



A Computer Science Perspective on Learning and Knowledge Building

H. Ulrich Hoppe

Universität Duisburg-Essen / COLLIDE

[http:// www.collide.info](http://www.collide.info)



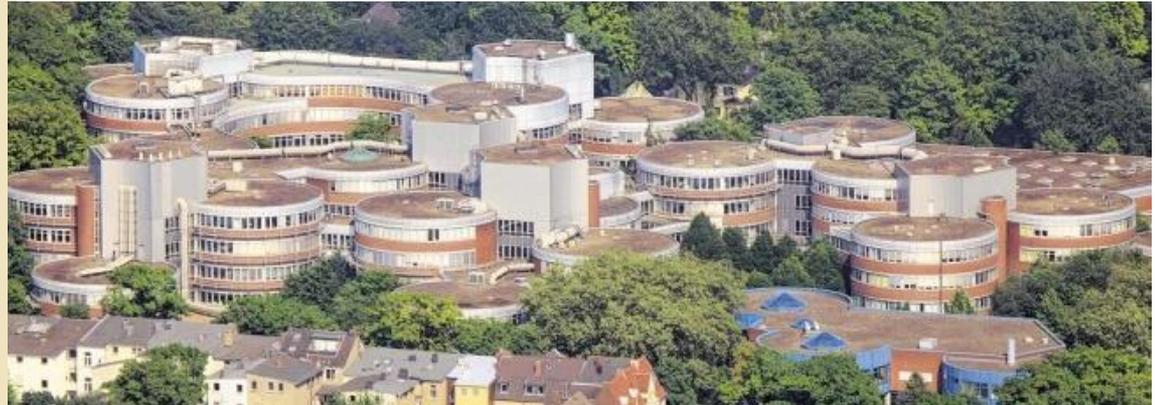


University of Duisburg-Essen (UDE)

founded by merger in 2013

11 Faculties

- Humanities
- Social Sciences
- Educational Sciences
- Economics
- Business Administration
- Mathematics
- Physics
- Chemistry
- Biology
- Engineering
- Medicine



39,343 students

442 professors

2,691 academic staff

1,375 employees technical support and administrative services
(excluding Faculty of Medicine)

Our Department

... of Computer Science and Applied Cognitive Science in the Engineering Faculty (Duisburg)

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Focus on Interactive Media and "Human-oriented Computing"

3 B.Sc./M.Sc. Study Programmes with approx. 1500 students

Research Group COLLIDE

<http://www.collide.info>



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mobile learning
learning environments
knowledge management
ontologies
sqlspaces
freestyler
IMS LD
lifelong learning
trend analysis
elearning 2.0

interactive boards
intelligent systems
interaction analysis
tuple space
agent systems
competence management
sna
emerging learning objects
workplace learning
community support
repositories
blackboard architecture
student modelling
learning design
ontologies

Learning



Learning Analytics

Welcome to the Collide Portal

C
O
Laborative
Learning in
Intelligent
Distributed
Environments

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Faculty of Engineering
Department of Computational and Cognitive Sciences
Building LF
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Fax +49 - 203 - 379 3557

Upcoming Events

- ICCS 2014 (10.06.14)
- ICLS 2014 (23.06.14)
- ICALT (07.07.14)
- ASONAM 2014 (17.08.14)
- CRIWG 2014 (07.09.14)

[More...](#)

Project History I

- **COLDEX** ("Collaborative Learning and Distributed Experimentation", 2002-05, coord. by Collide): collaborative modelling tools for various areas of science learning; creation of a globally accessible repository of learner-created models ("emerging learning objects").
- **SCY** ("Science Created by You", 2008-12, U. Twente): SCY-Lab environment facilitates learner experience through larger "missions" ; sharing of emerging learning objects.

Project History II

- **Go-Lab** (2012-16, U. Twente):
uniform access to a variety of remote laboratories, both virtual and physical; customisable web-based learning environments and learning analytics components.
- **JuxtaLearn** (2012-15, Open Univ. Milton Keynes):
fostering understanding of core science concepts through video creation on the part of the students; collaborative production and discussion around videos.

Project COLDEX

("Collaborative Learning and Distributed Experimentation", 2002-05)

Collaborative Learning and Distributed Experimentation



The space planting scenario enables students to experiment with computer and robotic controlled plant growth chambers in the context of Advanced Life Support Systems

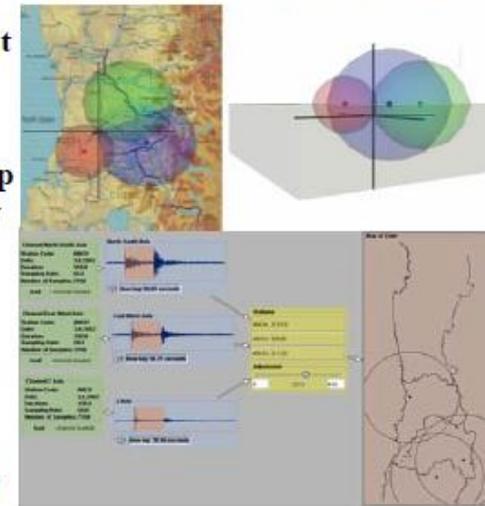
BioTube and Seismo Scenarios

Chemistry, biodiversity, seismology, astronomy ... these are the scientific topics which are combined in the COLDEX project

Originating from the pedagogical idea of "challenge based learning", we support student groups – from face-to-face groups up to international learning communities; they can have a realistic look inside scientific work. Various "digital experimentation toolkits" containing virtual and physical tools enable open-ended learning activities.

By using a synchronised "learning object repository" (LOR) learners can find people with similar interests. The LOR supports retrieval in a big pool of models and data, reuse of learning objects and building of learning communities between Europe and South-America.

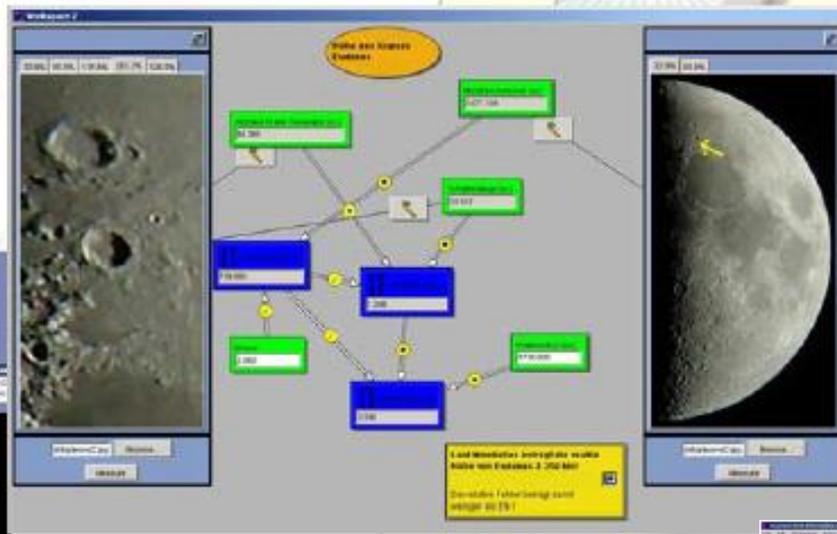
Finding epicenter and hypocenter of earthquakes is the main task in the seismo scenario



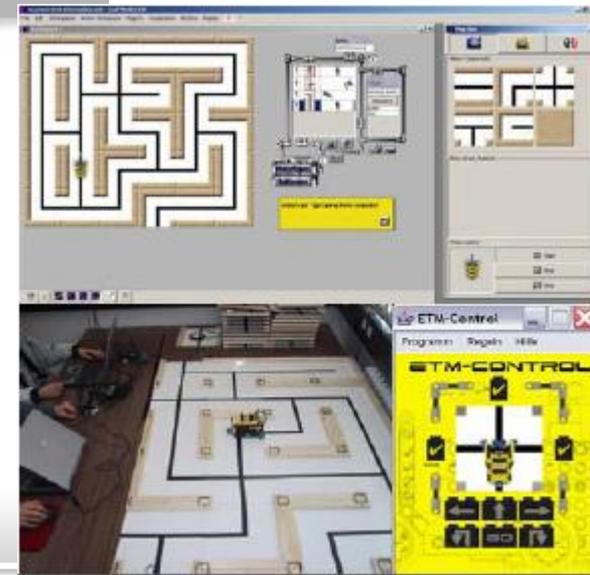
Project COLDEX

("Collaborative Learning and Distributed Experimentation", 2002-05)

The astro scenario contains remote control of telescopes, image processing and calculating moon crater heights



Astro and Maze Scenarios



COLDEX – Results and „Lessons Learned“

- Notion of „emerging learning objects“ (ELOs)
- Provision of a general purpose modelling environment (*CoolModes / FreeStyler*) with different „palettes“ for various modelling languages (e.g., *System Dynamics*, *Petri Nets*) and special applications
- Support for sharing ELOs in larger communities through similarity based search
- Resistance of teachers against „open production“

Project SCY



Science Created by YOU

Home

About SCY

Impressions

Partners

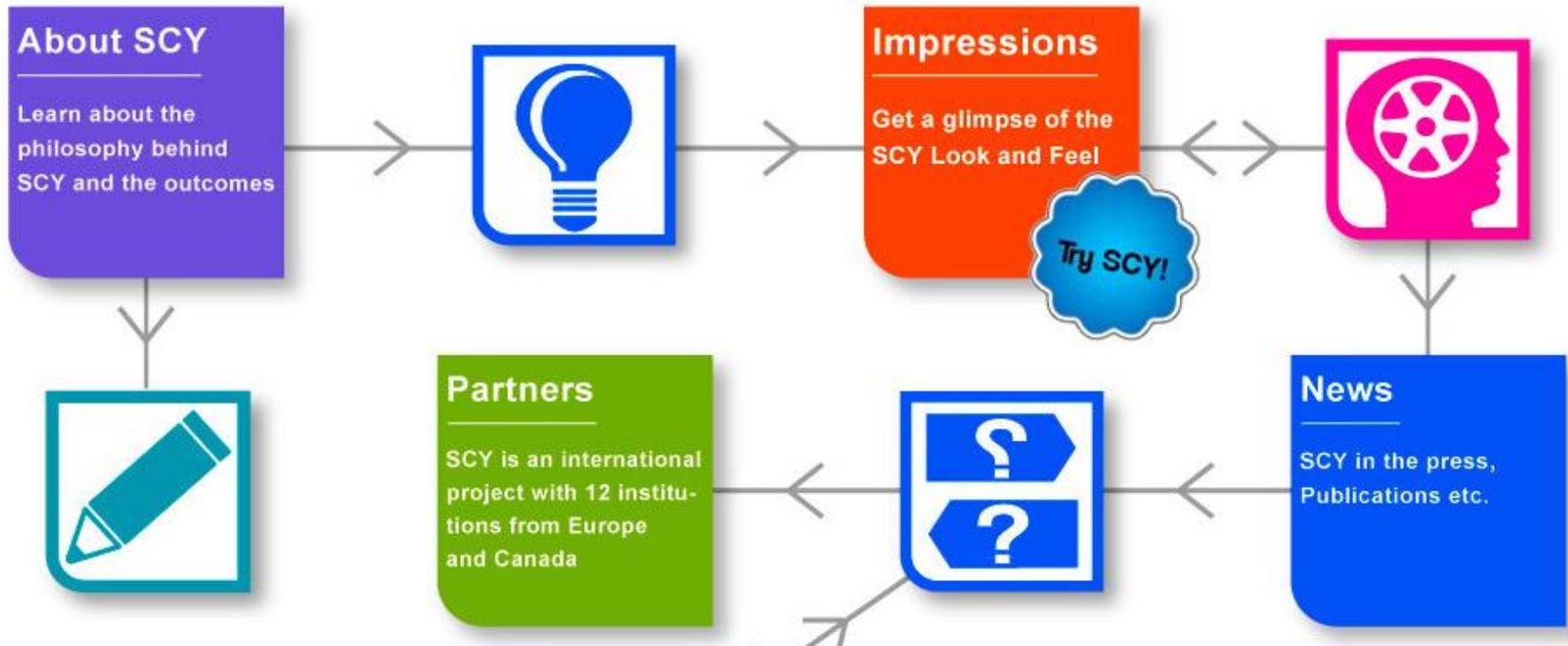
News

Deliverables

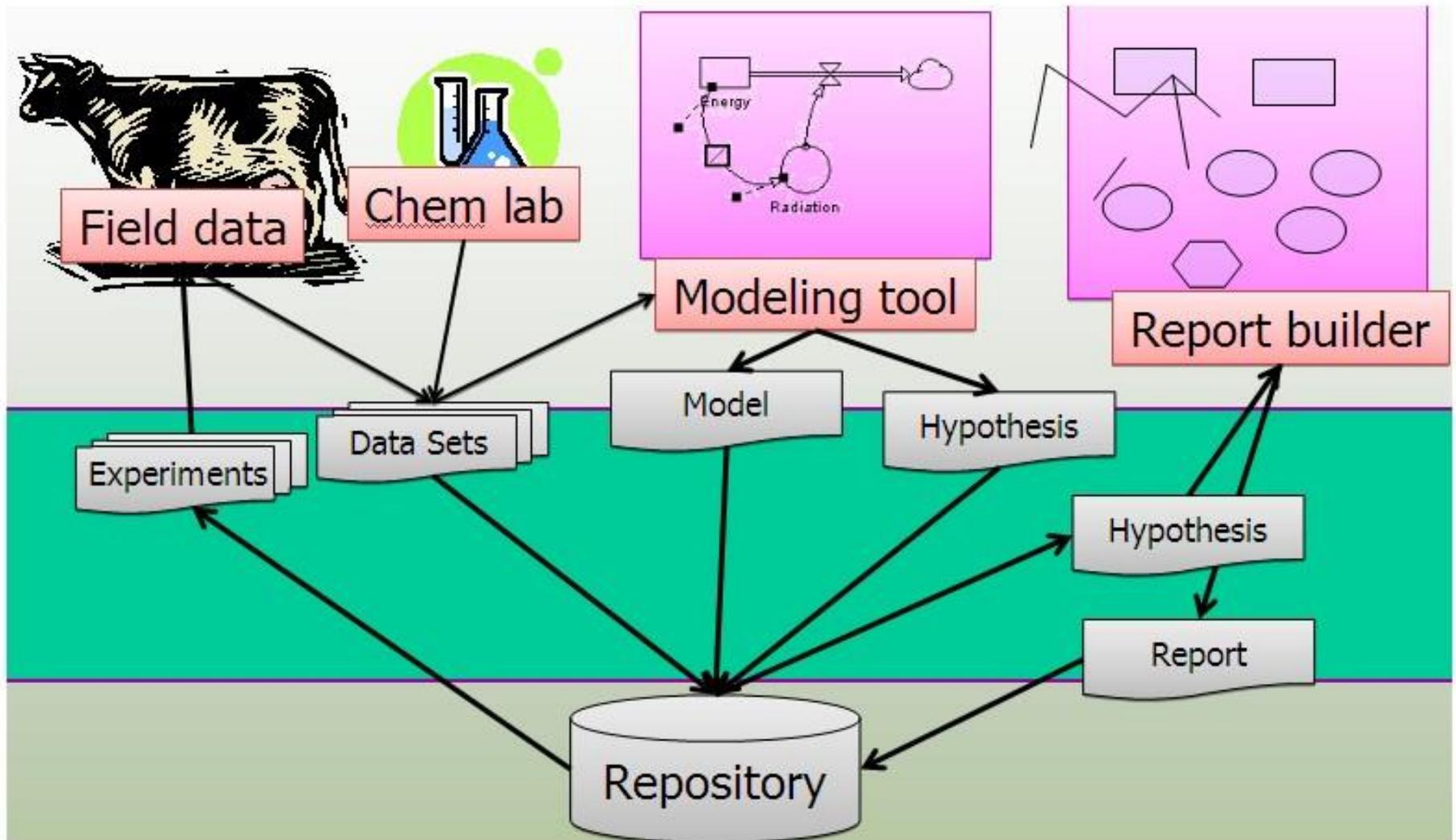
Forum

Try SCY

SCY for Teachers

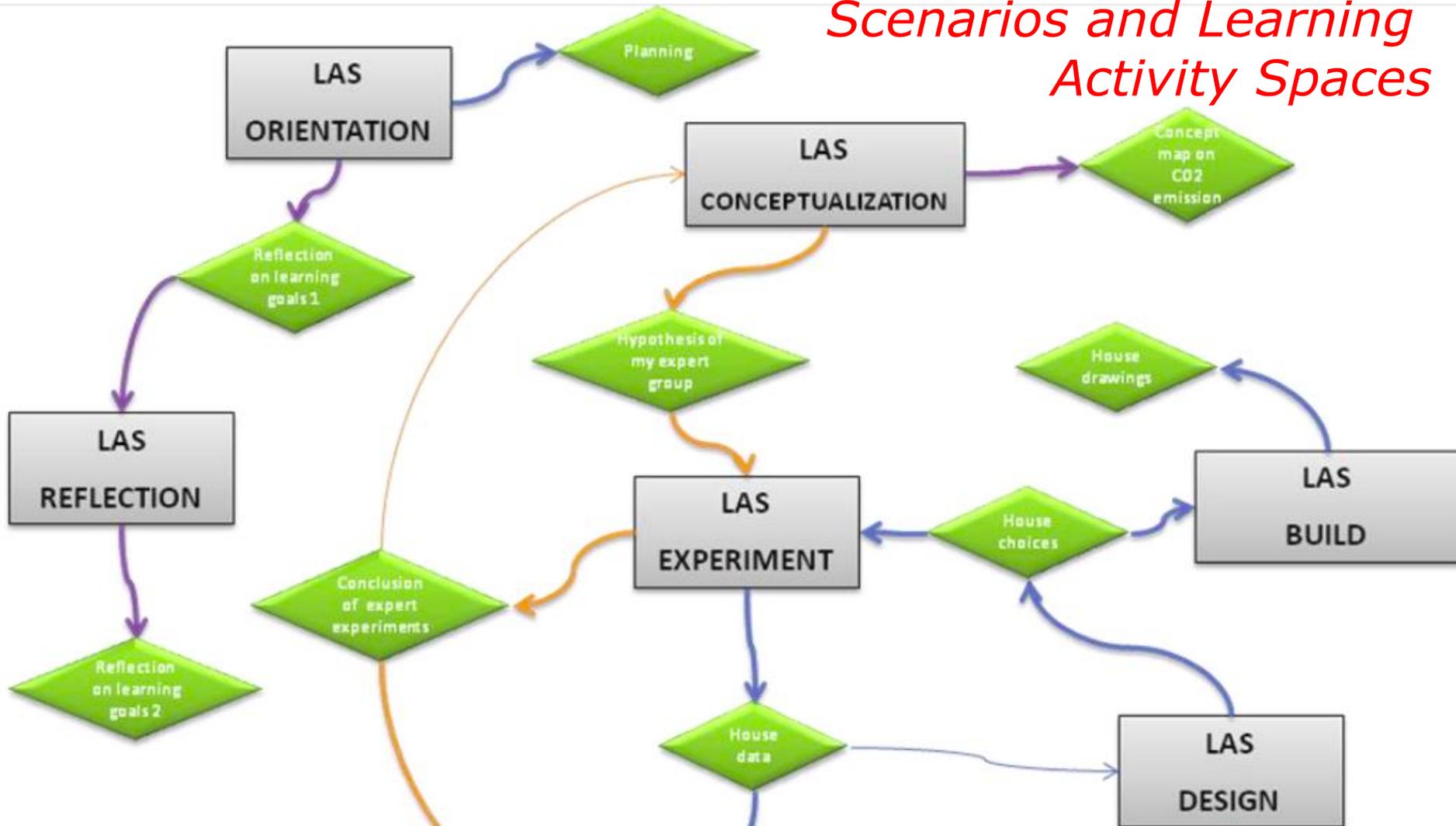


SCY – Tools and Architecture



Mission “CO2-Friendly House”

Scenarios and Learning Activity Spaces



SCY-Lab Environment

Fellow List
(online awareness)

SCYePortfolio &
SCYFeedback links

SCY-Lab : adam in Forensic mission on scy.collide.info

Biology: Goal of the analysis

Biology: Choice of techniques

ELO of this learning activity

Biology: Experimental procedure

ELO Archive

ELO Templates

ELO Search in RoOLO

Assignment

Assignment

Experimental procedure

As you know you have six DNA samples that need to be tested: one DNA sample from the crime scene and five reference samples to investigate if there is a match with the DNA from the crime scene.

You have to take the following steps:

1. Drag-and-drop the icon of the "Goal of the analysis" you have written before to the "Research question" field.
2. Write your hypothesis.
3. Describe the principle of the manipulation by using the previous step "Choice of the techniques".
4. Read the description of the material you are going to use during the experiment.
5. Read the "Manipulation and data treatment" section step by step. You will see some questions in Blue. Don't forget to answer them!

Research question / goal
Please, describe the goal of your experiment, the question you want to answer and/or the objects you want to produce.

Hypothesis / anticipated results
Describe hypotheses that you want to test in your experiment and/or the anticipated results.

Principle of the manipulation
Describe the rough description of your experiment. Specify the quantities you want to measure during the experiment.

Material

Pipet tips 2 - 200 µl	Microplates, 2 - 29 µl	Micro test tubes	Permanent marker
Wobble container	Foam micro test tube holder	Paper towels	DNA samples
DSBQ/SP6 enzyme mix	Waterbath	Container with ice	Agarose gel electrophoresis unit
Agarose gel	TAE-buffer (0.25x or 1x)	DNA sample loading dye (LD)	HindIII lambda digest (DNA read)
Gel staining tray	Large container for destaining performing quick staining	Warm tap water	Power supply (100-200V / low m)
Fast Blast stain 100x			

Manipulation and data treatment

Restriction digestion

- Place the tube containing the restriction enzyme mix, labeled ENZ, on ice.
Which enzymes does the enzyme mix contain? Why is it interesting to use more than one enzyme?
- Place the tubes with the DNA samples in the foam micro test tube holder.
Pipet 10 µl of each DNA sample from the stock tubes and transfer to the correct micro test tubes.
Which samples do you have chosen for the restriction digest?
- Pipet 10 µl of enzyme mix (ENZ) into micro test tubes with DNA.
Tightly cap the tubes and mix the components.
- Place the tubes in the foam micro tube holder and incubate for 45 min at 37°C.
Why 37°C is a good temperature for the enzymes?

Link to Mission Map

SCY – Results and „Lessons Learned“

- SCY-Lab as a powerful environment
(yet – might be better delivered as a web application)
- Integration of feedback/scaffolding facilitated through multi-agent architecture
- „Mission Maps“ as navigation aids guide learners through complex inquiry processes
- „Complexity overkill“ with big socially relevant learning challenges

The Go-Lab Project

<http://www.go-lab-project.eu/>



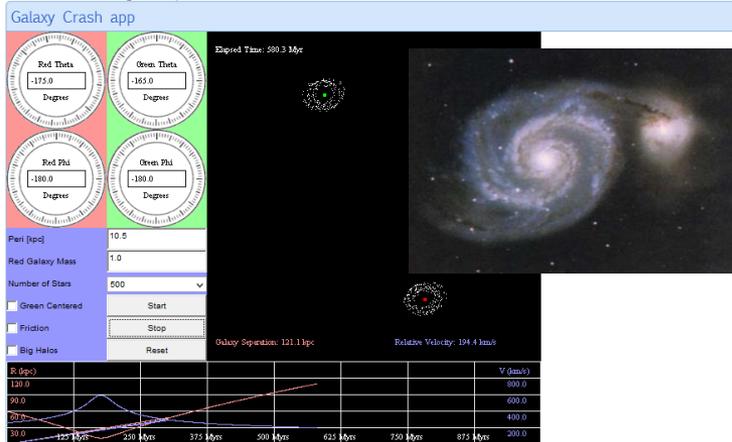
GO-LAB

- Large scale use of online labs in education.
- The Go-Lab Portal offers students the opportunity to perform personalized scientific experiments.
- Teachers enhance their classroom activities with a personalized web-based environment.

Experimentation with Remote and Virtual Laboratories

Orientation Conceptualisation Investigation Conclusion Discussion

This is the Investigation phase.



Remote lab: Students control real physical laboratories using a web-interface.

Electricity lab

Create electrical circuits and measure voltages and currents. The circuits are limited to static situations.

Orientation Conceptualisation Investigation Conclusion Discussion

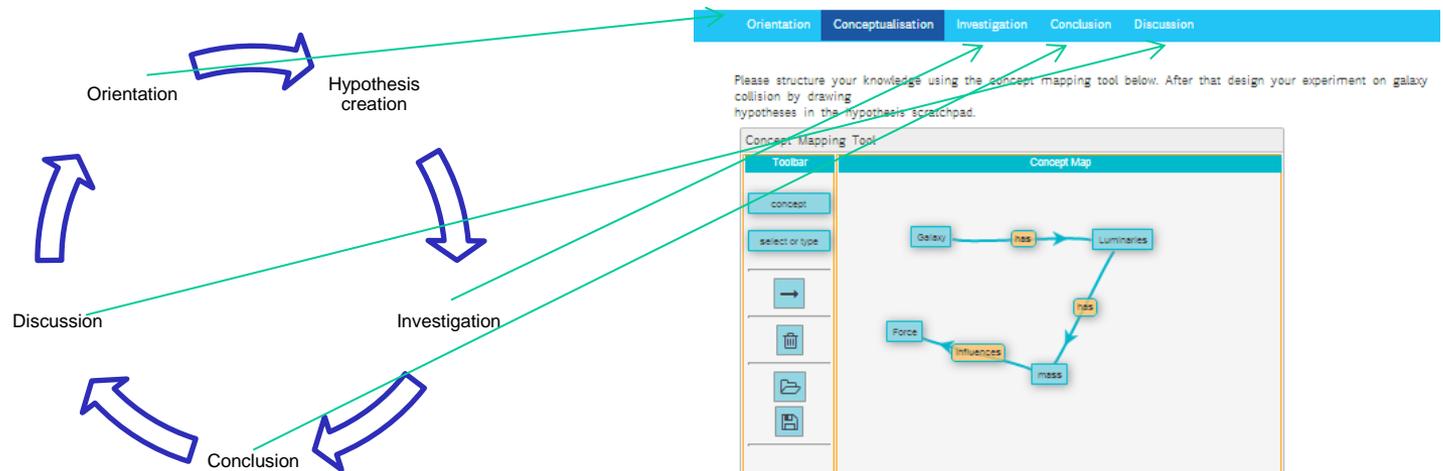
This is the Investigation phase.

The screenshot shows the 'Circuit Simulator' interface. It is divided into several sections: 'Components' on the left, 'Circuit board' in the center, and 'Meters' on the right. The 'Components' section contains various electrical symbols like resistors, capacitors, voltage sources, switches, and sensors. The 'Meters' section includes a power supply icon, an ammeter (amp 1), a voltmeter (volt 1), a power meter (power 1), and an ohmmeter (ohm). The 'Hints' section at the bottom left provides instructions on how to use the power supply and sensors. The 'Circuits' section at the bottom right shows a 'Predefined' category of 'test circuits' and buttons for 'Open', 'Save', 'Import', 'Export', and 'New'.

Virtual lab: Simulation of real-world processes.

Inquiry Learning at School

- Mapping of the inquiry cycle to virtual inquiry learning spaces.



- Open Social Apps support the activities in different phases.

Federation of Labs and Apps

Online Labs

The online labs aim at supporting inquiry-based learning and providing the possibility to conduct scientific experiments in a virtual environment. Importantly, the inquiry process should be well structured and scaffolded to achieve optimal learning results. Scaffolded refers to support (classroom software tools) that help students with tasks that they cannot complete on their own. For example, they can help students to create hypotheses, design experiments, make predictions, and formulate interpretations of the data.

Online laboratories can be of two kinds. Remotely-operated educational labs (remote labs) provide students with the opportunity to collect data from a real physical laboratory setup, including the equipment. Remote and virtual labs both have specific advantages for learning and can be combined to support specific learning activities. Additionally, the Go-Lab project offers courses to scientific educators, tools, and resources supporting inquiry learning activities of the students.

Please use the links on the right to find appropriate online labs and resources for your class.

HY.PA.T.I.A. - Hybrid Pupils' Analysis Tool for Interactions in ATLAS

HY.PA.T.I.A. is an event analysis tool for data collected by the ATLAS experiment of the LHC at CERN. Its goal is to allow high school and university students to visualize the complexity of this hadron-hadron interactions through the graphical. [More info](#)

Lab content: Particle Accelerators

Subject: Electrons and magnetism, Electric charge - generally, Electromagnetism - generally, Energy

Language: English, German, French, Greek

Grade level: Secondary Education (15-18 years old), Higher education teacher, Higher education master

RED Lab

This lab allows students to control a remote electrical device and visualize its output. [More info](#)

Lab content: Circuits, Batteries

Subject: Physics, Electrical Engineering

Language: English

Grade level: Secondary Education (15-18 years old), Higher education teacher, Higher education master

Black-body Radiation Lab

From the theory it is known that the energy which is radiated outwardly by a body in three-dimensional space from a source is inversely proportional with the square of the distance from the source. This process is known as the inverse square law. [More info](#)

Lab content: Dark Matter, Dark Energy, Cosmology

Subject: Cosmology, Dark Matter, Dark Energy, Physics



Conceptualisation

Tags: 0

Description:

This is the Conceptualization phase

[Print description](#) [Email description](#)

Find

enabled members Spaces Resources Apps

Hypothesis Spreadsheet **Concept Mapping Tool**

Teacher assembles inquiry learning spaces for certain scenarios in the **Go-Lab ILS platform**.



The Faulkes Telescope Project Hello Axel

The Faulkes Telescope Project is an education partner of Las Cumbres Observatory Global Telescope Network (LCOGT). Our aim is to provide free access to robotic telescopes and a fully supported education programme to encourage teachers and students to engage in research-based science education. Access to our resources and those of our partners is provided at no charge to teachers and students. We provide access to the robotic telescope for all schools in the UK and Ireland and limited access to telescope time for schools outside of the region. All users have unlimited access to the data and image archives, from where they can download data. LCOGT operates a network of research class robotic telescopes. Currently there are two telescopes, one in Hawaii and the other in Australia. These telescopes are available to teachers for them to use as part of their curriculum or extra-curricular activities and are fully supported by a range of educational materials and a team of educators and professional astronomers. [fa href="http://www.faulkes-telescope.com/resources/advice/16-long-pro-duction/"](http://www.faulkes-telescope.com/resources/advice/16-long-pro-duction/)

Orientation **Conceptualisation** **Investigation** **Conclusion** **Discussion**

This is the Orientation phase. Watch the videos about the Faulkes telescope and colliding galaxies

globular cluster NGC 6934 Döllschütz Faulkes

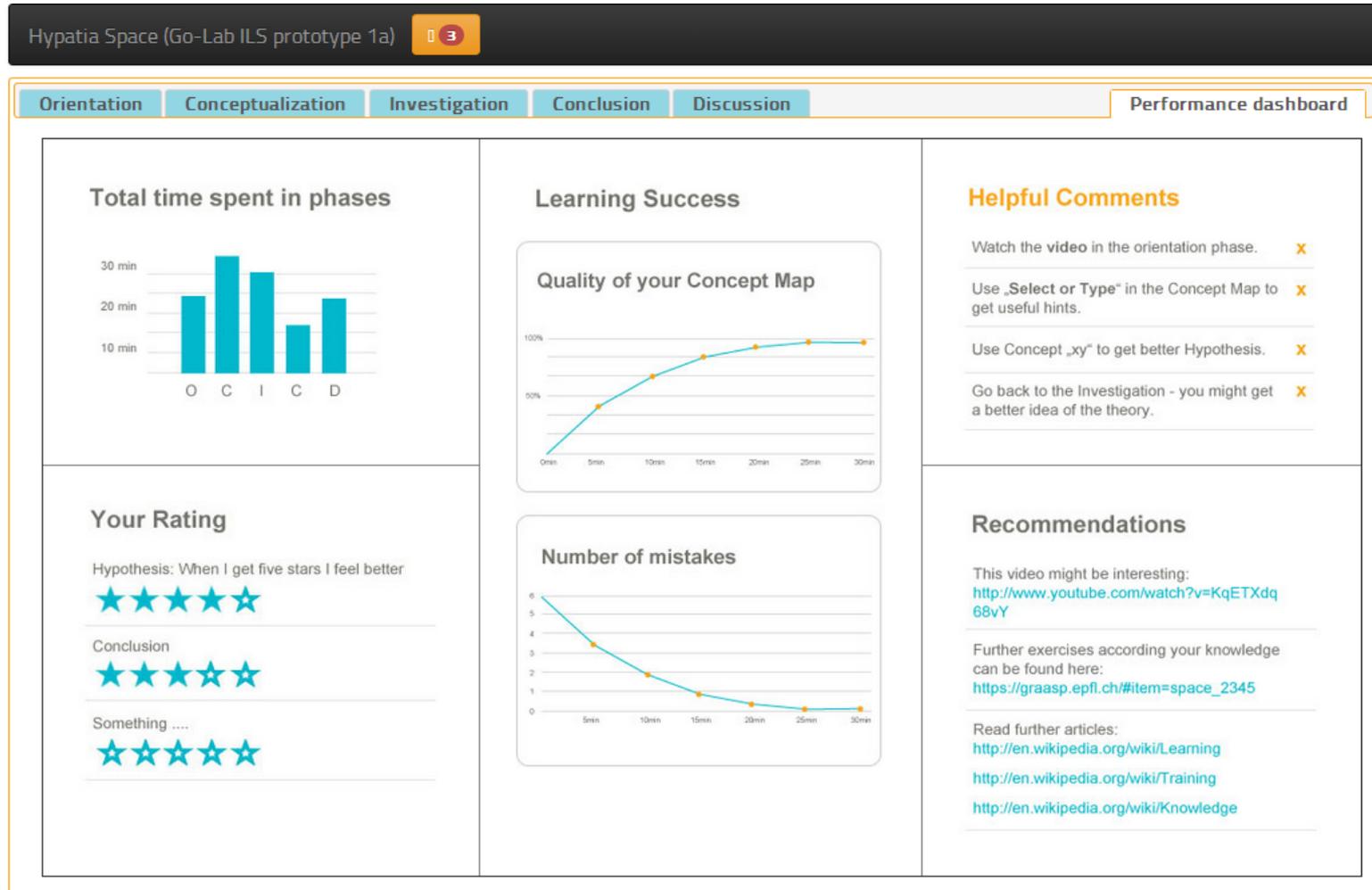
Why My Virtual Astronomer As Seen From Earth

Student view distributed by url.

Sharing of predefined inquiry learning spaces, apps and online labs in a **lab repository**.

Intelligent Student Support

- Supporting self-reflection through student dashboards.



Intelligent Student Support

- Intelligent feedback mechanisms.

The image displays two screenshots of the LA test ILS (Intelligent Learning Support) interface, illustrating intelligent feedback mechanisms.

Left Screenshot: Concept Mapper

- URL: shindig.epfl.ch/gadgets/ifr?container=default&mid=0&...
- Page Title: LA test ILS
- Navigation: Orientation, **Conceptualisation**, Investigation, Conclusion, Discussion
- Tool: Concept Mapper
- Diagram: A concept map showing 'density' connected to 'mass' via the relationship 'increases'.

Right Screenshot: Hypothesis Scratchpad

- URL: graasp.epfl.ch/metawidget/1/8f55c8308061522059441360416c91a65da49a79
- Page Title: LA test ILS
- Navigation: Orientation, Conceptualisation, Investigation, Conclusion, Discussion
- Tool: Hypothesis Scratchpad
- Notification: A pop-up message states: "Check your concept map for this hypothesis. In your concept map mass and density are related differently." with an "Ok" button.
- Content: A hypothesis scratchpad showing a hypothesis: "IF mass increases THEN density increases".

Learning Analytics

Learning Analytics - a common denominator for all types of measurement, collection, analysis and reporting of data about learners and their learning contexts with the aim of understanding and optimising learning and learning environments.

*big data?
(MOOCs?)*

*interest in algorithms &
computational methods*

*relation to educational
data mining?*

Spectrum of Learning Analytics Topics and Applications

- Prediction of students at risk from academic records
- Monitoring of course participation on learning platforms (e.g. Moodle)
- „Open Learner Modeling“ as a tool for reflection support
- Discourse and argumentation analysis

The Methodological „Trinity“ of LA

Activity analysis:

- process-oriented
- sequence analysis
(e.g. „process analysis“)
- action patterns

Artefact analysis:

- product-oriented
- information / text mining
- „semantic richness“

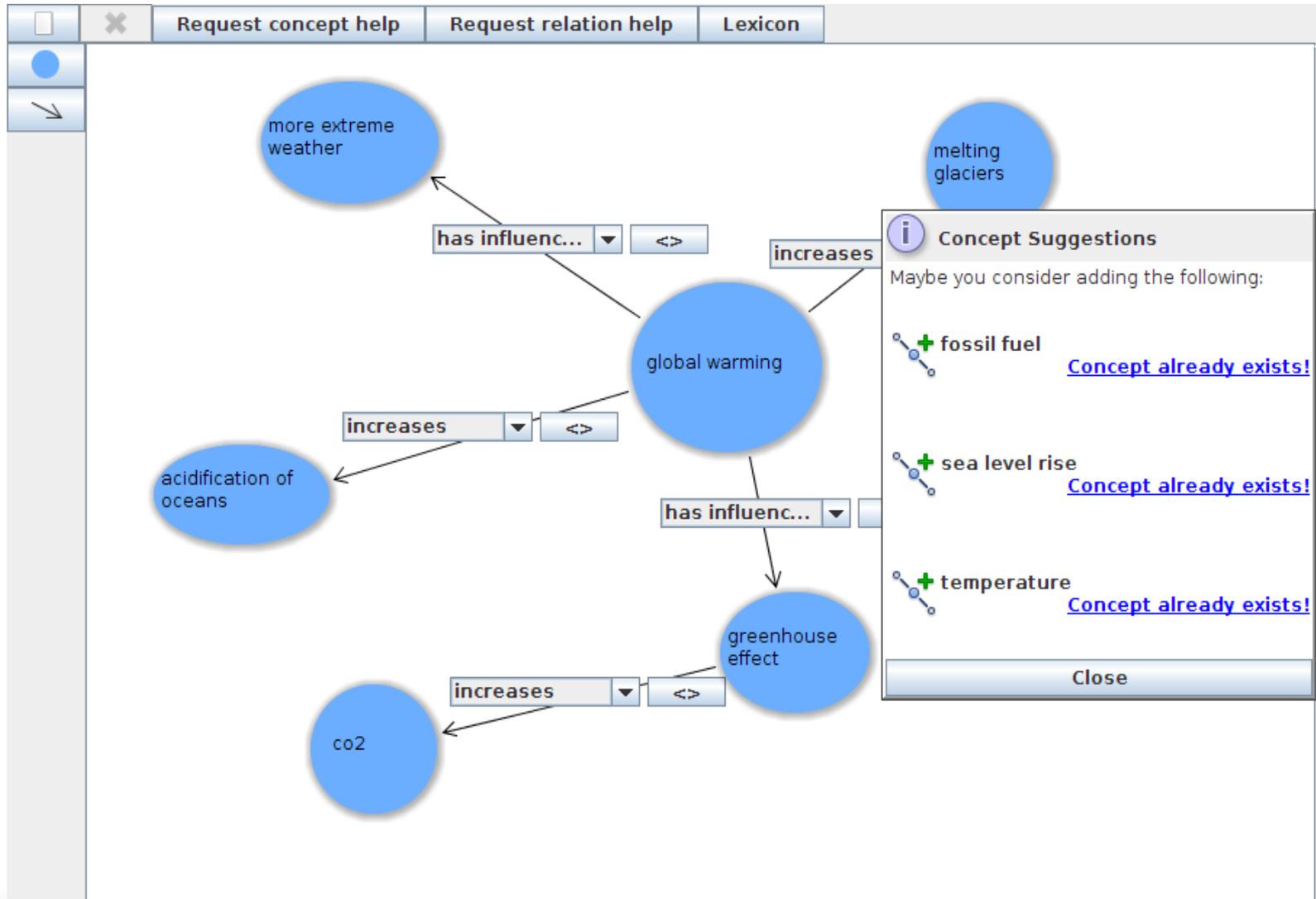
Network analysis:

- social or actor-artefact relations
- network measures
(centrality, cohesion, ...)
- no inherent time

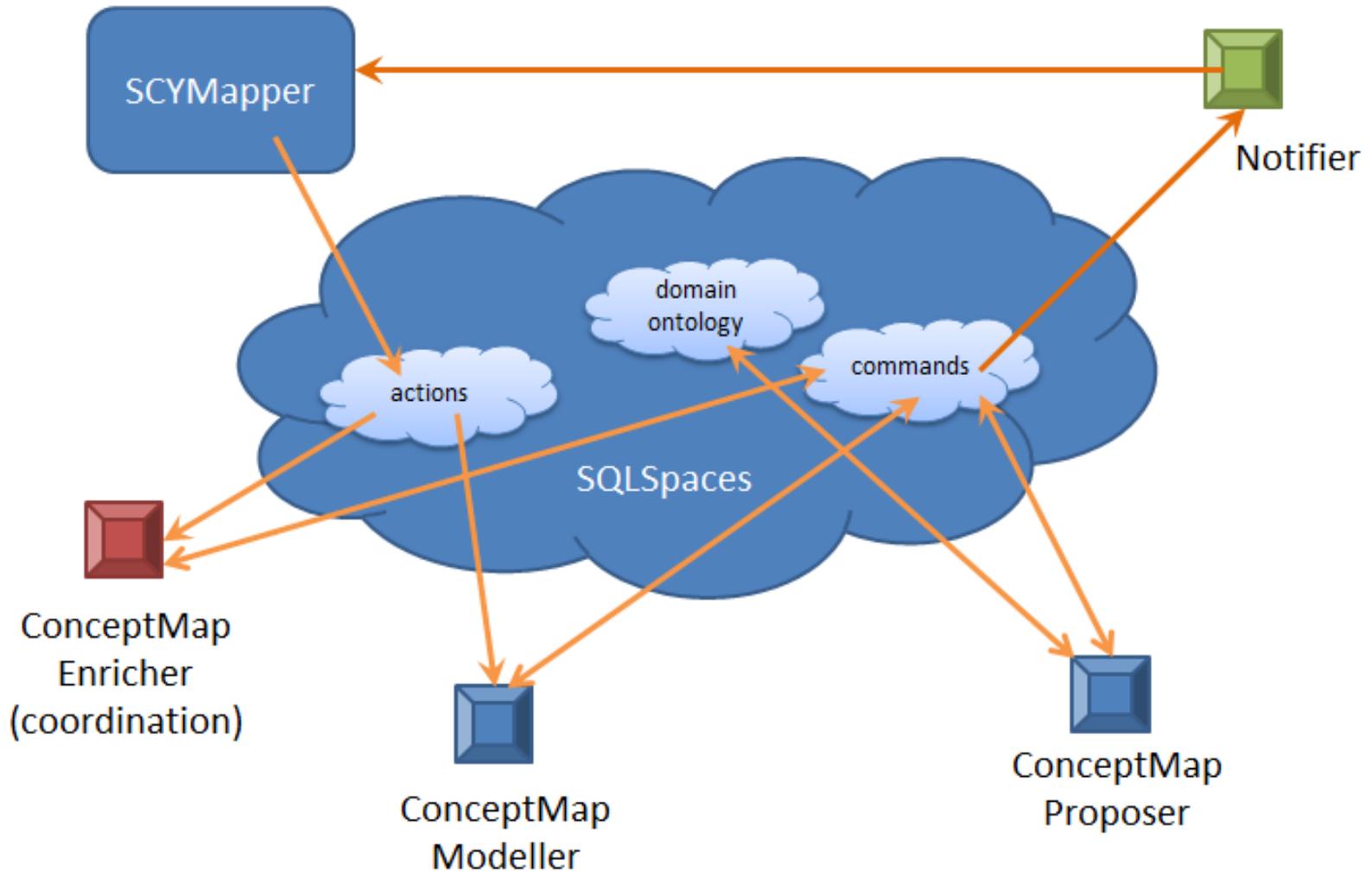
Example #1:

**Analyzing student created concept maps
(from project SCY)**

Scaffolding of CM Construction



Agent Architecture



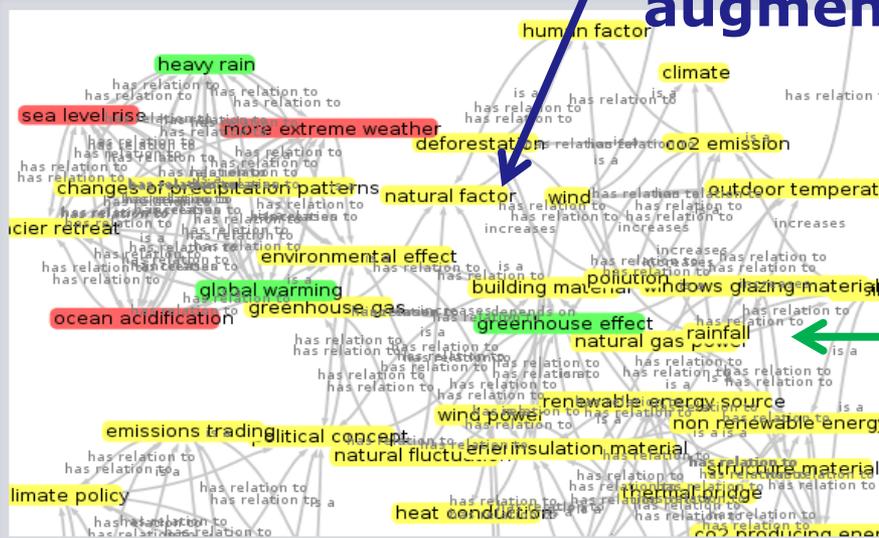
Ontology-based Support / Matching

keyword
extraction
(LDA)

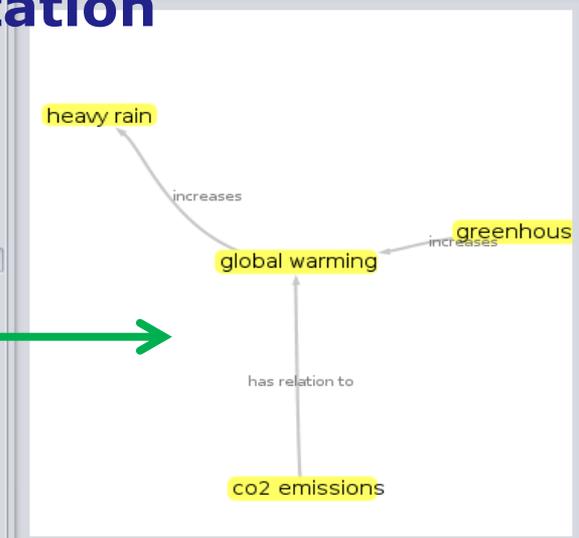
Global warming refers to the increase observed in recent decades the average temperature of the lower atmosphere and the oceans and their expected future warming. Between 1906 and 2005, the average temperature near the ground by 0.74 °C (+ / - 0.18 °C) has increased. The decade 2000-2009 was by far the warmest on record, followed by the 1990s, which in turn were warmer than the 1980s. According to current scientific understanding of this is 'very likely' the reinforcement of the natural greenhouse effect of human influence cause. The man-made warming caused by burning fossil fuels, deforestation and world-embracing agriculture and livestock. As a result, the greenhouse gas carbon dioxide (CO2) and other greenhouse gases like methane and nitrous oxide accumulates in the atmosphere so that less heat radiation emitted by the Earth's surface into space. By far the largest part of the past and expected anthropogenic warming is due to the recent and still growing increase of the greenhouse gas carbon dioxide. Through strong feedback processes is the direct heating effect of the carbon dioxide but with significantly less likely than expected, resulting from the heating, warming also secondary effects. By the year 2100, depending on future CO2 emissions and the actual response of the climate system to ensuring expect a warming of 1.1 to 6.4 °C. This would have a number of consequences: increased glacier melt, sea level rise, ocean acidification, changes in precipitation patterns, more extreme weather events, including With regard to the projected rise in sea level, many questions remain unanswered. The measured bandwidth of the rise in sea level by the end of the 21 Century is, depending on the scenario, 18 to 59 centimeters. The scenarios take into account but not the polar ice dynamics (eg, the collapse of large ice sheets in Antarctica) and uncertainties in climate-carbon cycle feedbacks: In a warmer climate will reduce the capacity of the oceans and the land surface of man-made CO2 because in warmer water less CO2 is dissolved and remove the soil at higher

ontology
augmentation

Ontology-generated Concept Map



Student Concept Map



Quality Assessment of CMs

Comparison to expert map(s)

Conlon, T.: 'Please argue, I could be wrong': a reasonable fallible analyser for student concept maps. Proc. of Ed-Media 2004.

Gouli, E., Gogoulou, A., Papanikolaou, K., Griggoriadou, M.: How to qualitatively + quantitatively assess concepts maps: the case of COMPASS. Proc. of AIED 2005.

Generic approach using *background knowledge* (a domain ontology) and *information extraction* (LDA) + *structural (graph-theoretical) measures*

Concept Mapping Study

Participants:

37 high school students aged between 16-18

Procedure:

- 45 min - introduction to concept mapping
(+ tool “SCY Mapper”)
- 45 min - reading/highlighting of a two page text on global warming followed by CM construction
- experimental group received adaptive suggestions
- control group could only access a dictionary

Expert Assessment

Four experts assessed the concept maps produced by the students ...

based on two criteria (inspired by Marra, 2002):
completeness regarding the concepts used
connectedness regarding the relations introduced (adequacy, missing rel's)

First Results

No significant differences between scaffolded and non-scaffolded conditions.

Predictive power of simple structural measures cannot be much improved by including of semantic features (ontology).

Correlations

*Correlation of **structural measures**
with expert judgments*

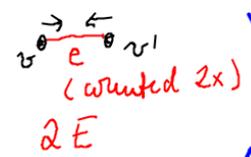
	Criterion 1 (completeness)	Criterion 2 (connectedness)
# nodes	$r = 0.79, p = 0.000$	-
# edges	$r = 0.74, p = 0.000$	$r = 0.63, p = 0.000$
density	$r = -0.53, p = 0.001$	$r = -0.26, p = 0.11$

A mathematical explanation

Problem: What is the average degree $d(G)$ for a given density?

$|V| = N$

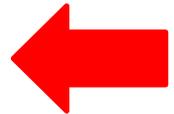
$$d(G) = \frac{1}{N} \sum_{v \in V} d(v)$$



$$S = \frac{2|E|}{N(N-1)}$$

$$= \frac{d(G)}{N-1}$$

$$d(G) = \frac{2 \cdot |E|}{N}$$



- In any graph *density* is *average degree* divided by #nodes.

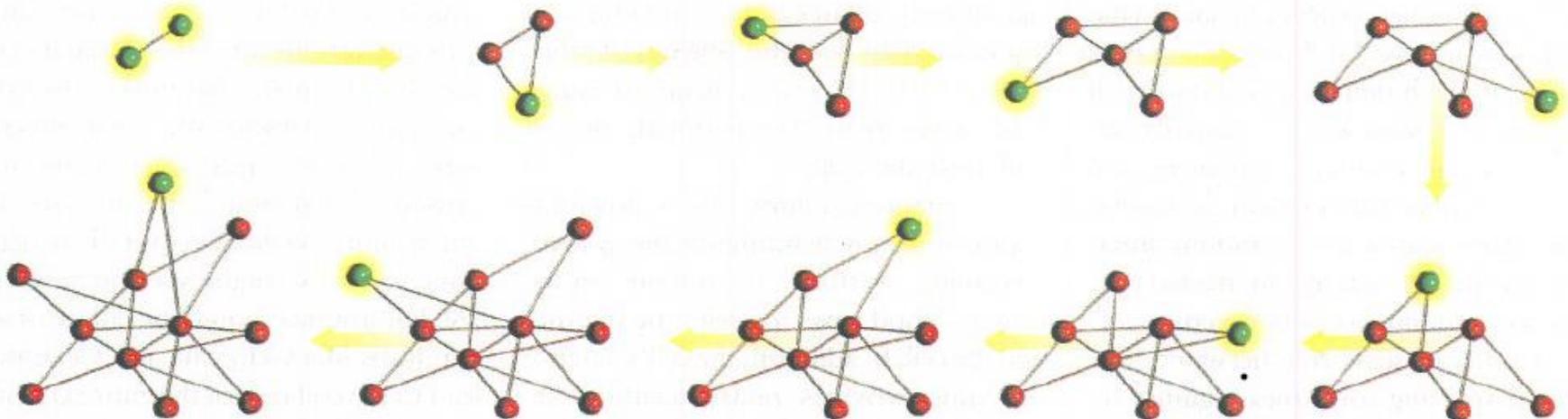
- In „scale-free networks“ the *average degree* tends to be stable.

- Hence: If CMs evolve like SFNs the density is highest for the ***smallest maps*** !

The Evolution of Scale-free Networks: *Preferential Attachment*

BIRTH OF A SCALE-FREE NETWORK

A SCALE-FREE NETWORK grows incrementally from two to 11 nodes in this example. When deciding where to establish a link, a new node (*green*) prefers to attach to an existing node (*red*) that already has many other connections. These two basic mechanisms—growth and preferential attachment—will eventually lead to the system's being dominated by hubs, nodes having an enormous number of links.



Barabási, Albert-László, Bonabeau, Eric (May 2003). "Scale-Free Networks".
Scientific American **288** (5): 60–9.

A Network Perspective on Concept Maps

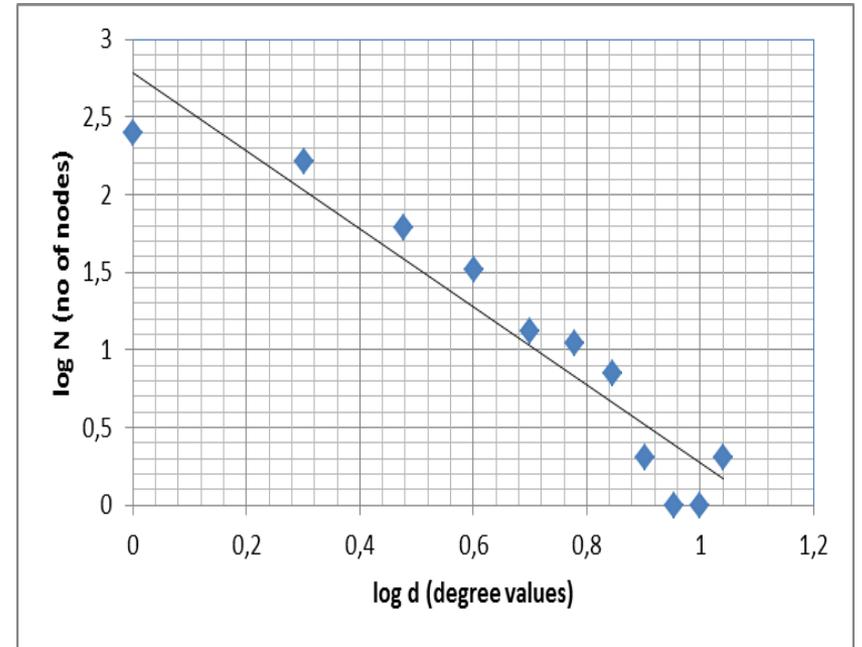
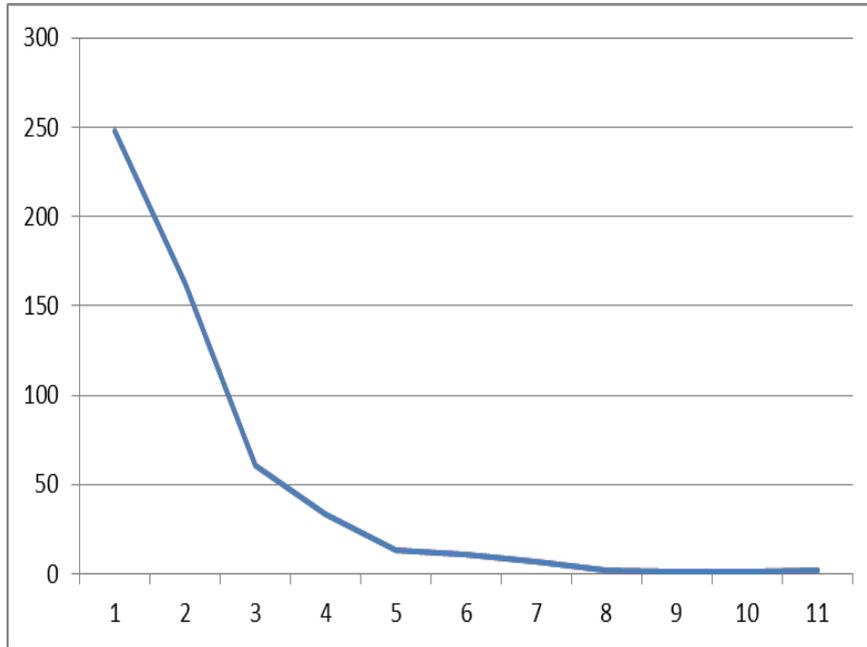
Concept maps are scale-free networks!

=> evolution of concept maps is governed by “preferential attachment”;

density decreases with growing networks

***M. Jacobson & M. Kapur (2010):
“Ontologies as scale free networks –
implications for theories of conceptual
change” (panel paper at ICLS 2010)***

The Litmus test



Aggregated degree distribution (from 37 maps)
left: number of nodes per degree value,
right: log-log graph

Related empirical work

Ifenthaler, Masduki and Seel (*Instructional Science*, vol. 39, 2011) compare a number of general graph theoretic measures to identify changes in cognitive structures using concept maps from five consecutive stages of a learning process

Table 4 Average scores (standard deviations in parenthesis) of graph theory based measures (organization) for measurement points 1–5 ($N = 25$)

		MP1	MP2	MP3	MP4	MP5
Surface structure	<i>M</i> (SD)	14.64 (7.99)	27.34 (14.13)	45.84 (23.85)	67.72 (48.94)	71.80 (46.71)
Graphical structure	<i>M</i> (SD)	5.52 (2.83)	7.62 (3.57)	9.48 (3.42)	12.08 (4.91)	11.72 (4.19)
Connectedness	<i>M</i> (SD)	.68 (.48)	.80 (.41)	.44 (.51)	.44 (.51)	.36 (.49)
Ruggedness	<i>M</i> (SD)	1.44 (.71)	1.32 (.74)	2.12 (1.42)	2.28 (1.49)	2.72 (2.01)
Average degree of vertices	<i>M</i> (SD)	1.93 (.43)	2.06 (.53)	2.12 (.39)	2.11 (.24)	2.09 (.26)
Number of cycles	<i>M</i> (SD)	2.52 (2.37)	3.38 (2.59)	4.12 (2.68)	4.76 (3.95)	4.48 (3.00)
Number of vertices	<i>M</i> (SD)	14.40 (6.69)	24.65 (11.76)	42.24 (22.60)	63.96 (45.85)	68.16 (44.33)

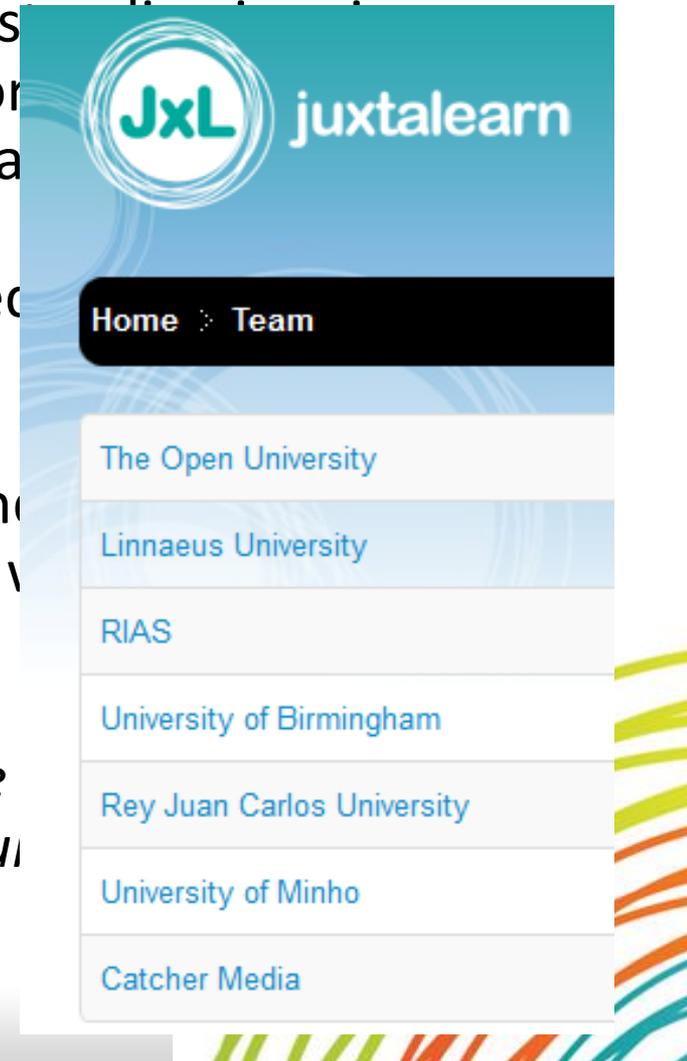
Example #2:

**Extraction of semantic networks
from textual artefacts created by students
(from ongoing project JuxtaLearn)**

Background:

EU Project JuxtaLearn (2012-2015)

- Provoking student curiosity and understanding of learning and technology through creative performance (concretely: film making – editing – sharing)
- Teaching and learning support is guided by learning concepts
- First step: identifying such concepts and their application by conducting face-to-face workshops with students
 - *Learning Analytics techniques are used to extract representations of the underlying conceptual relations*



Initial Workshops

- Teacher-student workshop
- Six A-level students
- Role reversal:
students teach the teachers
- Topics: Chemistry - moles,
Biology - alleles,
Physics - potential energy
- *transcripts and summaries analysed
using the AutoMap/ORR toolset
for Network Text Analysis*



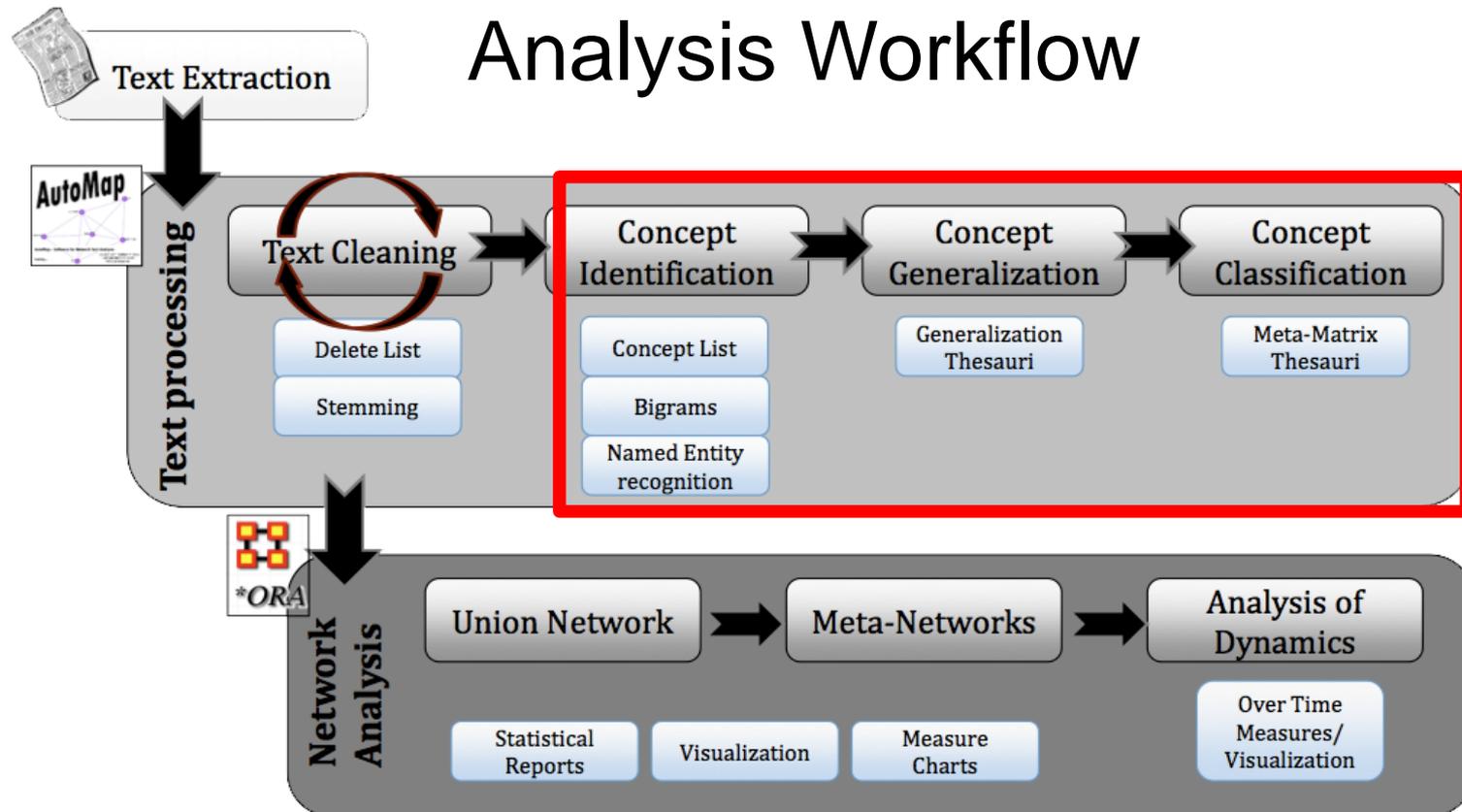
Network Text Analysis

- Use of the AutoMap and ORA software tools for „network text analysis“ developed by the CASOS group at CMU



- Workflow:
 - collection of workshop transcripts (textual artefacts)
 - pre-processing and analysing with AutoMap¹
 - visualization through ORA-Netscenes²
- Result:
generation of multi-modal concept maps
(with categories: actor, domain concepts, pedag. concepts ...)

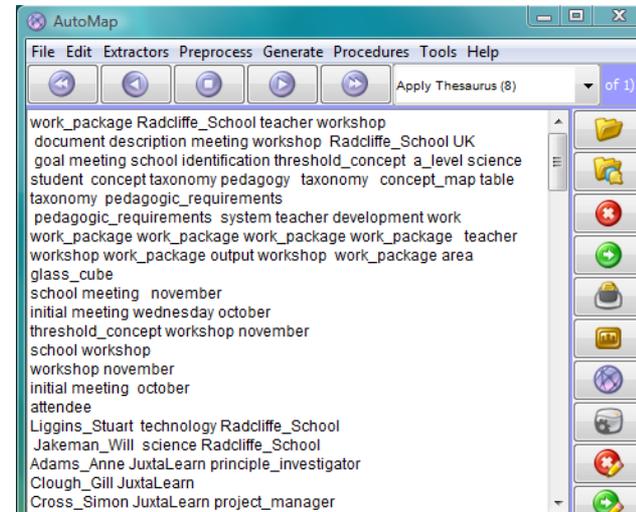
Network Text Analysis - Process



Concept generalization

Concept Generalization -> Generalization Thesaurus

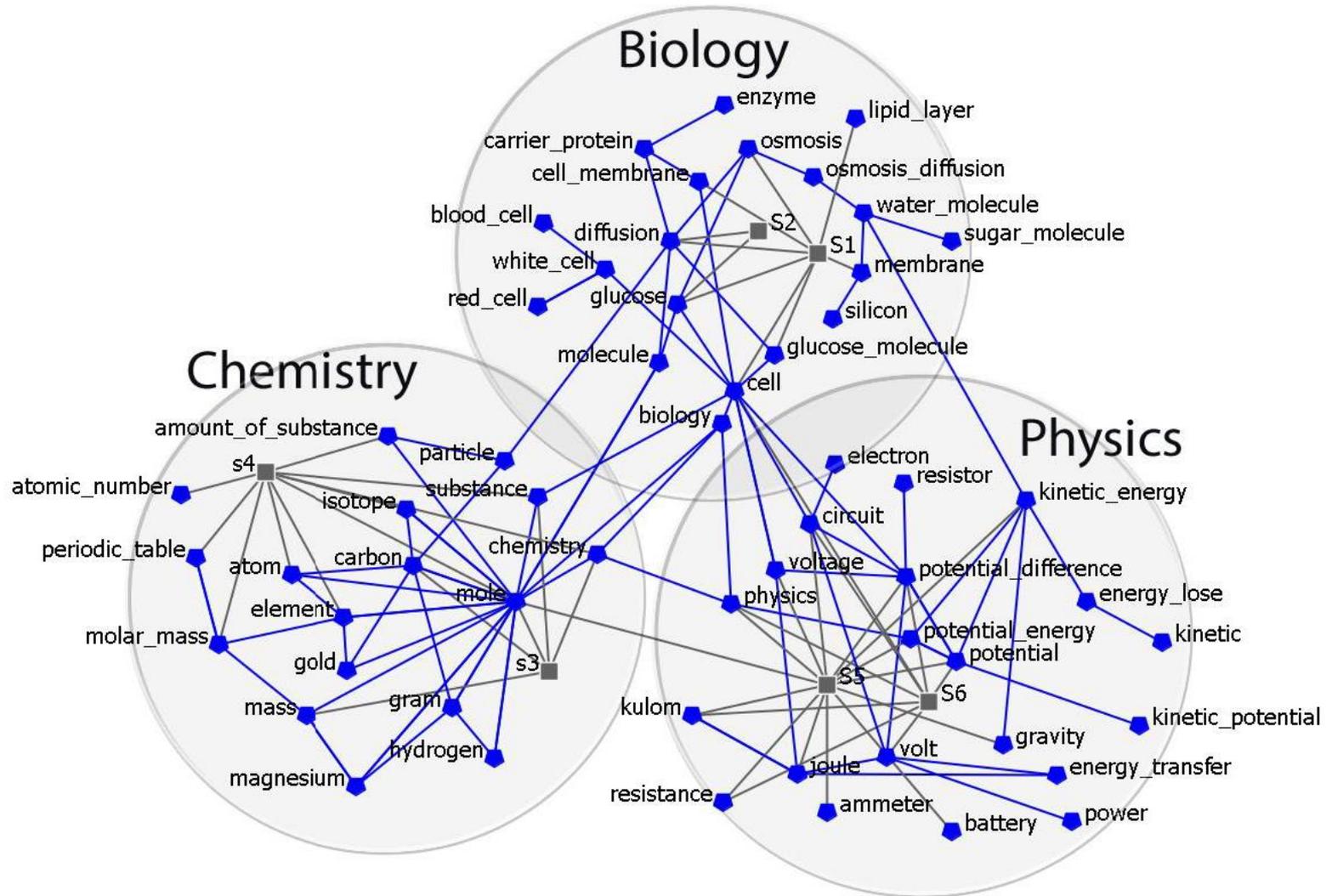
	A	B
2	Teachers	teacher
3	Teacher	teacher
4	teachers	teacher
5	teacher	teacher
6	Head of Technology	head_of_technology
7	Head of technology	head_of_technology
8	head of technology	head_of_technology
9	Head Technology	head_of_technology
10	Head technology	head_of_technology
11	head technology	head_of_technology
12	Head of science	head_of_science
13	Head of science	head_of_science
14	head of science	head_of_science
15	Head Science	head_of_science
16	Head science	head_of_science
17	head science	head_of_science



Concept Classification

- actor
- country
- general_concept
- (domain) knowledge
- pedagogical_concept
- role
- technical_concept
- tools_and_technologies
- > Meta Thesaurus

Teacher-Student Workshops - Results



„External“ Learning Analytics in JuxtaLearn

Extraction of information from *video comments* about:

- associations of concepts
(adequate or inadequate from a scientific point of view)
- identification of concepts that are frequently addressed in questions as indicators of possible origins of comprehension problems
- associations between concepts often used in answers as indicators for missing relations in students' mental models (=> misconceptions or “stumbling blocks”)

Case study: Khan Academy

Scaffolded questions & answers

Questions

Tips & Feedback

Top

Recent

Ask a question...

I understand the process, but I don't see why the water has a better chance of going IN than going OUT. I mean, if the sugar molecule is blocking from the inside, doesn't that mean the water from outside won't be able to squeeze in either? Why is it any different from either side of the membrane? Either way, the sugar is blocking...

[Show all answers](#) · [Answer this question](#)

Artefact Analysis - the JxL Approach

- Textual annotations of videos as indicators for students' understanding and potential misconceptions
- In addition to domain concepts “signal concepts” (difference between X and Y, help on X needed, etc.) indicate special relations
- Benefits for...
 - Researchers: insight into patterns of learning
 - Teachers: monitoring learning processes around videos
 - Students: system recommends videos or peer helpers

Data Selection / Extraction

- 1.284 comments from educational videos

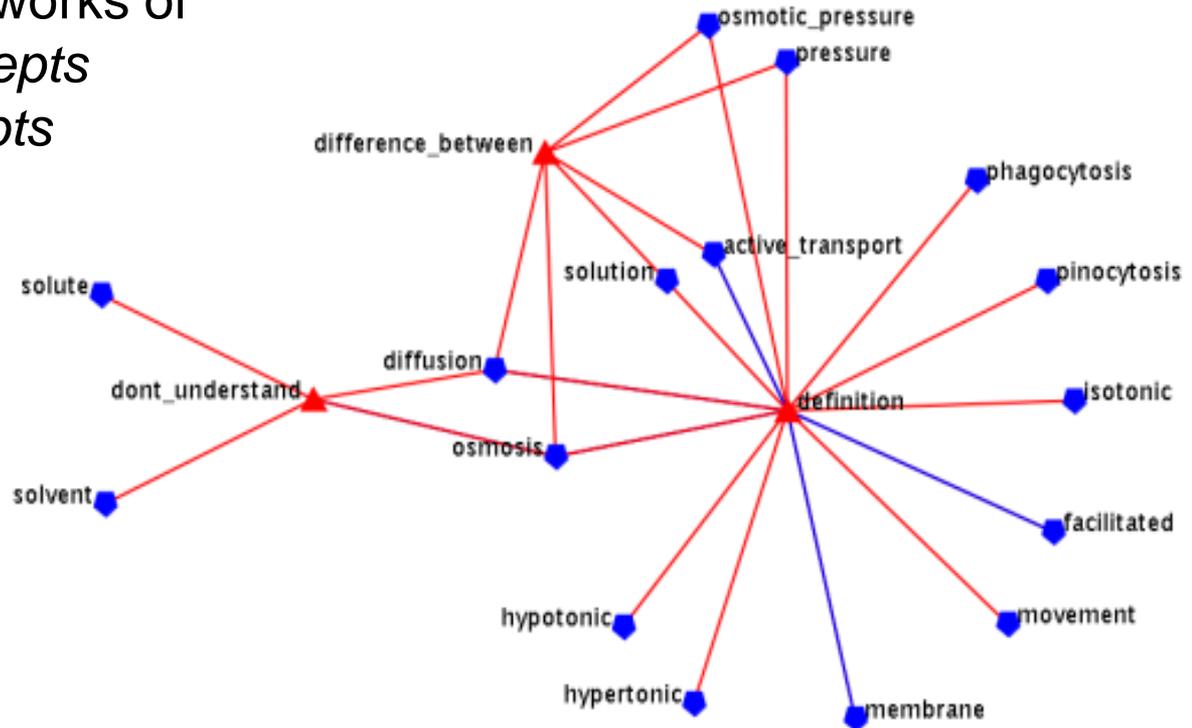
	chemistry	biology	physics
# <u>users</u>	328	309	86
# questions	279	184	70
# answers	362	312	77

- Video topics:
 - Chemistry: *Mole and Avogadro's Number*
 - Biology: *Diffusion and Osmosis*
 - Physics: *Voltage and Electrical Potential*

Resulting Multi-modal Network

Multimodal networks of

- *domain* concepts
- *signal* concepts

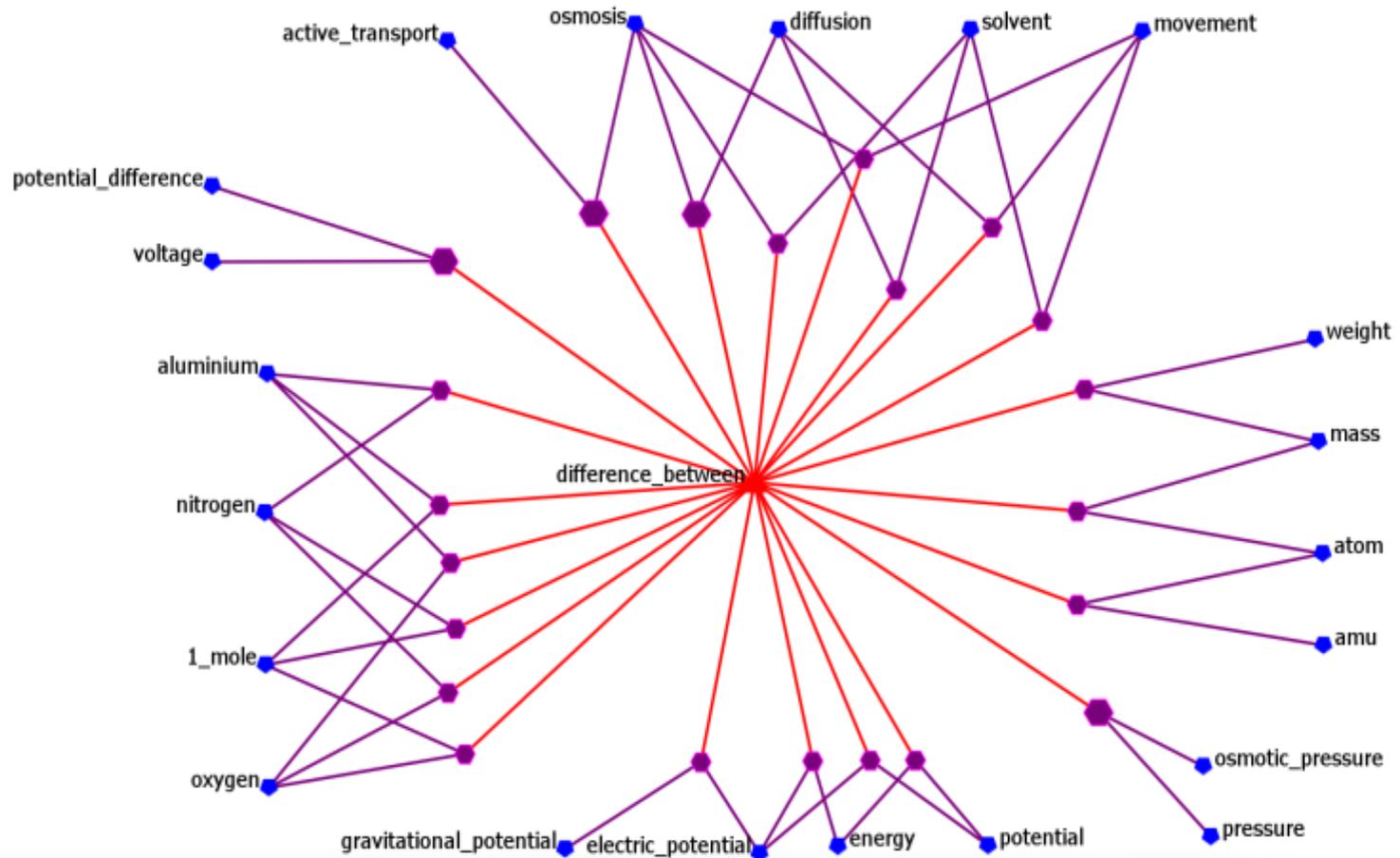


Examples:

- *I don't understand diffusion, but*
- *What's the difference between osmotic_pressure and solution??*

Multimodal Analysis - disambiguated

Introduction of *combination* nodes between *domain* concepts and *signal* concepts



Highlighting Results in Context

I finally understand osmosis. Thanks Khan!!

I: `do_understand` `osmosis` thanks khan

how i know if the membrane will allow sugar to diffuse or not? plzany body reply.

I: `explanation` i know if `membrane` be allow sugar diffusion not plzany body reply

KhanAcademy helped me to review a unit on OSMOSIS AND DIFFUSION in my BIOLOGY class!

I: `khan_academy` `help` review `unit` on `osmosis_diffusion` in biology class

hey is it possible for you to create a video explaining the pressure flow theory of phloem transport?

I: hey be possible creation video `explanation` `pressure` flow theory phloem transport

Still confused about osmotic pressure :/ wasted a bit of time..

I: still `confusion` about `osmotic_pressure` / waste bite time

how do the sugar molecules get out?

I: `explanation` `sugar_molecule` get out

Embedment into JxL Process



- Stimulate and support reflection & feedback by
- providing awareness of one's own performance
 - providing awareness about the learning process (students' progress, group structure)

Short Summary / Outlook

- *Artefact analysis* can help to identify problems of understanding and misconceptions
- Network perspective on knowledge artefacts facilitates new theoretical approaches
- For learning analytics combinations of the perspectives (*artefact – activity – network*) are needed!



Rauchen
verboten!

**QUESTIONS –
COMMENTS ?**