University of Zurich[UZH]

Institute of Education & Faculty of Science

“Trickle Up” Improvement of University Science Teaching

Evaluation of PCK-based training for PhD students

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Teaching Science at University

What is the problem?

High drop out rates in STEM

= 45% at 4-year US institutions (NSF, 2012)

Lecture hall 1940 - University of Wisconsin Archives

https://news.wisc.edu/newsphotos/aghall.html

The continued use of lecturing is the “pedag[redacted]8320)

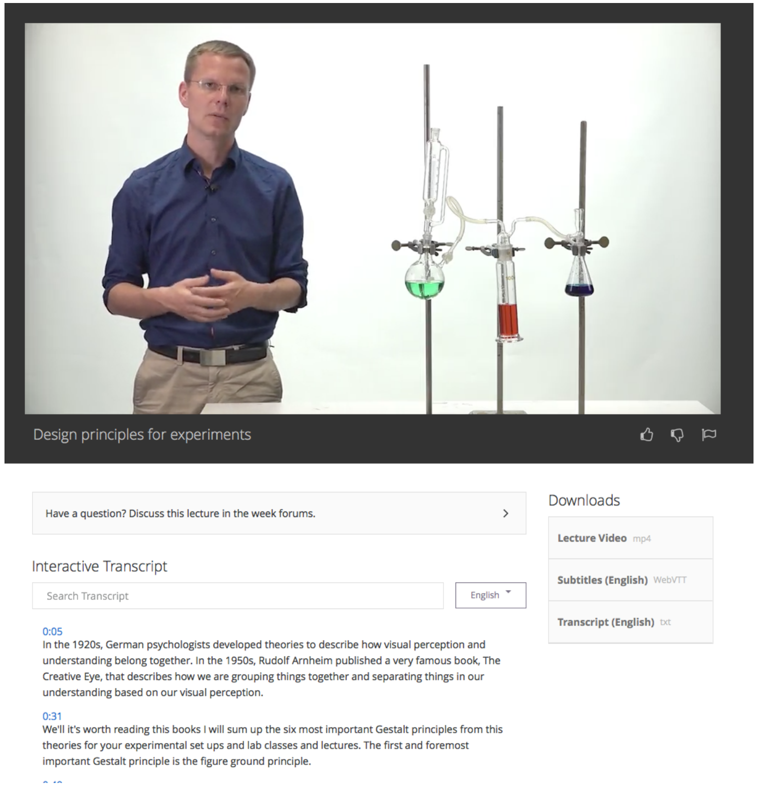
What is the problem?

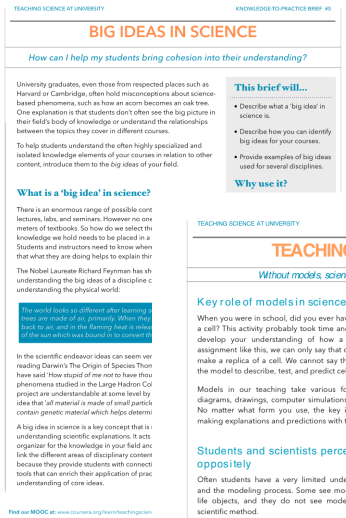
PhD students are asked to teach with little or no training

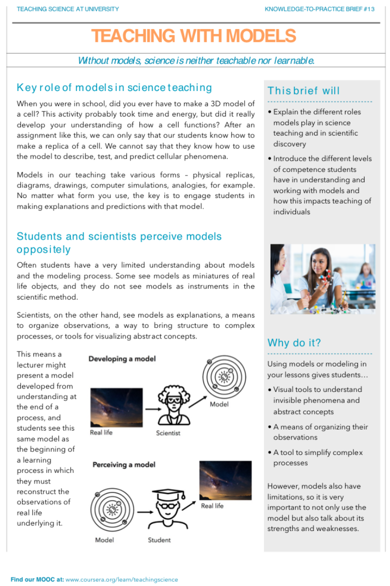
What makes someone a good instructor?	Vital
Explains clearly	97%
Fair	77%
Approachable to students	74%
Expertise in the subject matter	72%
...	
Promotes active student participation	51%
Gives students regular feedback on their learning	50%
Asks students about their prior learning	28%

How confident are you to...	Not so confident
Manage a class full of students with varying ability?	46%
Use a variety of teaching techniques (e.g. group work, collecting and giving feedback, discussions, etc.)?	38%
Promote student participation in your course?	34%
Determine final grades for a course?	34%
Plan learning activities (e.g. a series of lectures, a lecture then lab, homework, etc.)?	28%
…	
Answer students' questions and explain material clearly?	15%
Stand and teach in front of an audience?	10%
Create a positive learning environment?	10%

Teaching Science at University – MOOC format







Lecture → Transcript → Briefs → Assignment → Feedback

5 modules

- Evidence-based teaching strategies
- Conceptual Change
- Teaching with Analogies
- Teaching with socio-scientific issues
- Teaching science in the lab

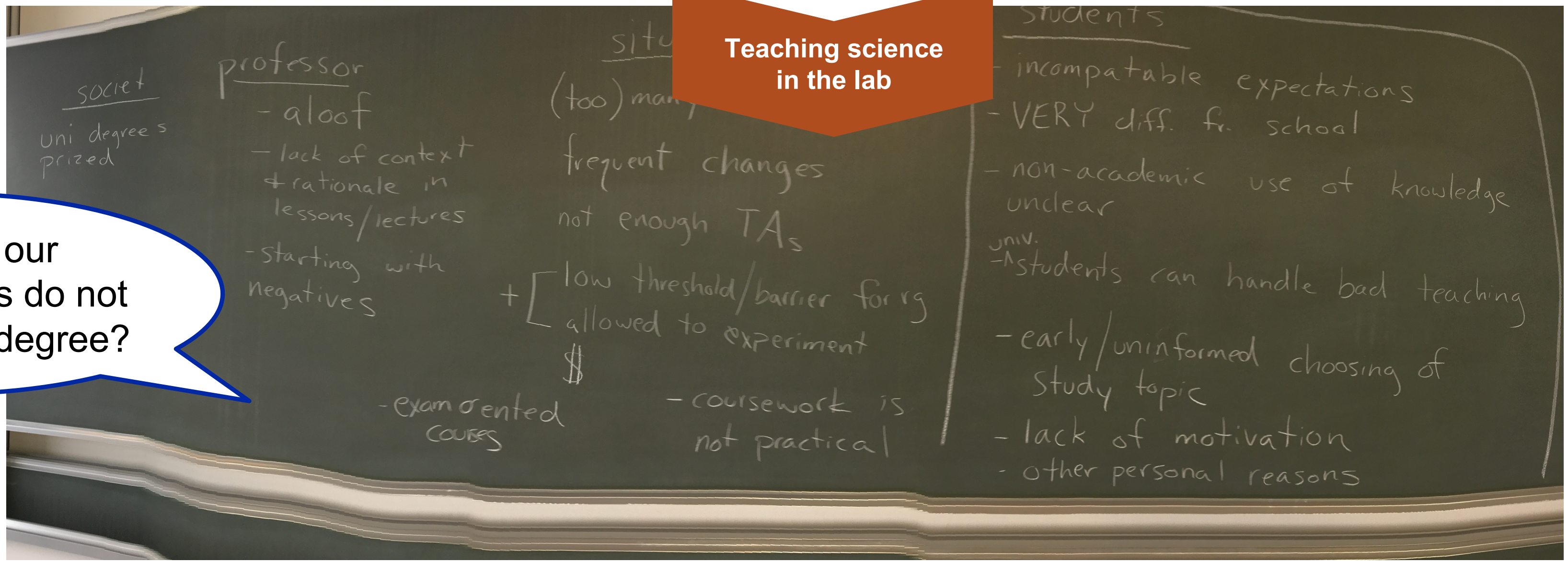
Blended format

Open to all PhD students

In-person Day 1:
- (Pre-course survey)
- Critical reflection on orientation to teaching
- Conceptual change basis

5 online modules
- Evidence-based teaching
- Conceptual Change
- Teaching with Analogies
- Teaching with socio-scientific issues
- Teaching science in the lab

In-person Day 2:
- Reflections on teaching experience & orientation
- Post-course survey



What % of our undergraduates do not complete their degree?

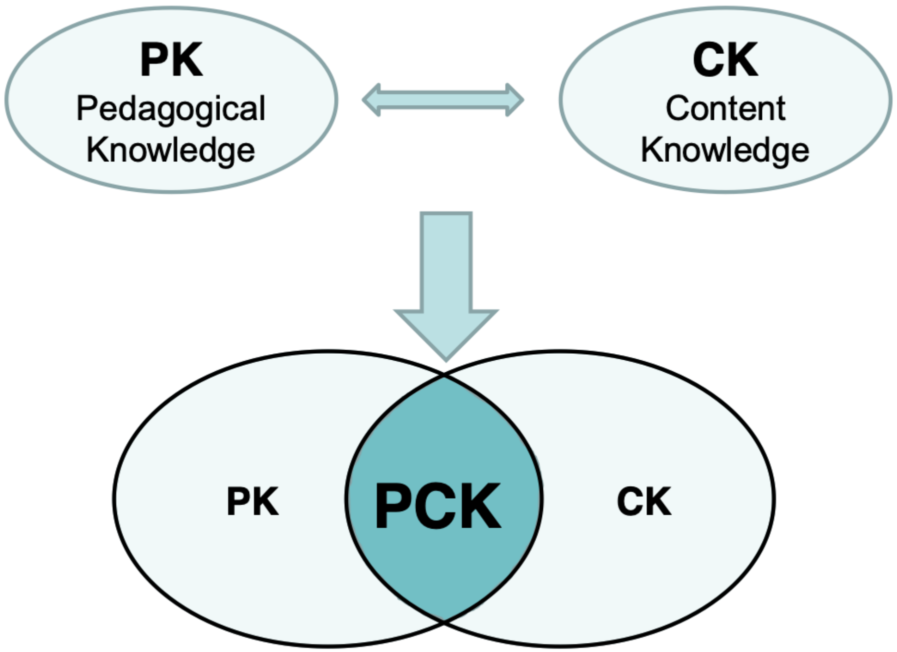
Does our intervention work?

Research question: How does a course on teaching science in higher education influence the teaching abilities and beliefs of PhD students?

Methodology

- Abilities? —> qualitative content analysis of assignments (n=63)
- Beliefs? —> pre/post survey analysis (n=100)

Pedagogical Content Knowledge



What is PCK?

- subject matter knowledge for teaching- “embodies the aspects of content most germane to its teachability” (Shulman, 1986, p.9)
- knowledge base for planning and delivering topic- and audience- specific teaching (Gess-Newsome, 2015)

Why focus on PCK?

- positive effect on instructional quality (e.g. Kunter et al., 2013)
- “reliable predictor” of teacher ability and action in the classroom (Park et al., 2010, p.254)

How to focus on PCK

- authentic practice (Putnam & Borko, 2000)
- individual and collective reflection (Van Driel & Berry, 2012)

Effects of the course I: Demonstration of PCK

Conceptual Change

Assignment questions:

1. Identify concept to teach
2. Identify relevant student everyday conceptions
3. Identify learning demands
4. Design a conceptual change intervention
5. Self Reflection

Peer review prompts:

1. Anything missing and why might this matter?
2. Most important preconception?
3. Will it improve student learning?

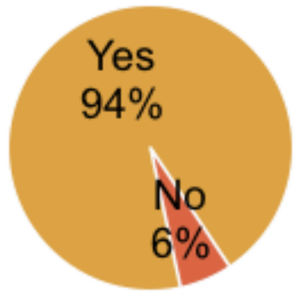
Effects of the course I: Demonstration of PCK

Conceptual Change

Assignment questions:

1. Identify concept to teach
2. Identify relevant student everyday conceptions
3. Identify learning demands
4. Design a conceptual change intervention
5. Self Reflection

Is this different from how you have taught before or were taught as a student?



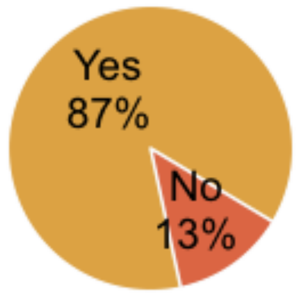
Effects of the course I: Demonstration of PCK

Conceptual Change

Assignment questions:

1. Identify concept to teach
2. Identify relevant student everyday conceptions
3. Identify learning demands
4. Design a conceptual change intervention
5. Self Reflection

Grain size of topic appropriate for a single intervention?



e.g. Newton's Laws of Motion vs. friction

Effects of the course I: Demonstration of PCK

Conceptual Change

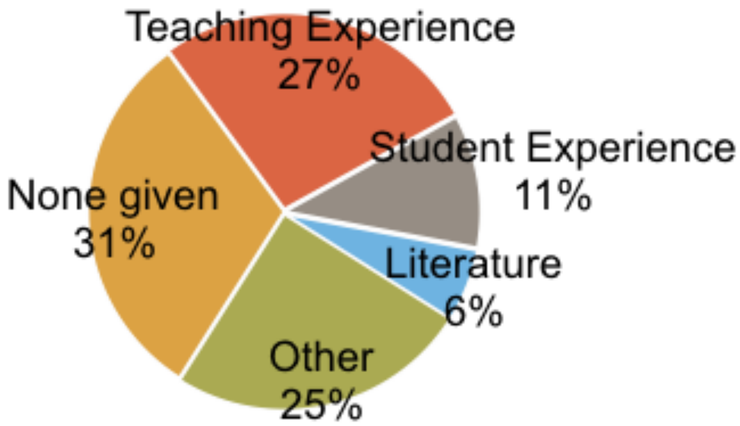
Assignment questions:

1. Identify concept to teach
2. Identify relevant student everyday conceptions
3. Identify learning demands
4. Design a conceptual change intervention
5. Self Reflection

Relevant conceptions?

e.g. Students think that objects with no forces acting upon them naturally come to rest.

Source of awareness?



Effects of the course I: Demonstration of PCK

Conceptual Change

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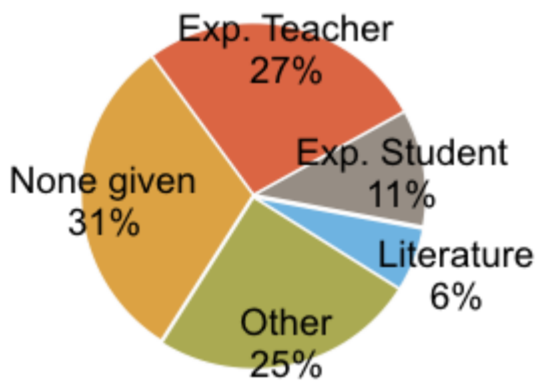
Source of awareness?



Breakdown by cohort:

Experience as a teacher:
Coursera 34%, Blended 18%

Experience as a student:
Coursera 0%, Blended 24%

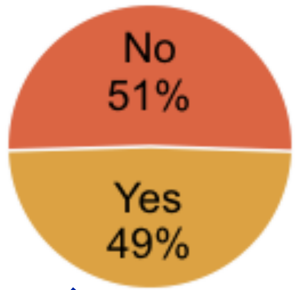
Effects of the course I: Demonstration of PCK

Conceptual Change

Assignment questions:

1. Identify concept to teach
2. Identify relevant student everyday conceptions
3. Identify learning demands
4. Design a conceptual change intervention
5. Self Reflection

Included cognitive conflict in intervention plan and in what form?



44% Afford a student experience/inquiry
e.g. experiments with collisions on
air hockey table

50% Information transmission

Effects of the course II: Changes in orientation to teaching

1. Increased metacognition about teaching

*"I had **never thought the actual act of giving feedback**, and I believe being conscious of it while doing it may help me provide more insightful feedback."*

*"I have never thought of raising socioscientific issues using frames… Probably, it's very intuitive, but **I never managed to actively put a name to it**"*

2. Shift in attitude towards teaching

*"I think our work as TAs is not appreciated during our PhD. After this course, I feel that it is actually important for others… **It was pleasant to feel satisfied with my teaching and not just see that as "unproductive" time during my PhD**."*

*"I used to think that that histology and embryology could not be taught in a motivating, engaging way. But now I think **it can be fun for me as a professor and for the students as well**, elevating the possibilities that the knowledge that the students build will be more significant and last longer."*

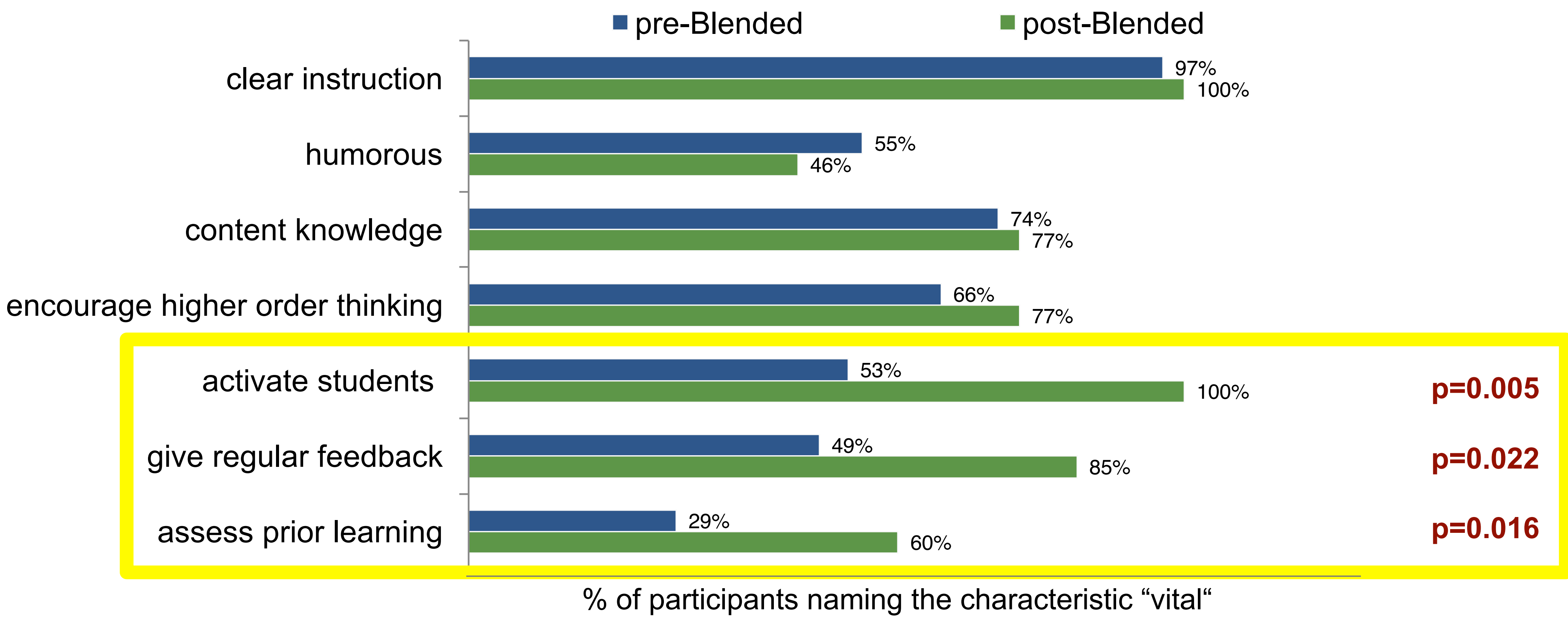
Effects of the course II: Changes in orientation to teaching

3. Shift of focus towards students and their learning

*"I used to think … learning objectives are a **formality**. Now I think, … learning objectives **genuinely guide student learning** to give them confidence."*

*"I used to think of **how I would teach** and the clarity of how/what to deliver, but now I think more from what is more **important for the students and what they struggle understanding the most."***

Pre/Post Survey: What makes someone a good instructor?



n=37 blended, Participants were able to rate any/all as “vital,” “somewhat important” or “less important.”

Conclusions

- TSAU offers transformation, not just a few more tricks.
- Most participants report teaching differently, and in a way that is:
  - more PCK- and student- oriented
  - more able to identify and use student preconceptions
  - more confident

- All PhD students should receive similar training.

How confident are you to...	PRE Not so confident	POST Not so confident
Manage a class full of students with varying ability?	46%	14%
Use a variety of teaching techniques (e.g. group work, collecting and giving feedback, discussions, etc.)?	38%	0%
Promote student participation in your course?	34%	7%
Determine final grades for a course?	34%	14%
Plan learning activities (e.g. a series of lectures, a lecture then lab, homework, etc.)?	28%	7%
…		
Answer students' questions and explain material clearly?	15%	3%
Stand and teach in front of an audience?	10%	7%
Create a positive learning environment?	10%	0%

Thank you!

Citations:

Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK Summit. In: Berry, A., Friedrichsen, P. & Laughran, J. (eds) *Re-examining Pedagogical Content Knowledge in Science Education.* New York: Routledge.

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www.coursera.org/learn/teachingscience

Teaching Science at University

Top Tip

Narrative, formative peer review feedback, **especially when well curated**, leads to better exchange between participants than rubric-based, summative feedback.

Version 1

47% Retention

Does the writer has a realistic feeling for how students will respond to the teaching strategy.

Poor – The writer did not reasonably address the student perspective. - 0

Fair – The writer anticipates student response to the strategy, but I think it could be more realistic. - 1

Good – The writer seems to really understand how students would respond to this strategy and shows realistic insight into student learning and behavior in this situation. - 2

Version 2

71% Retention

How realistic is the writer's sense of how students will respond to the teaching strategy?

Change in confidence

PRE

	PRE Not so confident	POST Not so confident
Manage a class full of students with varying ability?	46%	14%
Use a variety of teaching techniques (e.g. group work, collecting and giving feedback, discussions, etc.)?	38%	0%
Promote student participation in your course?	34%	7%
Determine final grades for a course?	34%	14%
Plan learning activities (e.g. a series of lectures, a lecture then lab, homework, etc.)?	28%	7%
…		
Answer students' questions and explain material clearly?	15%	3%
Stand and teach in front of an audience?	10%	7%
Create a positive learning environment?	10%	0%

POST

	Not so confident
Manage a class full of students with varying ability?	14%
Determine final grades for a course?	14%
Stand and teach in front of an audience?	7%
Promote student participation in your course?	7%
Plan learning activities (e.g. a series of lectures, a lecture then lab, homework, etc.)?	7%
Support and encourage students who are having difficulty learning?	7%
Be sufficiently knowledgeable in the subject matter?	3%
Answer students' questions and explain material clearly?	3%
Assess student understanding?	3%
Encourage higher level (independent, critical, creative) thinking?	0%
Use a variety of teaching techniques (e.g. group work, collecting and giving feedback, discussions, etc.)?	0%
Create a positive learning environment?	0%

Participant numbers

Coursera

Participant numbers to date:
- 23 sessions
- 3500 enrollments
- 154 completers

Blended

Participant numbers to date:
- 3 sessions
- 42 enrollments
- 37 completers
- 2 ECTS

Blended format II

TAs for a specific course

In-person Day 1:

- Intro and logistics by course leader
- Top 10: most challenging content
- Top 10: most challenging teaching situations

In-person Day 2:

- Reflections on teaching experience
- Top 10 strategies from TSAU online
- Group development of teaching tools

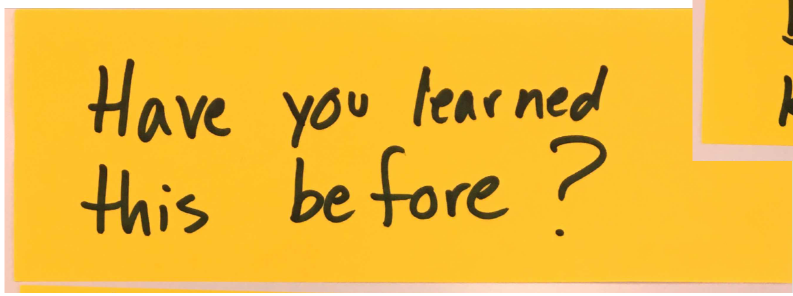
Start

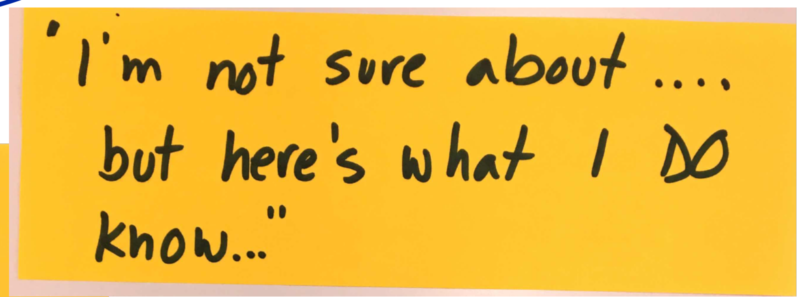
End of semester

Participant numbers to date:

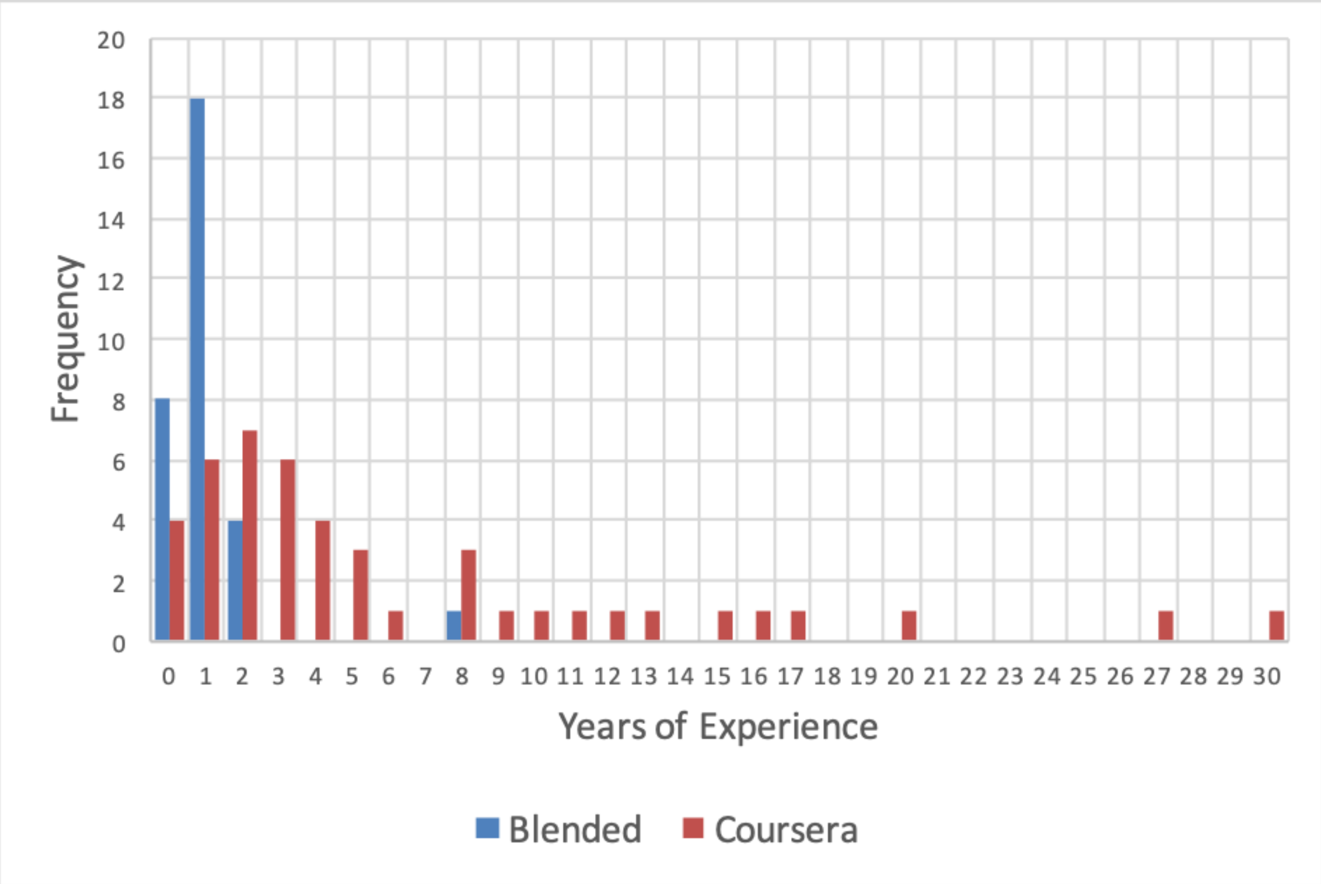
- 1 session
- 9 participants

How can I improve my 1-to-1 work with students?





Two distinct cohorts



Previous training?

Coursera 50%

Blended 15%

Pedagogy certificate/degree?

Coursera 13%

Blended 0%

"Very confident" to stand and teach in front of an audience?

Coursera 80%

Blended 21%

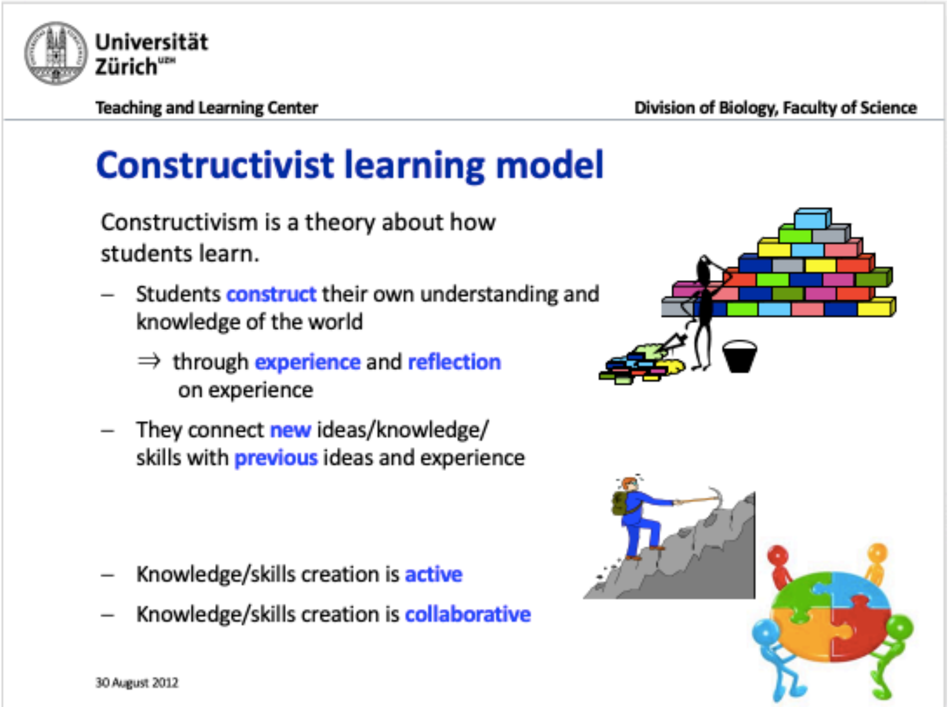
Survey numbers

Coursera n=61

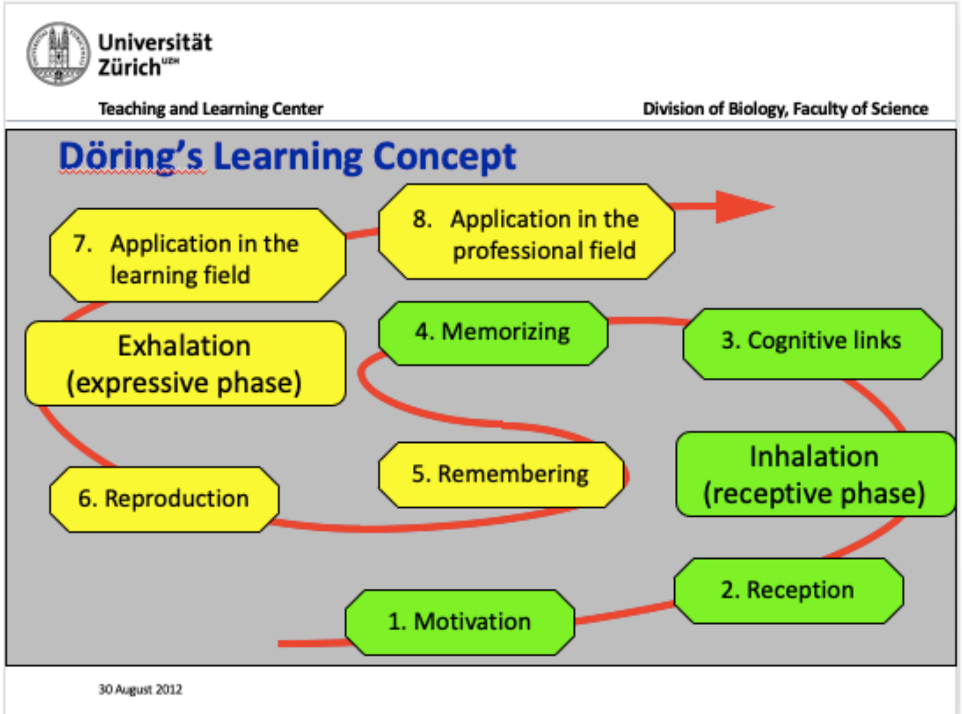
Blended n=39

Useful? anecdote/example

Constructivism



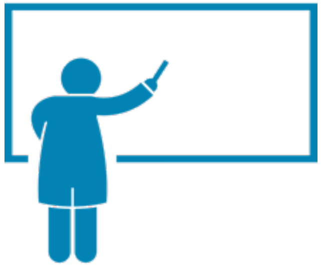
Döring's Learning Concept



Course Completion

		Version 1	Version 2
		12 SESSIONS	4 SESSIONS and going
		Peers = summative graders	Peers = critical peers
		TOTAL ASSIGNMENTS SUBMITTED	**TOTAL ASSIGNMENTS SUBMITTED**
1	Evidence-based teaching strategy	219	46
2	Initiate a conceptual change	153	33
3	Develop an analogy	137	31
4	Reframe your teaching	124	29
5	Foster students' inquiry skills	104	29
	AVG retention (%)	48%	63%

Teacher-centered



What scientific content will you teach?

Describe an experiment you teach.

Five modules

- Evidence-based teaching strategies
- Conceptual Change
- Teaching with Analogies
- Teaching with socio-scientific issues
- Teaching science in the lab

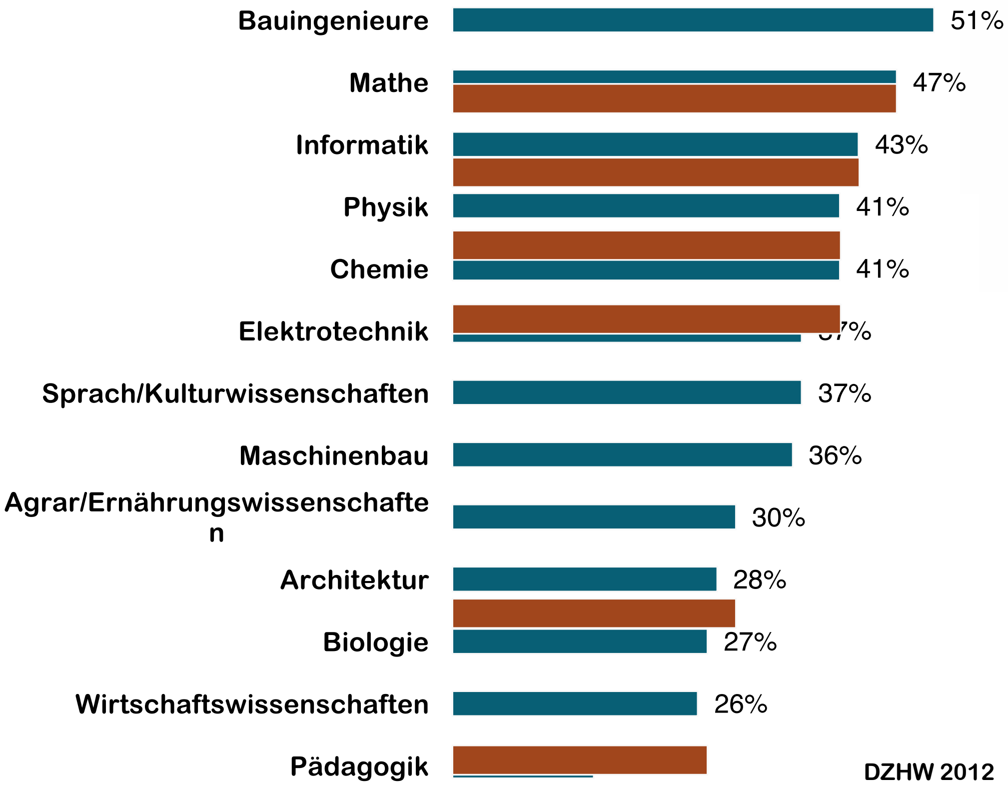
Student-centered

Describe the typical everyday conceptions of your students on the topic.

Think how this concept, method, or experiment has a relevance for your students' everyday life.

How will you know if students are learning?

Dropouts and their reasons



Studienabbruch und Studienfachwechsel in den mathematisch-naturwissenschaftlichen Bachelorstudiengängen der Humboldt-Universität zu Berlin

Autorinnen: Wenke Seemann und Maika Gausch

Berlin, Januar 2012

80%) und niedrigere Absolventenquoten von teilweise nur 10 bis 20 Prozent aufweisen und demnach besonders stark von dem Phänomen betroffen sind.

Die Ergebnisse der Onlinebefragung von Studienabbrechern und Studienfachwechslern mathematisch-naturwissenschaftlicher Bachelorstudiengänge machen deutlich, dass aus der Sicht der Befragten insbesondere Gründe, die mit den Studienbedingungen und Leistungsanforderungen der Fächer zusammenhängen, für das vorzeitige Verlassen eines mathematisch-naturwissenschaftlichen Studiengangs entscheidend sind. Leistungsprobleme und ein als zu hoch empfundener Zeit- bzw. Arbeitsaufwand sind nach Angaben der Befragten Hauptursache für den Studienabbruch, wobei diese Faktoren durch zu wenig Betreuung und eine als unzureichend eingeschätzte didaktische Qualität der Lehre flankiert werden. Darüber hinaus wird ein vorzeitiges Beenden eines mathematisch-naturwissenschaftlichen Bachelorstudiengangs häufig mit falschen Erwartungen hinsichtlich der inhaltlichen Ausrichtung und einem fehlenden Praxisbezug begründet, während Aspekte der beruflichen Neuorientierung oder persönliche Gründe im Allgemeinen eine eher untergeordnete Rolle spielen. Für die Mehrheit der Befragten ist mit dem Studienabbruch kein Abschied aus dem Hochschulsystem verbunden, denn 57 Prozent der befragten Studienabbrecher haben zum Zeitpunkt der Befragung wieder ein Studium aufgenommen.

Training teachers versus training scientists

Differences in expectations, priorities and professional identity:

SCHOOL TEACHERS

- Assume a heterogeneous audience
- Smaller classes – more personal contact with students
- Care more for affective aspects of student performance (personal development, norms, values)
- **Career goal = Excellence in teaching**

UNIVERSITY TEACHERS

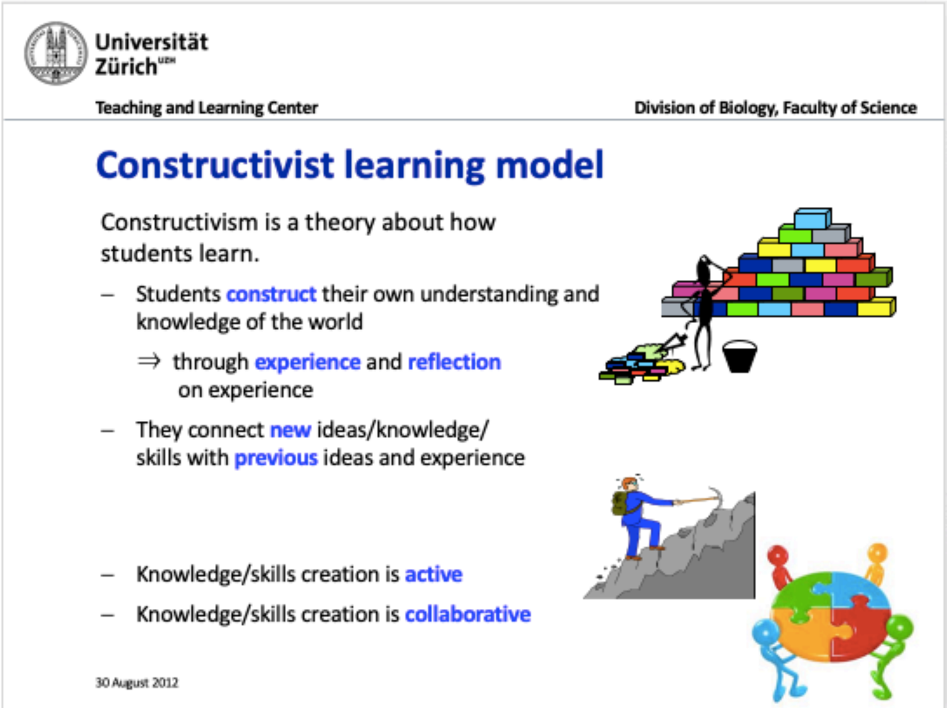
- Assume a (more) homogeneous audience
- Focus on training content specialists
- "Sink or swim" mentality - more likely to think student effort/ability underlies course failure
- **Career goal = Excellence in research**

"University teachers apparently consider themselves first and foremost not teachers but members of a certain discipline."

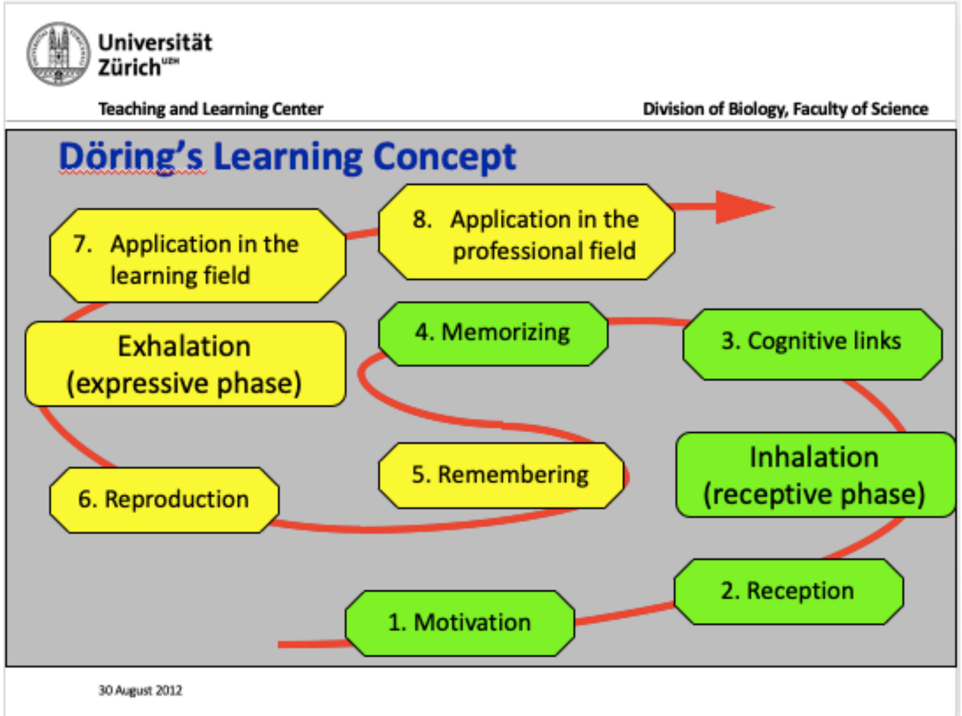
(p. 594, Oolbekkink-Marchand, van Driel & Verloop, 2006)

Useful? anecdote/example

Constructivism



Döring's Learning Concept



Improving peer feedback

BEFORE

RUBRIC
Give one point if at least one similarity and one dissimilarity are described.
Give two points if at least three similarities and two dissimilarities are described.
Give no points if nothing is described.

Give a short feedback to explain your decision.

Peer 1
"Very good attempt. But in question 1 the student's pre-conception has not been addressed."

Peer 2
"Great job! Very elaborate response and a very illustrative analogy"

Peer 3
"Very good description"

SUMMATIVE RUBRIC-BASED EVALUATION

AFTER

Criterion – Instructional Strategy
How well did the writer analyze the strengths and weaknesses of his/her analogy? What important strength or weakness did s/he leave out?

Criterion – Student understanding
Are you convinced that students will be familiar with the source domain? Why or why not?

FORMATIVE, NARRATIVE EVALUATION