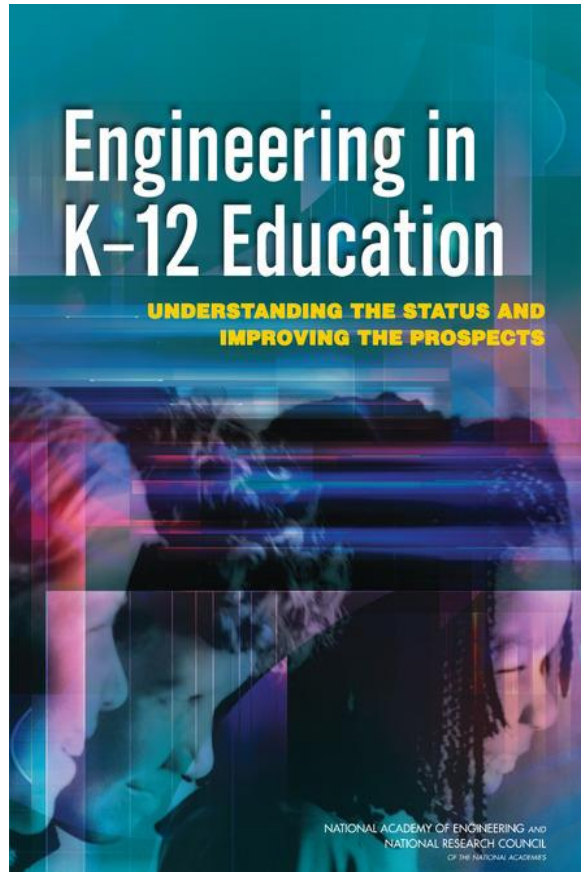
Study Ortiz: University of Washington first year engineering, physics, math and computer science students with high school physics experience (N = 674)	20%
Primary school teachers (N = 582)	3%
Lower secondary physics teachers (N = 167)	6%
University physics students in introductory calculus-based Mechanics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

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



PNAS PNAS PNAS

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

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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

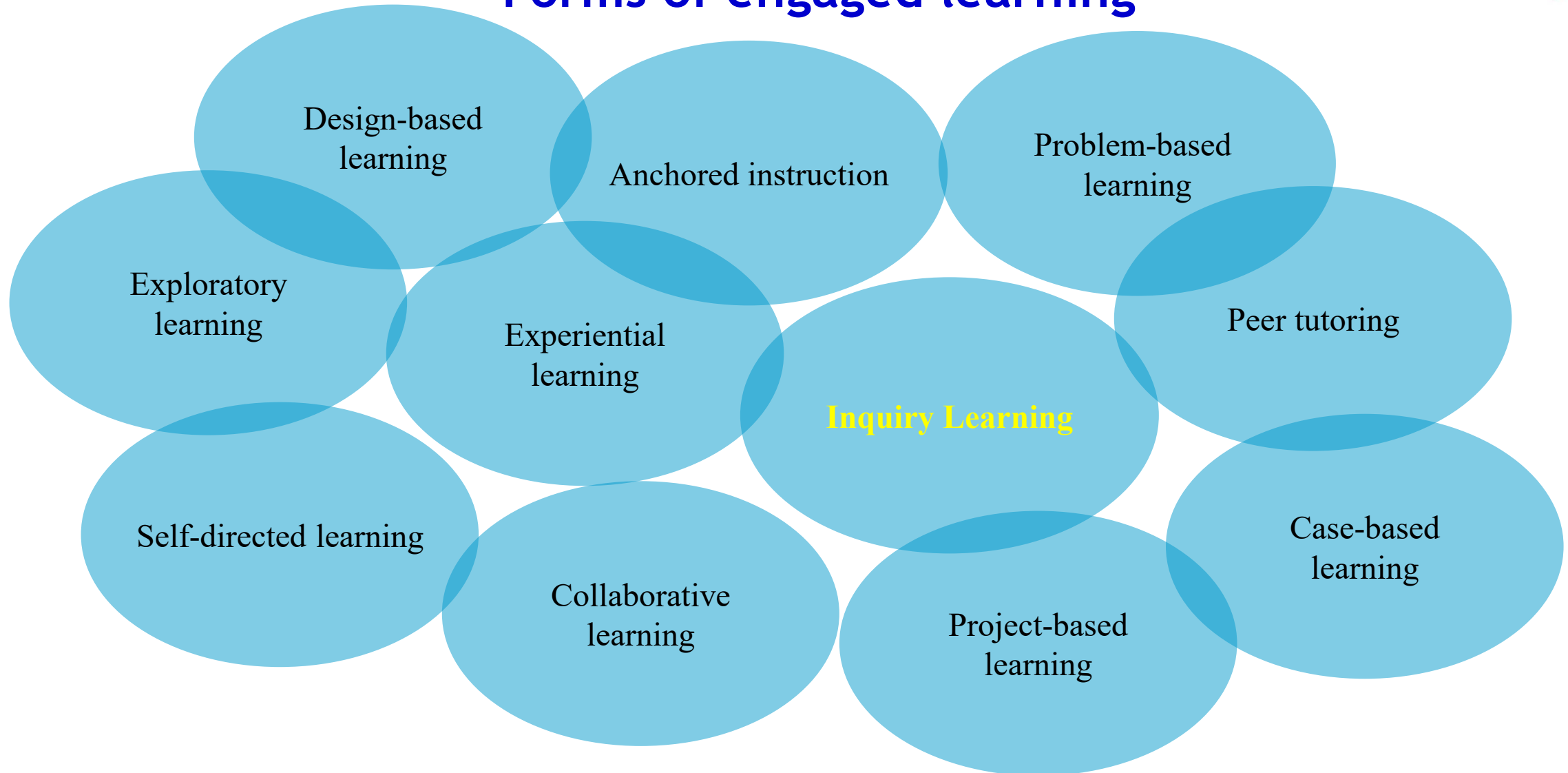
Engaged learning



- “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)



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

Beaker Solution	Volume (L)	Molarity (M)	Amount (mol)
Left NaOH (Sodium hydroxide)	0.100	0.050	0.005000
Right Fe(NO ₃) ₃ (Name not known)	0.100	0.050	0.005000

Instruction

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

A B C D E

Run Refresh Delete all Add

Input Parameters

Projectile Diameter
 6400 m
 Value: 6400 m

Trajectory Angle
 90°
 Value: 90°

Projectile Velocity
 0 m/s
 Value: 0 m/s

Projectile Density
 Porous Rock

Target Density
 Sedimentary Rock

Reset Submit ? Distance from crash site 0 km

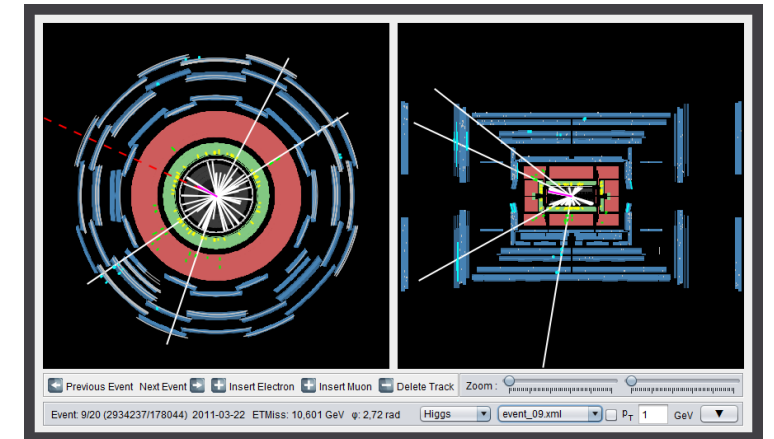
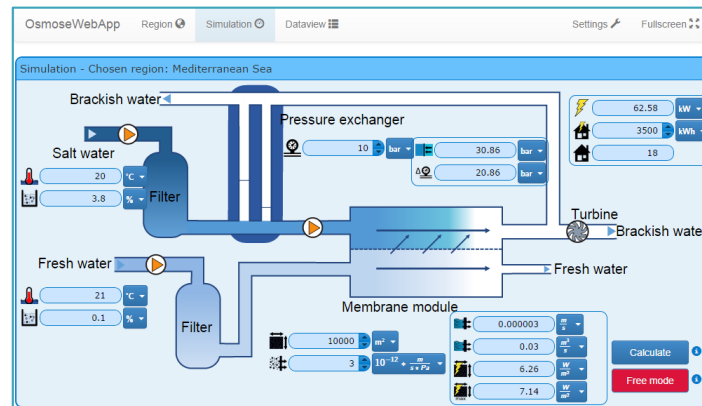
1st Tube 2nd Tube 3rd Tube 4th Tube

Sensors

Sensor	Value
Liquid Level	17.3 cm
Ball Weight	144.16 g

Liquid/Tube

Property	Value
Density	1 g/cm ³
Internal Diameter	9.4 cm



An example from psychology



Classical conditioning - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://zap.gw.utwente.nl/norton/srchnps/zaps/klassiekconditioneren.res/frames.html

Google Go 59 blocked Check Settings













zaps Classical conditioning Duration: 15 minutes [Print version](#)

Introduction
Discovery
Theory
Further info

available stimuli

graph of the amount of salivation

previous experiments

stimuli	salivation
 	
 	
 	
 	

help start restart further

Done Internet



Inquiry as engaged learning

Expository methods (teaching)	Inquiry methods (learning)
<ul style="list-style-type: none">Teacher explains – students do exercises (ready made science)	<ul style="list-style-type: none">Students do explorations first and design concepts and laws together with their teachers (science-in-the making)
<ul style="list-style-type: none">First: presentation of scientific principles (lecture)Then: experiment to verify (confirm) the principle (laboratory)	<ul style="list-style-type: none">Students construct (not only confirm) meaningNo 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?



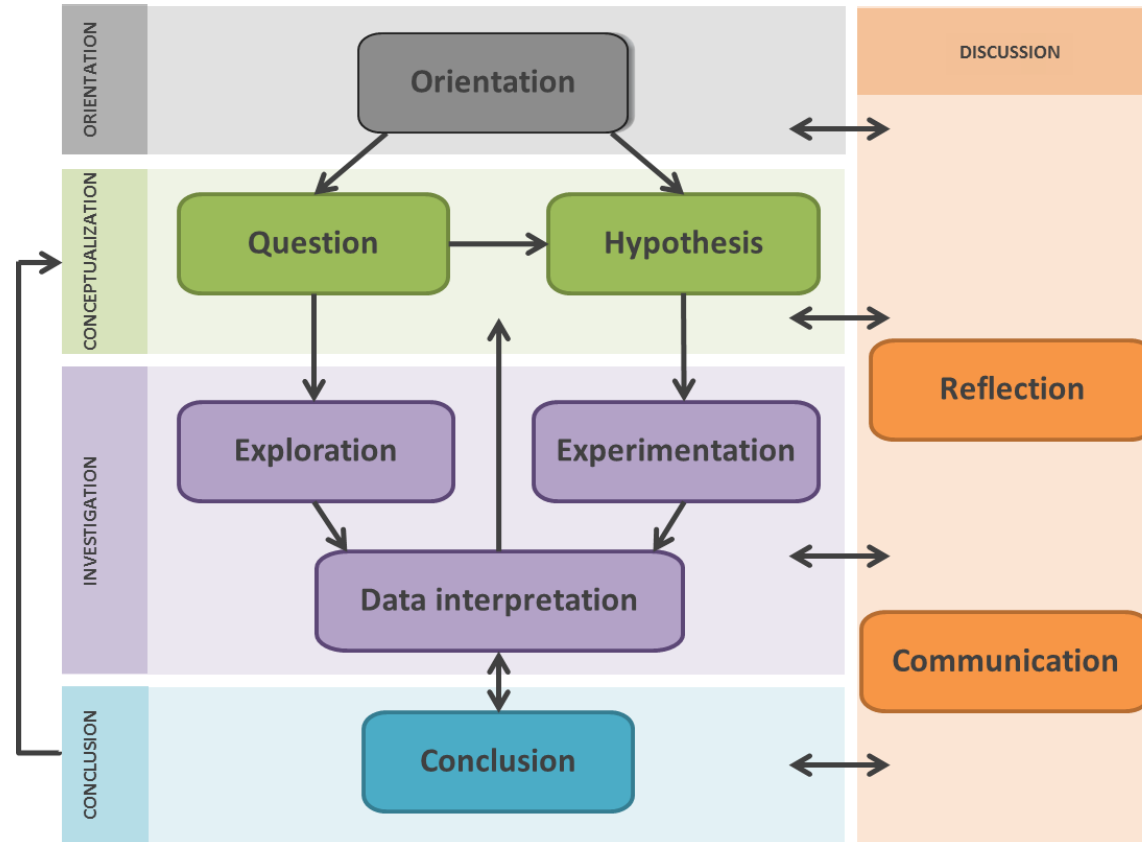
- Open inquiry (discovery) doesn't work
- Students need support:
 - By providing students with an overall strategy (inquiry cycle)
 - By connecting to the right level of prior knowledge
 - By providing students with scaffolds (apps)

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



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



Terms

IF THEN increases decreases is larger than is smaller than is equal to remains time luminous intensity electric current thermodynamic temperature amount of substance [type here]

Hypotheses



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

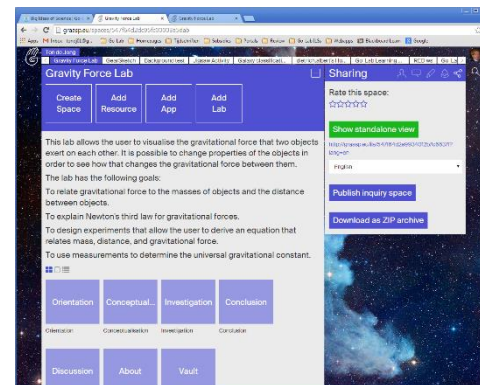




The Go-Lab ecosystem (www.golabz.eu)



Sharing platform



Authoring platform



Support platform

The sharing platform




Home | NextLab Reposit... | [Preview] Electrical Circu... | dev.golabz.eu


GO-LAB Labs Apps Spaces Authoring Support About

Sharing and Authoring Platform

Find the largest collection of online labs, try-out interactive inquiry apps, combine labs and apps into Inquiry Learning Spaces, and share these with your students and colleagues.




LAB



Electrical Circuit Lab

In the Electrical Circuit Lab students can create their own electrical...

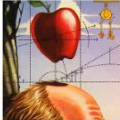
APP



Hypothesis Scratchpad

The Hypothesis Tool helps learners formulate hypotheses.


LAB



Gravity Force Lab

This lab allows the user to visualise the gravitational force that two objects...


LAB



Splash: Virtual Buoyancy Laboratory

In Splash students can create objects from object properties like mass...


APP



Experimental Error Calculator

This tool allows students to calculate experimental errors that stem from...


APP



Experiment Design Tool

The Experiment Design Tool (EDT) supports planning scientific experiments...

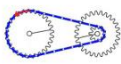
LAB



Acid-Base Solutions

How do strong and weak acids differ? Use lab tools on your computer to find out!


LAB



Gearsketch


A drawing-based learning environment for the gears domain.

LAB

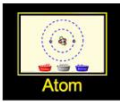


Atom

LAB





LAB



Atom

LAB





The authoring platform



Go-Lab Inquiry Learning Spaces



Zahnräder

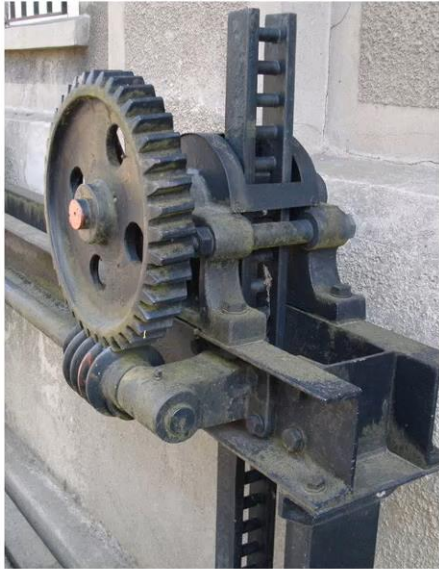
ton

Einleitung Theorie 1 Theorie 2 Experiment Diskussion



Wo findet man überall Zahnräder?

Es gibt viele verschiedene Arten von Zahnrädern und Mechanismen.
Das Rad im unteren Teil des Bildes (unterhalb des großen Rades) ist ein Schneckenrad.
Hast du so etwas schon einmal gesehen?

"Getriebe Klostermühle Walsrode" by ChristianSW - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons -



Ein Schneckenrad dreht sich so herum...





The support platform

The screenshot displays the Go-Lab Support platform interface. At the top, a dark navigation bar contains the 'GO-LAB' logo, a search bar, and links for 'Online Labs', 'Apps', 'Inquiry Spaces', 'Big Ideas', 'Support' (highlighted), 'About', and 'Forum'. Below this is a large blue banner featuring two cartoon characters, a girl on the left and a boy on the right, both with their arms crossed. The text in the banner reads: 'Learn more about the scope and functionality of the Go-Lab Portal' and 'Find video-tutorials, guidelines, manuals, FAQs and other resources here'. Below the banner is a row of five orange circular icons: a play button for 'Video tutorials', an open book for 'User manuals', a lightbulb for 'Tips & Tricks tutorial', two people for 'Community forum', and a computer monitor for 'Online course'. At the bottom, a light gray section contains the text: 'Do you have more questions? Do you want to talk with other teachers and with the Go-Lab experts in the Go-Lab Tutoring Platform?'. Below this text are two teal buttons: 'Go to the Tutoring Platform' and 'Send us an email'.

GO-LAB Search Online Labs Apps Inquiry Spaces Big Ideas Support About Forum

Learn more about the scope and functionality of the Go-Lab Portal

Find video-tutorials, guidelines, manuals, FAQs and other resources here

Video tutorials User manuals Tips & Tricks tutorial Community forum Online course


Do you have more questions? Do you want to talk with other teachers and with the Go-Lab experts in the Go-Lab Tutoring Platform?

Go to the Tutoring Platform Send us an email

Some learning analytics features



Timeline



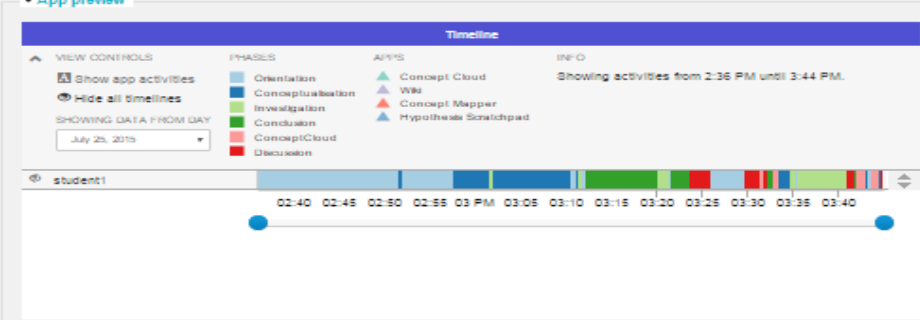
App type: OpenSocial gadget
App creator: [Sven Manske](#)
Category: Learning analytics apps
License: [Creative Commons Attribution-NonCommercial \(CC BY-NC\)](#)
Source code: http://goiab.colide.info/client/tools/activity_statistics/gadget.xml
Keyword: User activity, Participation in phases, Monitoring

[Like](#) [Tweet](#) [G+](#)

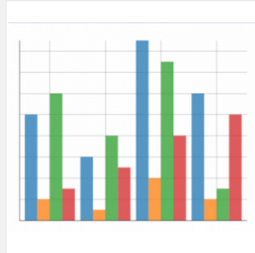
Description:
The Timeline app displays the time students have spent in a certain phase and the exact time a certain app has been used. Students can extend or reduce the time span and filter for apps.

The view can be altered between showing and not showing the app activities, depicted as small triangles below the chart, and minimised or maximised lanes, changing which users are shown. Also, single users can be removed from view by clicking on the eye before their names. The phase key shows all phases of the ILS, the app key shows all apps.

App preview



Action Statistics

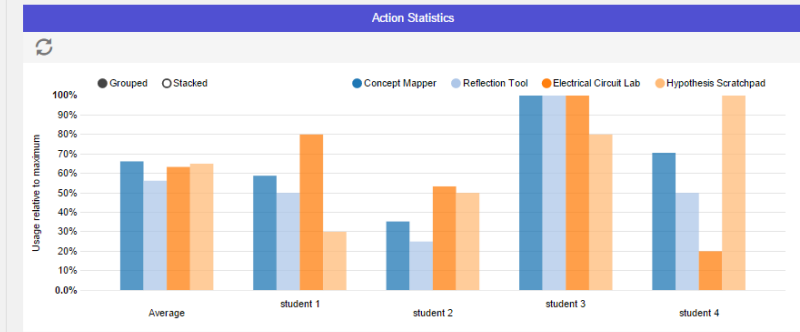


App type: OpenSocial gadget
App creator: [Sven Manske](#), [Tobias Hecking](#)
Category: Go-Lab inquiry apps, Learning analytics apps
License: [Creative Commons Attribution \(CC BY\)](#)
Source code: [Action Statistics](#)
Keyword: graph, visualisation, reflection, analytics


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Description:
This app displays the number of actions of the students in an ILS per app as a bar chart. Students can adapt the visualisation by filtering for apps and by altering the representation.


App preview



Similar Apps:

-  [Online users visualisation](#)
This app shows for every phase in an

Used in these spaces:

-  [Sistemas Digitais](#)
[Oll Boole-Deusto](#) + [WebLab-Deusto](#)



- H2020 EU project
- 12 partners
- Budget 7,2 million Euros
- 3 years (2017-2020)
- UT coordinator
- Innovation action
- Bring Go-Lab to primary education
- Include support for 21st century skills
- Extended in the H2020 GO-GA project



Collaboration: Electricity transport lab

Chat

test

test2

test3

Selecteer de gewenste les:

- Gelijkspanning
- Wisselspanning
- Transformatoren
- Elektrische transport (1)
- Elektrische transport (2)

Chat

No over else is here.

me

hjhjh

12:25:40

Type your message here

Sample

Opdracht 1

Opdracht 2

Opdracht 3

Opdracht 4

Opdracht 5

TRANSPORTLAB

Evaluatie

Transport lab

Ontwerp van de masten

Afstand masten	500	m
Doorhang	4,0	m
Kabellengte segment	500	m
Rendement netwerk	5,27	%

Algemene tools



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

Assessing the collaboration



Wat moet je doen?

Geef **individueel** op een schaal van 1 tot 10 jezelf en de andere groepsleden een cijfer voor elke RISA regel (1 = alles kan beter, 10 = alles is perfect).
Klik op **i** voor informatie.

Beoordeling samenwerking

	1	2	3	4	5	6	7	8	9	10
Respect voor een ander i										
Jij										
Judith										
Anjo										
Intelligent samenwerken i										
<ul style="list-style-type: none"> • Deelt alle relevante informatie en ideeën. • Geeft altijd uitleg als hij iets zegt. • Vraagt om uitleg als hij iets niet snapt of als hij die niet krijgt. • Geeft opbouwende kritiek op ideeën van anderen (niet op degene zelf). 										
Jij										
Judith										
Anjo										
Samen beslissen i										
Jij										
Judith										
Anjo										
Aanmoedigen i										
Jij										
Judith										
Anjo										

Klaar

Judith is klaar

Anjo is klaar

Judge yourself
and the others
on the four RIDE
rules



Visualizing the collaboration

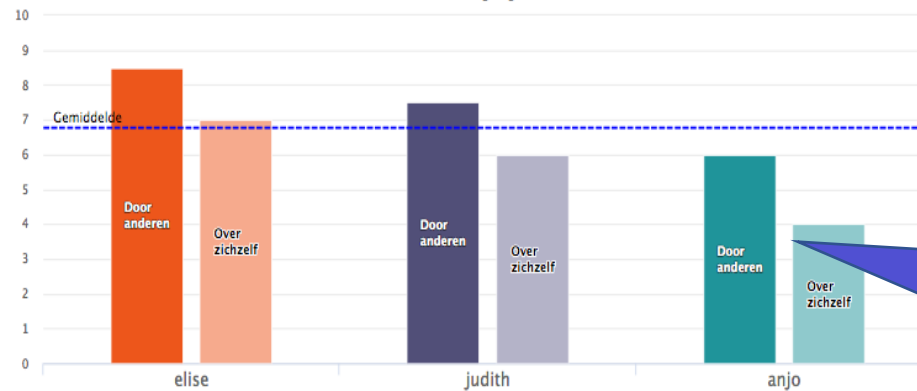
Wat moet je doen?

Hieronder zie je een overzicht van de gemiddelde groepsscores per RISA regel en de scores per groepslid voor elke RISA regel. Bekijk **individueel** zowel de groepsscores als de individuele scores goed.

Overzicht scores

Scores per groepslid voor 'Samen beslissen'

Klik om terug te gaan



Klaar

Judith is klaar

Anjo is bezig

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, ...

Statistics



The repository contains:

- 506 Labs.
- 628 Inquiry Spaces.
- 42 Apps.

Teachers' opinions on Golabz



What do you think?

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



next lab

www.golabz.eu