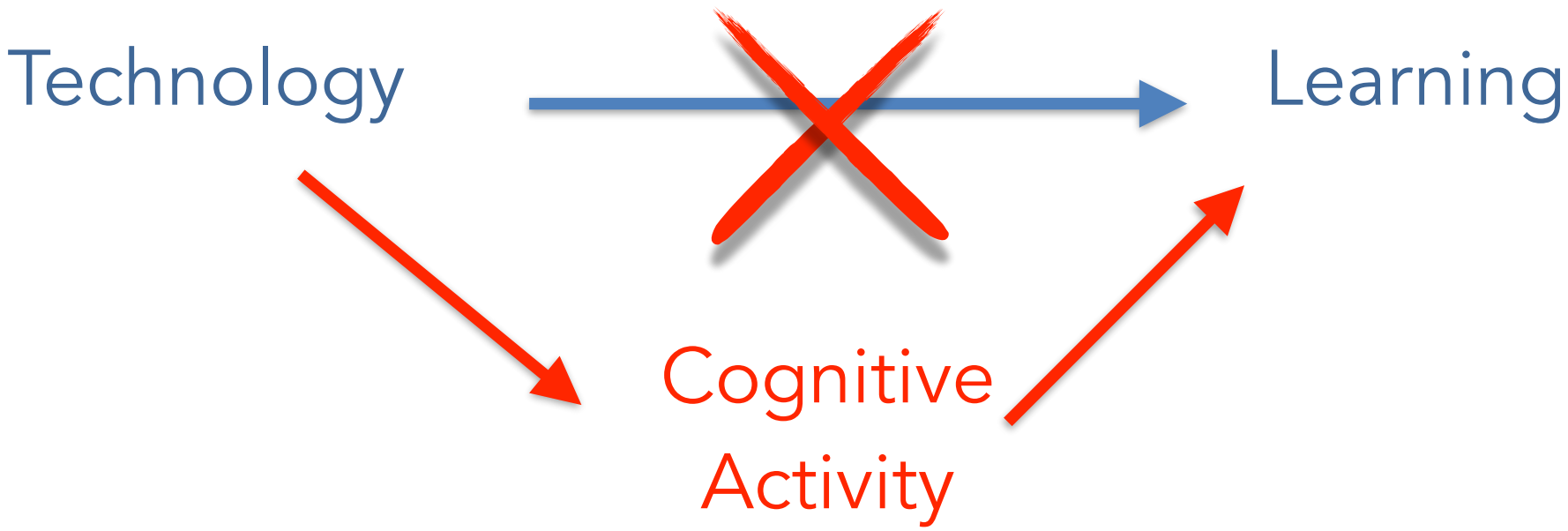
CS-411 : Digital Education

Chapter 1:

Introduction to digital education

Pierre Dillenbourg, Tanja Kaser, Patrick Jermann, Chris Petrie, Zhenyu Cai, Dominik Gandorf

EPFL



what learners learn
does not depend on the specific technology
but on the cognitive activity learners has to do
(with this technology)

CS-411

Technology

We design

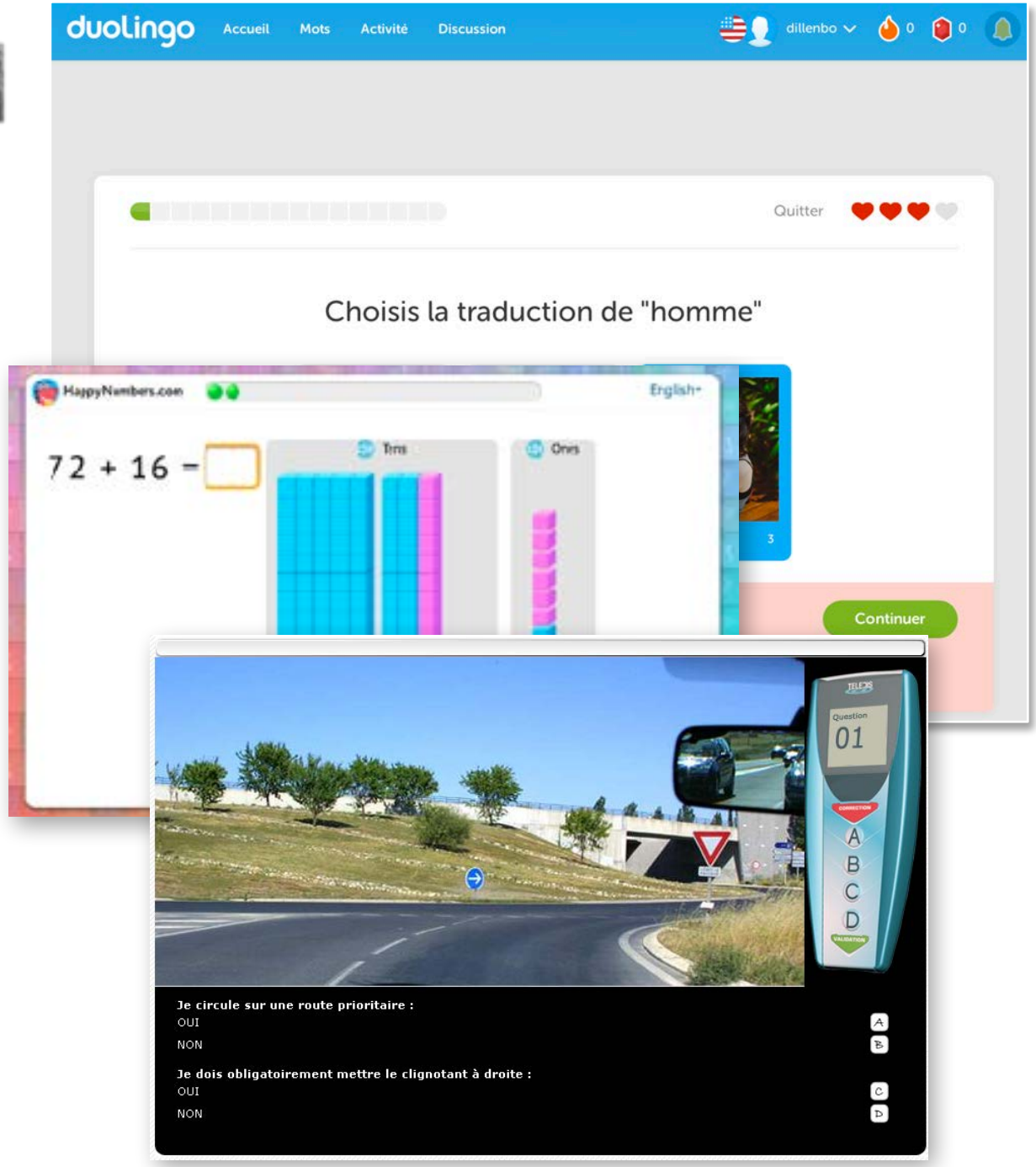
Learning

We measure

Cognitive Activity

We run causal experiments

- Drill & Practice
- Online education platforms
- Learning Management System
- Classroom participation systems
- Simulations
- Microworlds
- Teamwork support
- Augmented reality
- Virtual reality
- Serious Games
- Education Robotics



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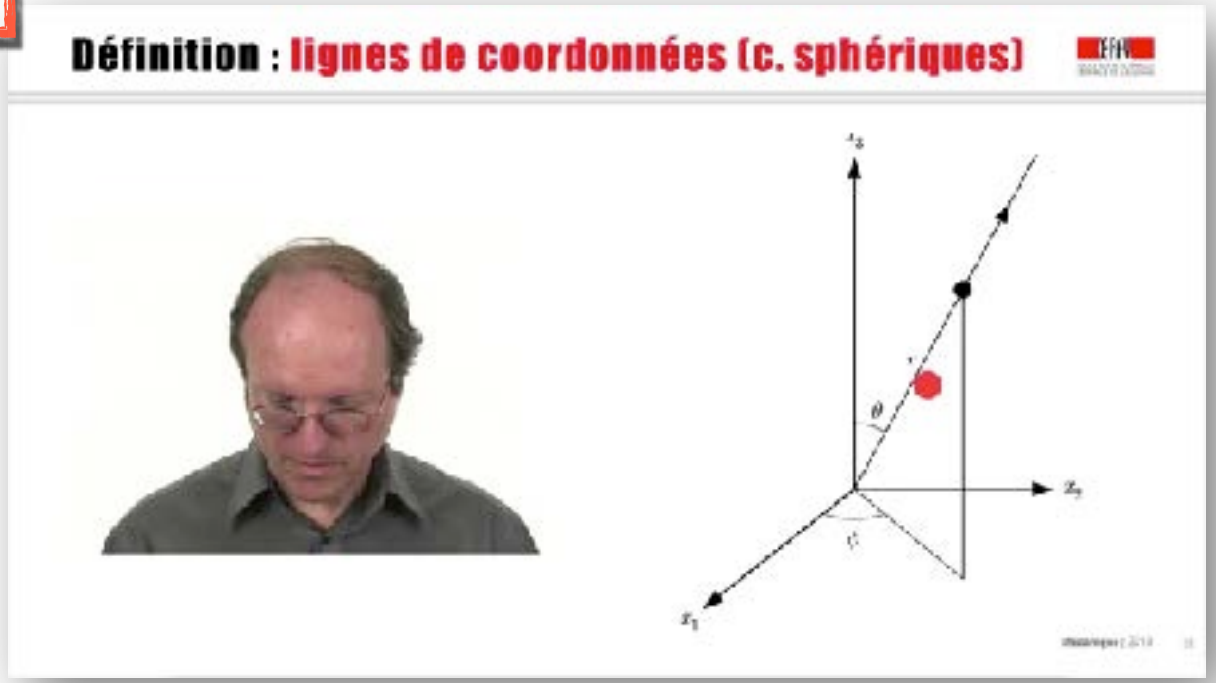

EdX
Coursera

https://www.epfl.ch/education/continuing-education/moocscatalogue/

Drill & Practice

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Education Robotics

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Professor Anna Fontcuberta i Morral (EPFL)

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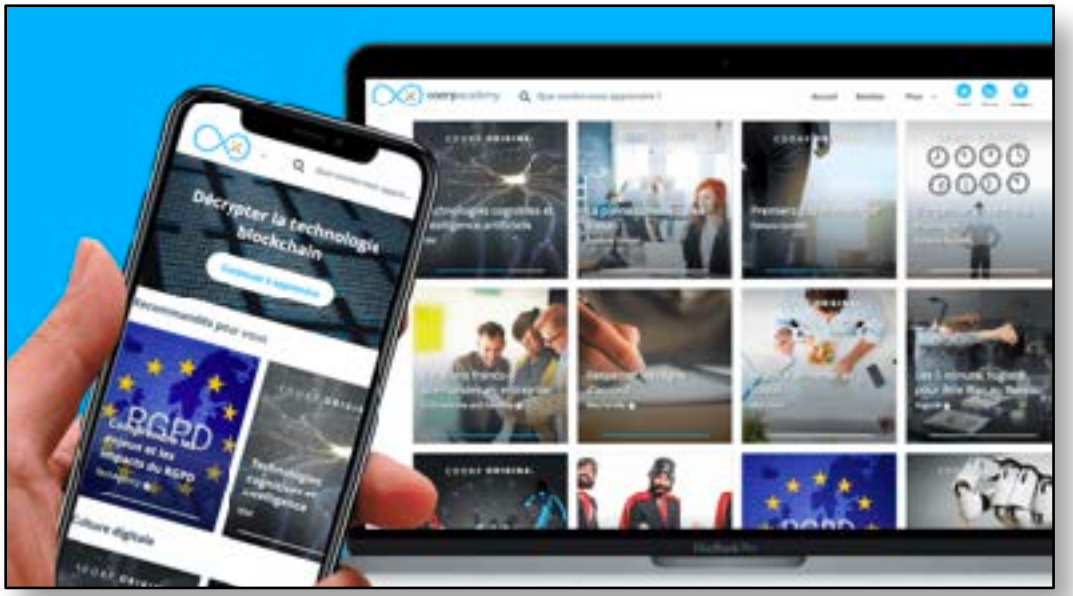
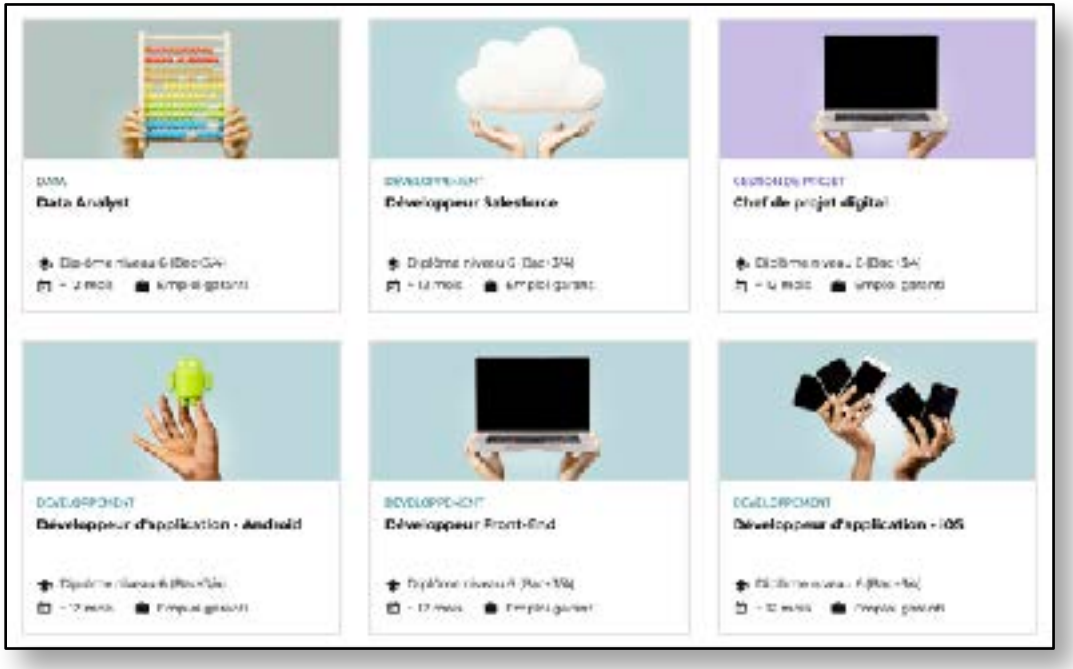
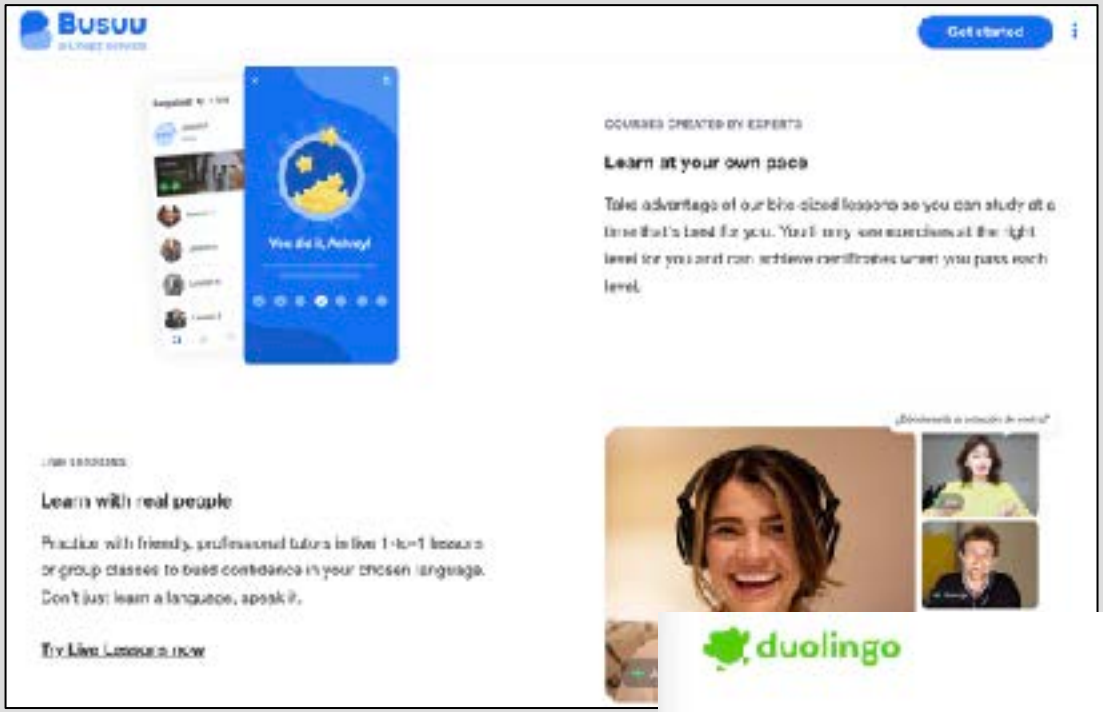


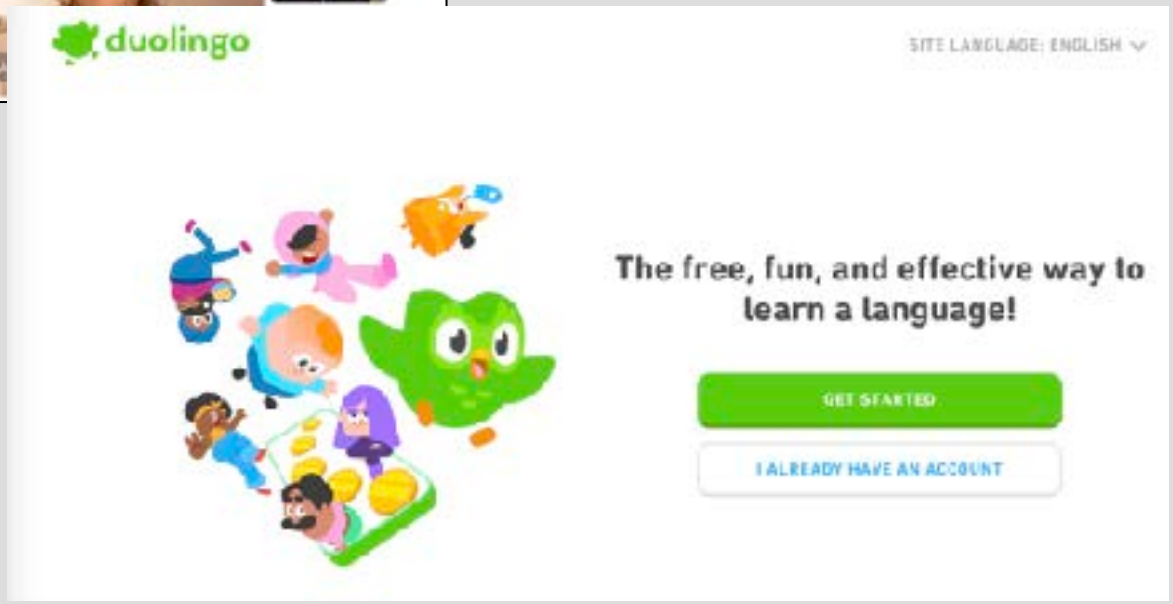
CoorpAcademy

OpenClassroom





120 millions users



110 millions users

DuoLingo, 110 million users

Severin Hacker, ETH graduate 2006

Busuu, 120 million users

Adrian Hilti, EPFL graduate 2001

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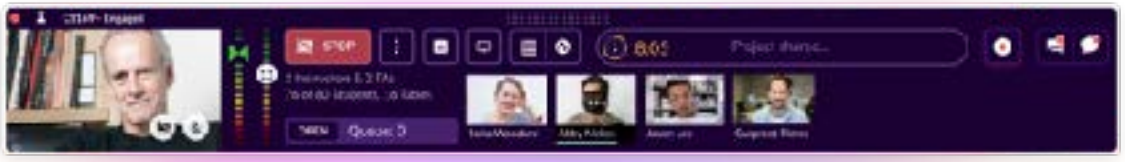
WhatsApp

zoom



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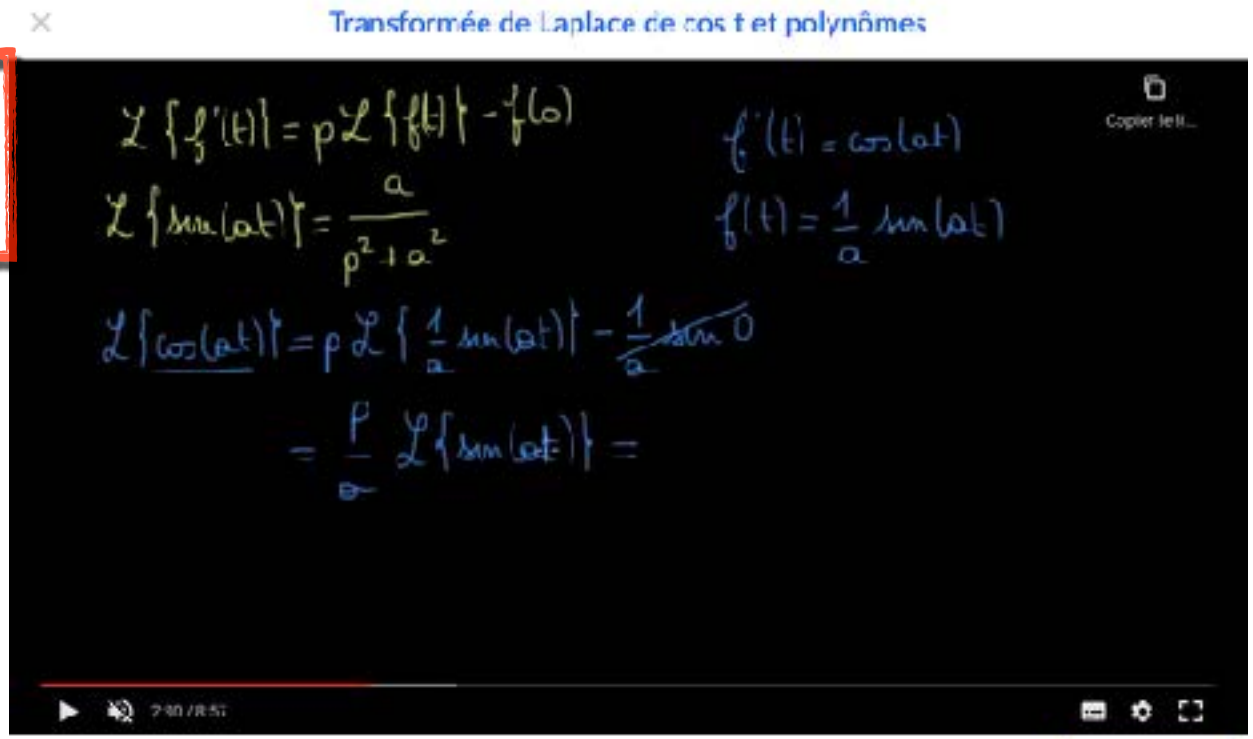

Khan Academy

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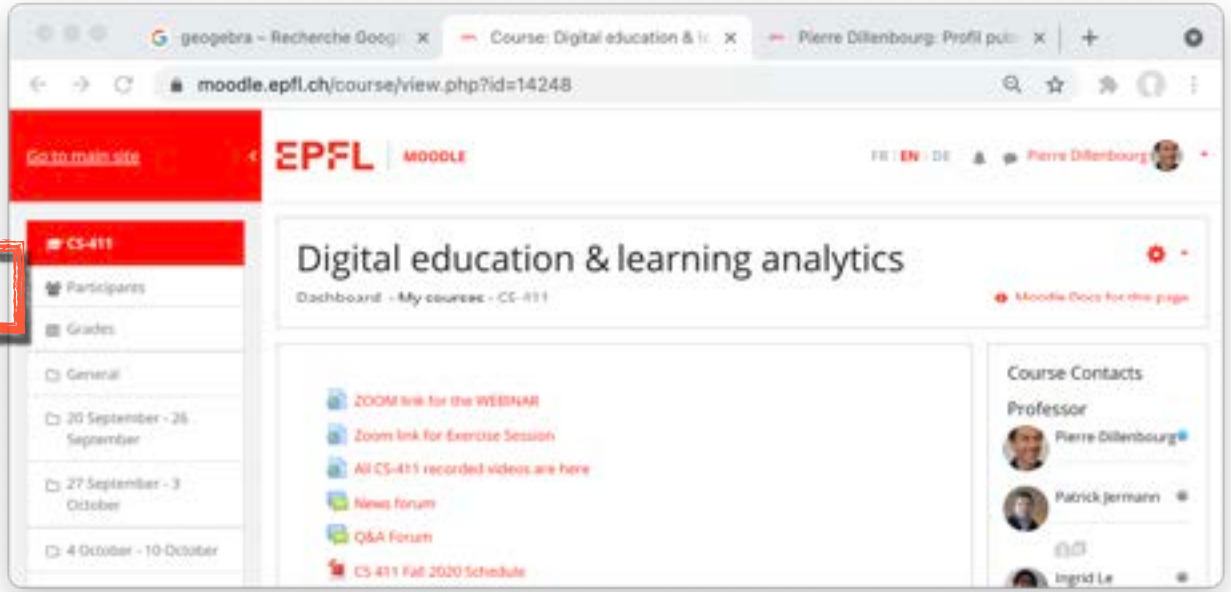

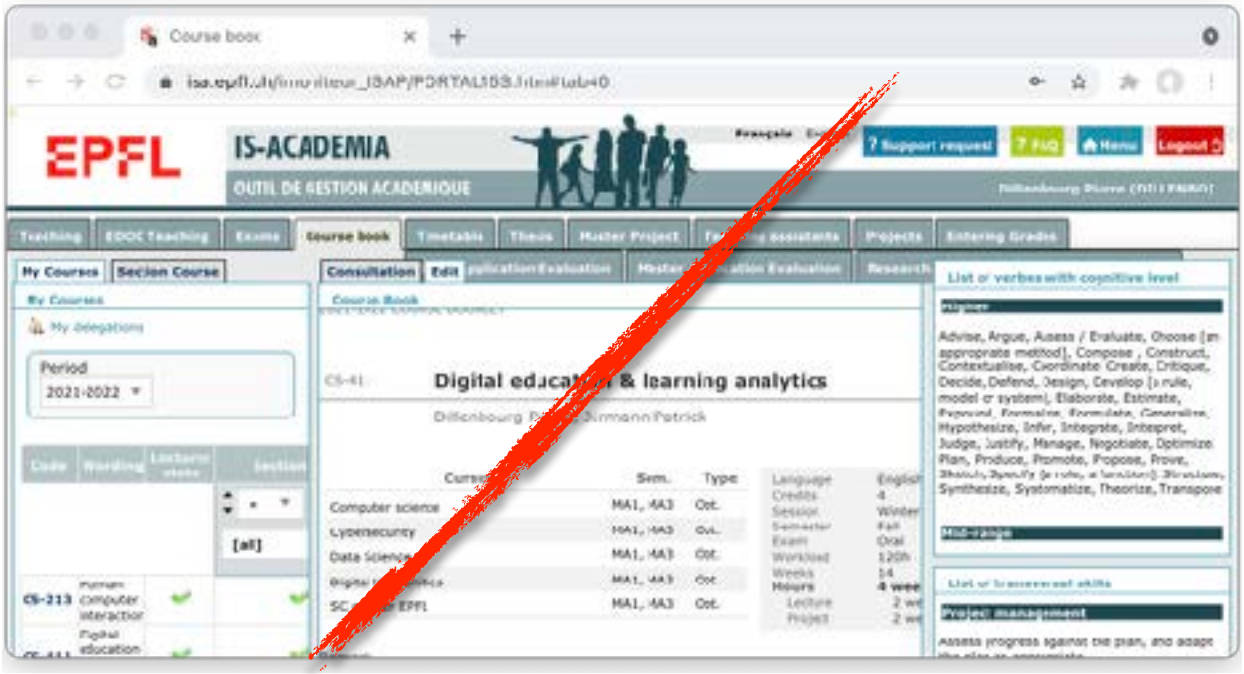

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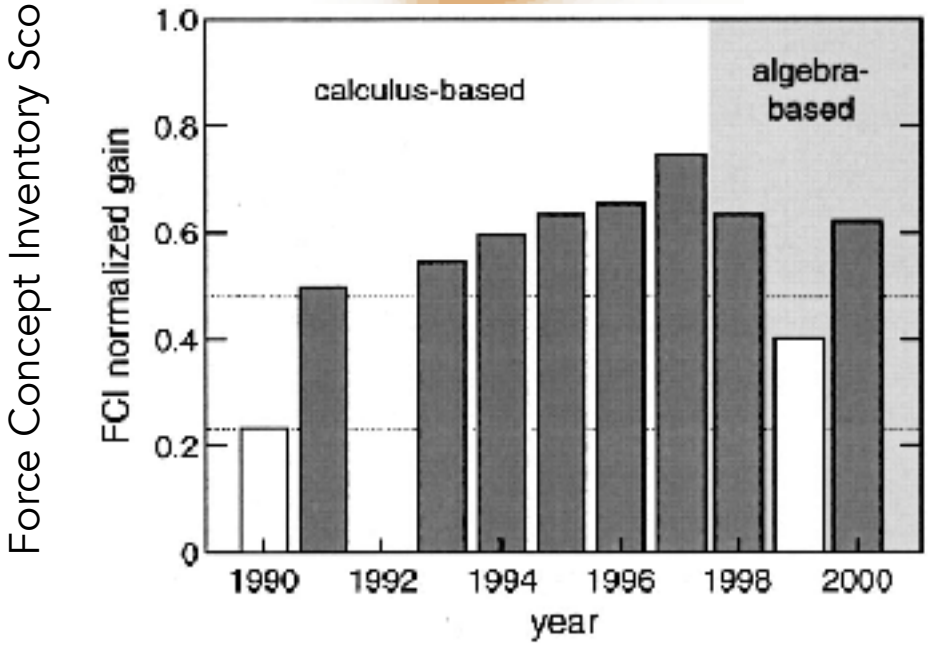

Crouch, C.H., & Mazur, E. (2001). Peer Instruction: Ten years of experience and results. *American Journal of Physics, 69*, 970-977.

Drill & Practice

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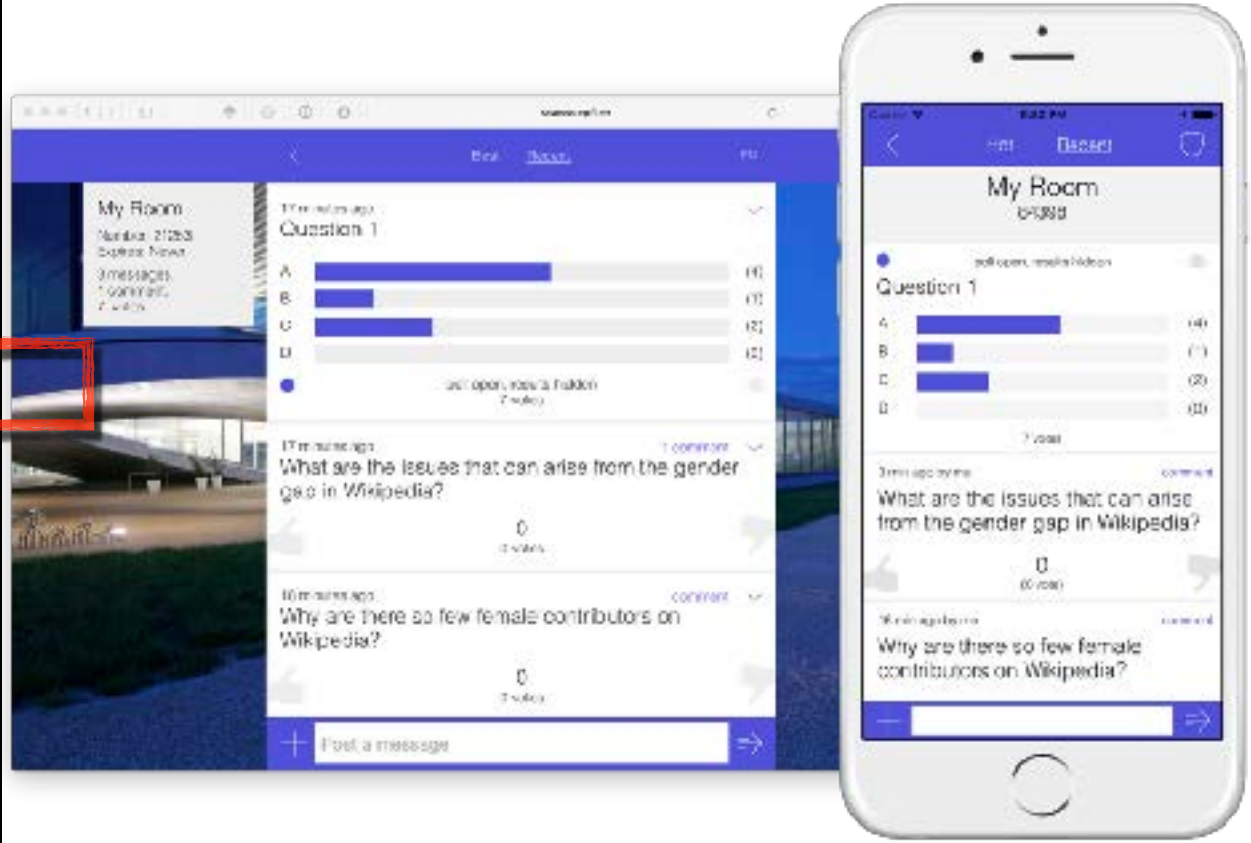

Speak Up

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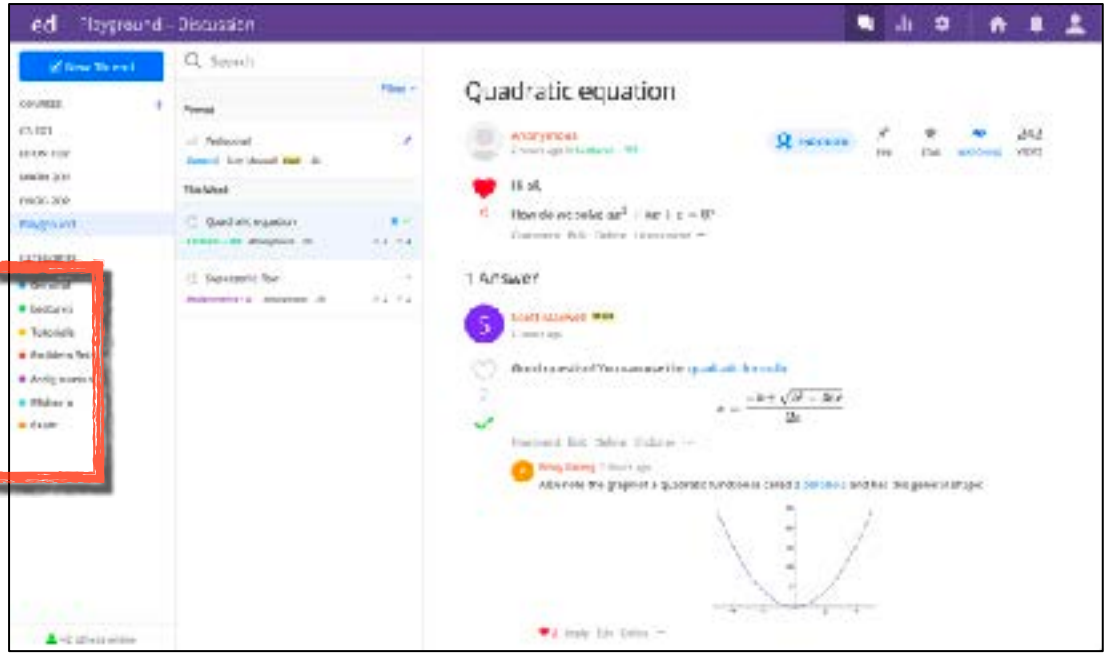

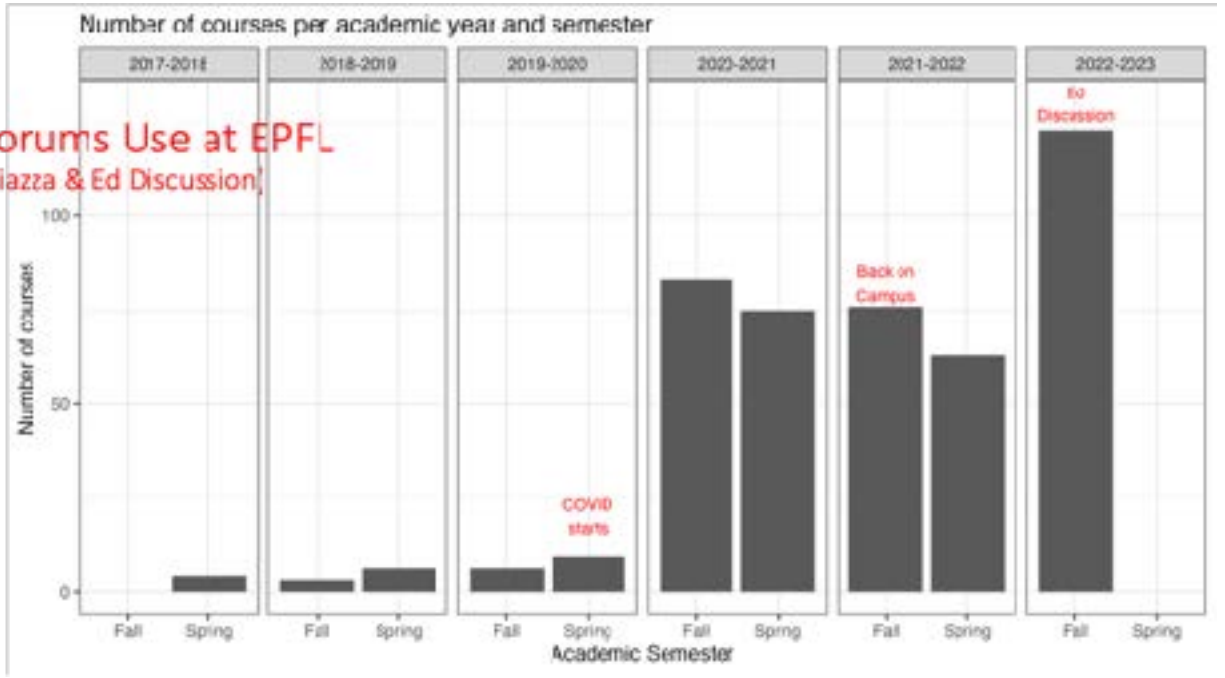

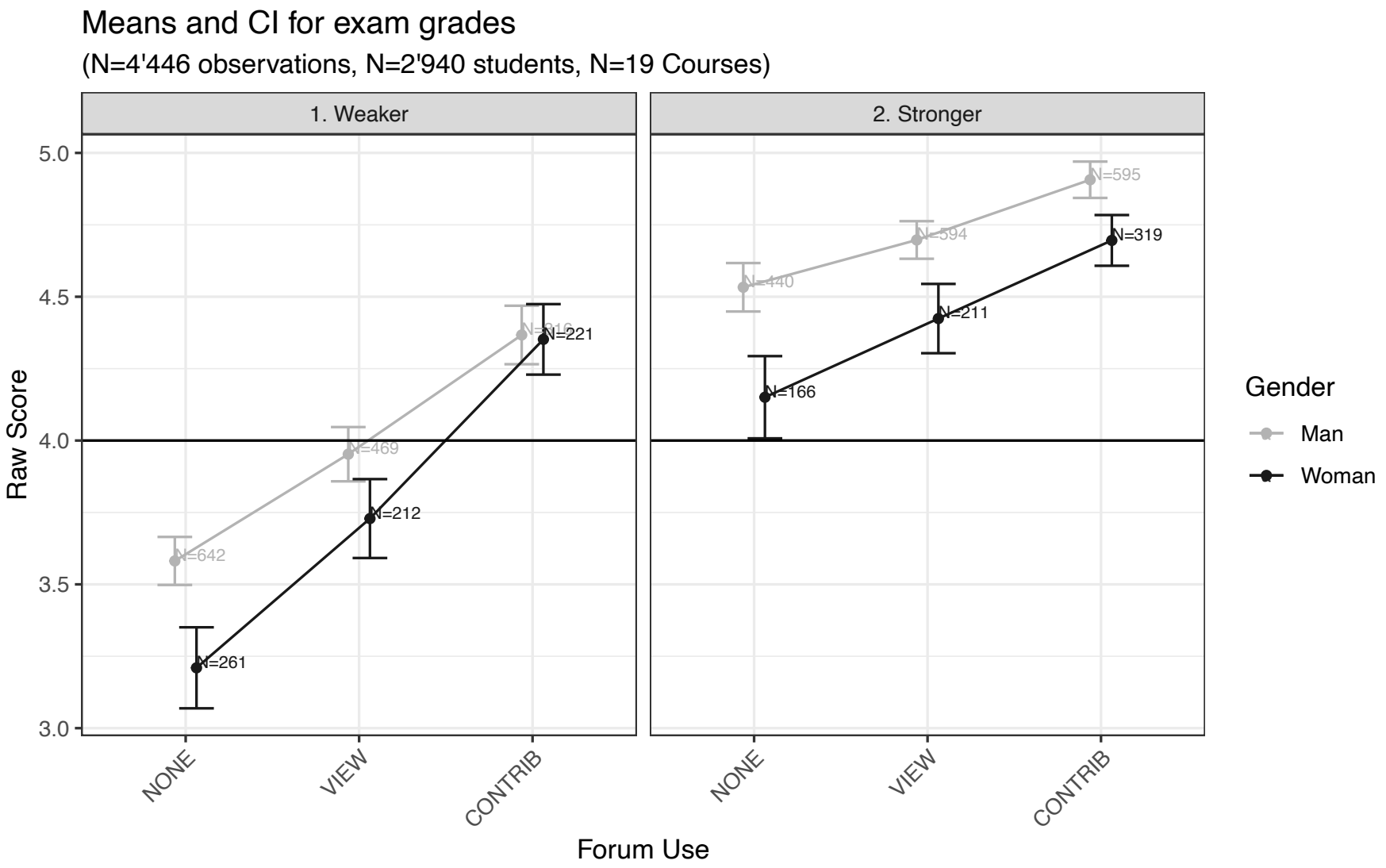
Means and CI for exam grades
(N=4'446 observations, N=2'940 students, N=19 Courses)
1. Weaker
2. Stronger
Raw Score
5.0
4.5
4.0
3.5
3.0
N=642
N=469
N=221
N=212
N=261
N=440
N=594
N=595
N=211
N=319
N=166
NONE
VIEW
CONTRIB
Forum Use
Gender
Man
Woman

Education is a data science

Drill & Practice

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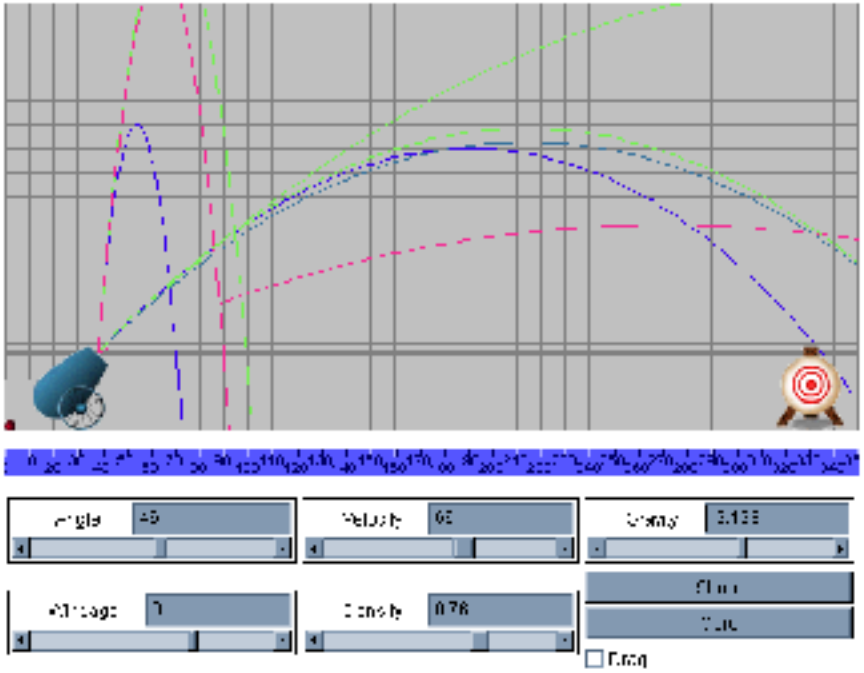

Jupyter Notebook

Prof. Cecile Hebert, EPFL

https://www.epfl.ch/education/educational-initiatives/jupyter-notebooks-for-education/

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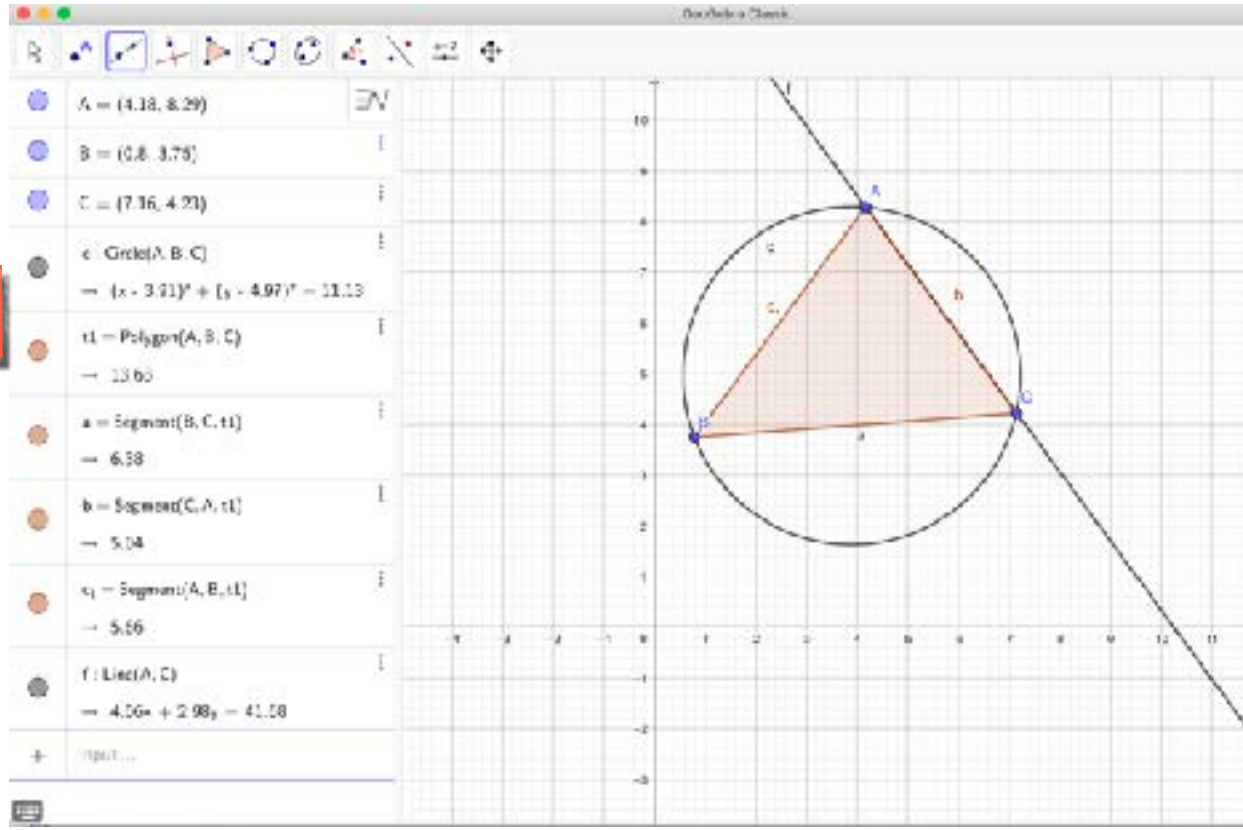

Geogebra

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Education Robotics

Minecraft

Drill & Practice

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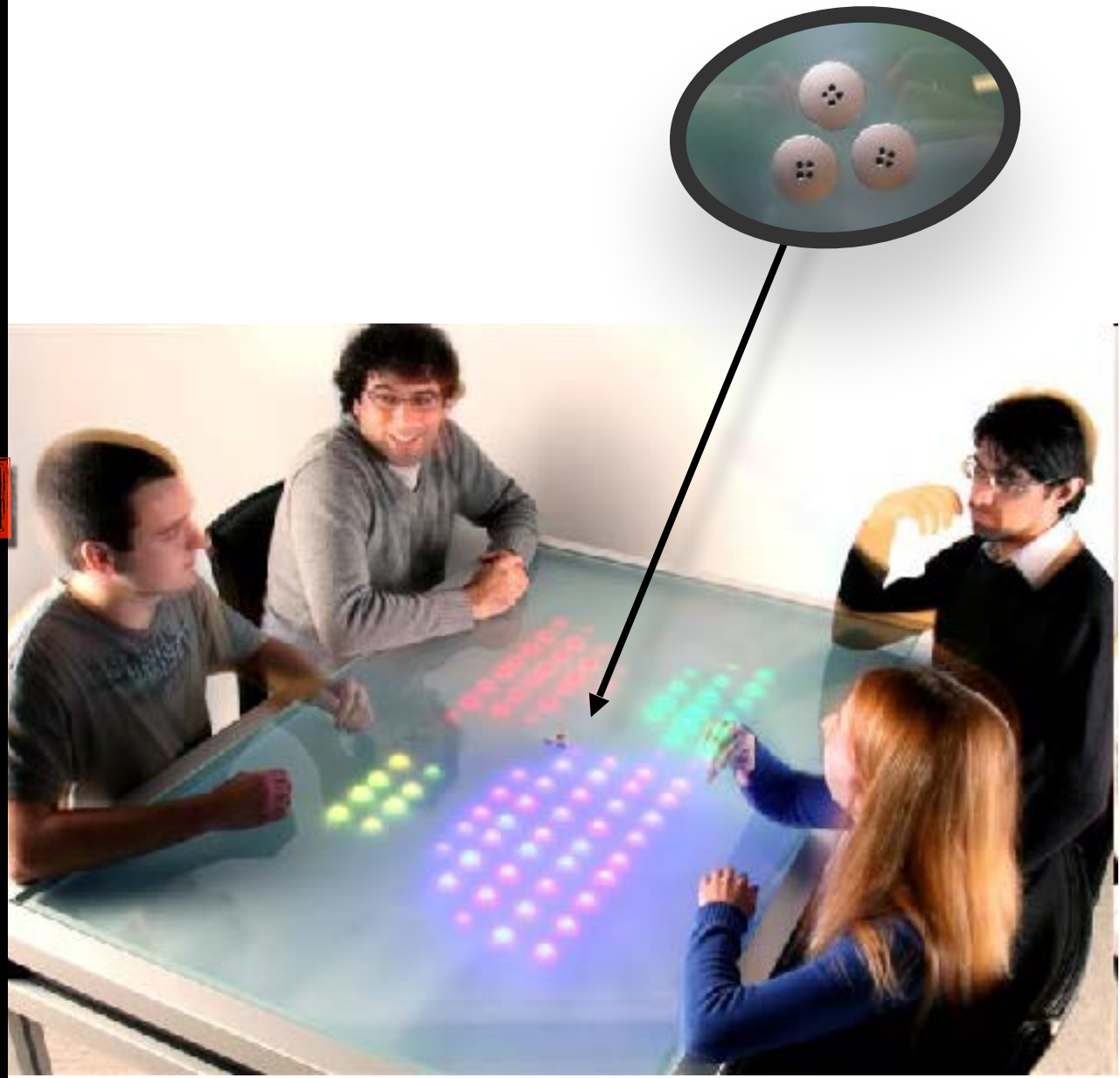

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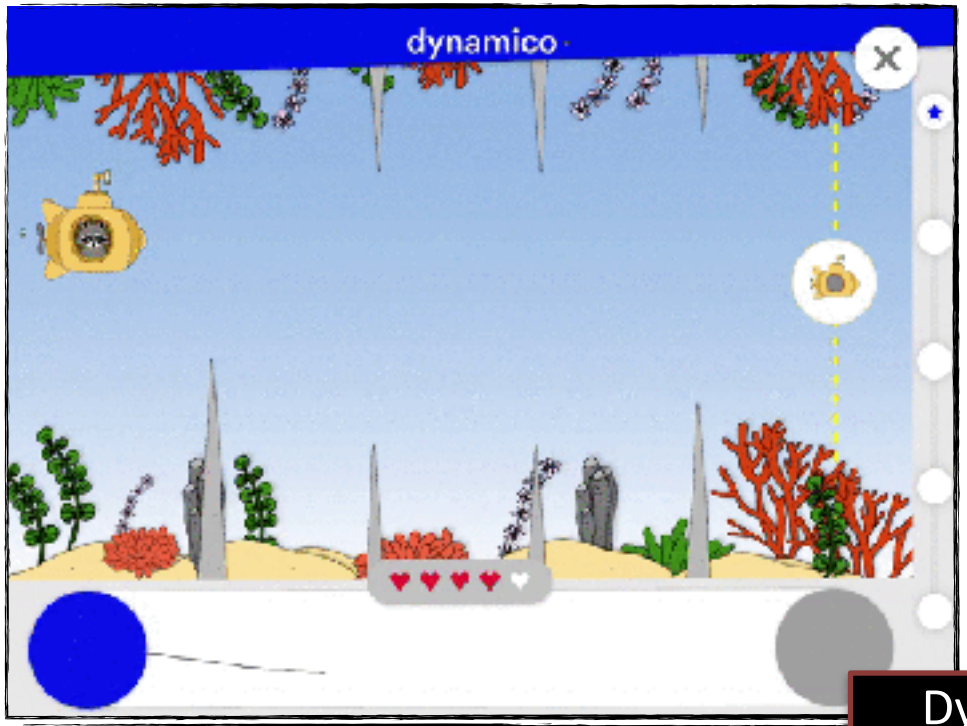
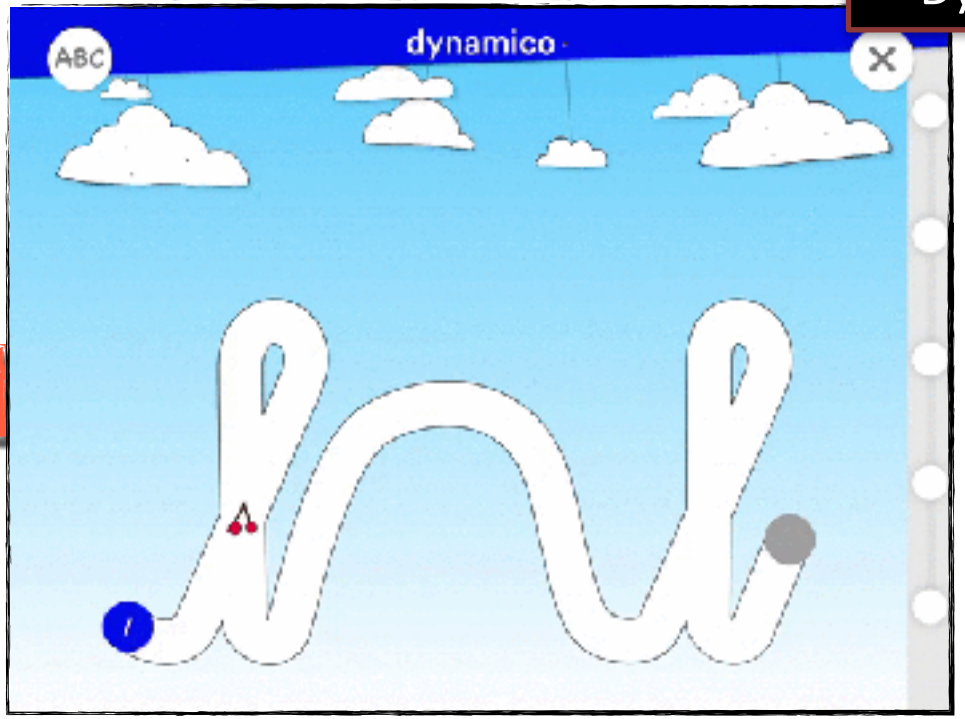


Dynamico



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thymio

Cellulo

Drill & Practice

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Education Robotics

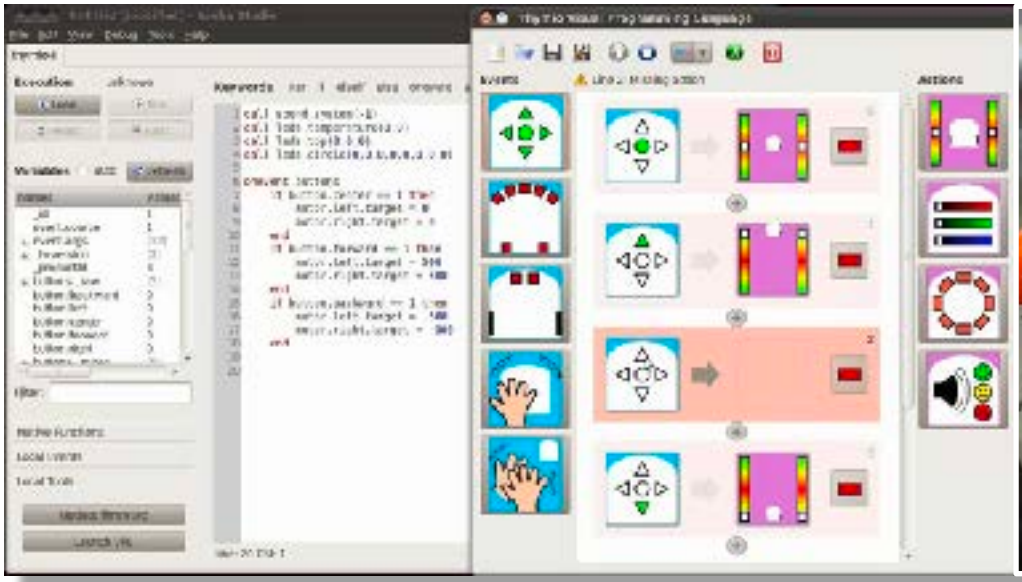
many technologies !

how do they support learning ?

how do we learn ?

Education Content
Digital Skills

Education method
Digital Tools

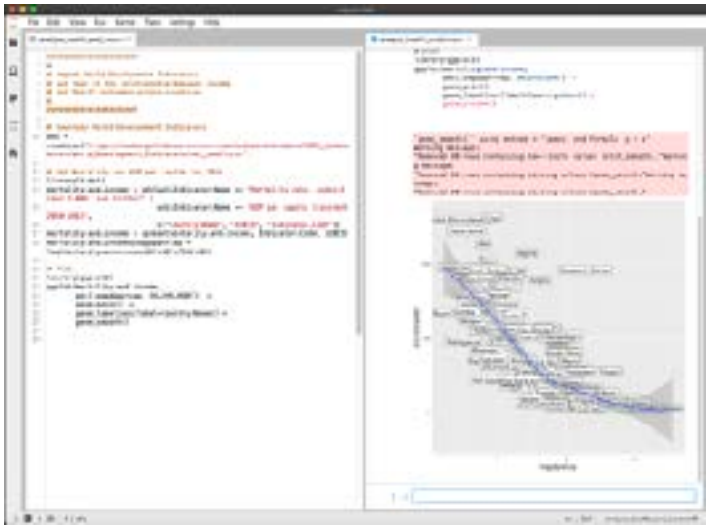


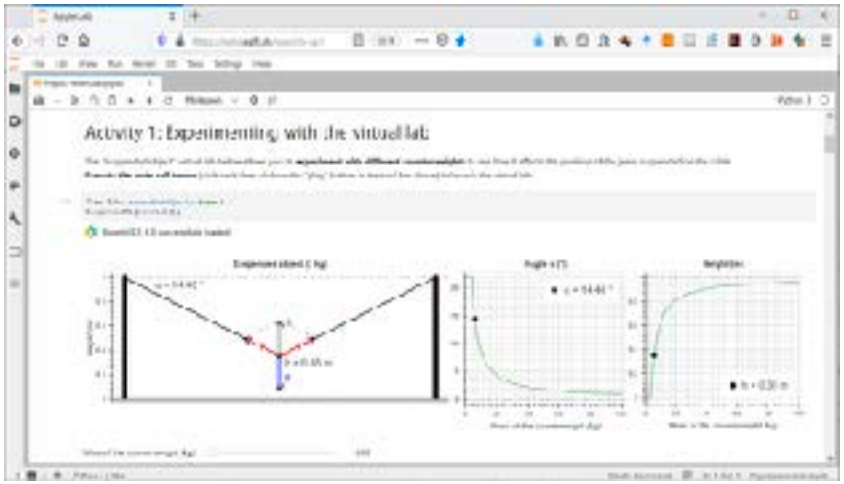
Education Content

Digital Skills: Data Sciences

Education method

Digital Tools: Physics





https://www.practicaldatascience.org/html/exercises/Exercise_jupyterlab.html#exercises-exercise-jupyterlab--page-root

Digital Tools

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Digital Skills

Computational thinking

Coding

Data analyses

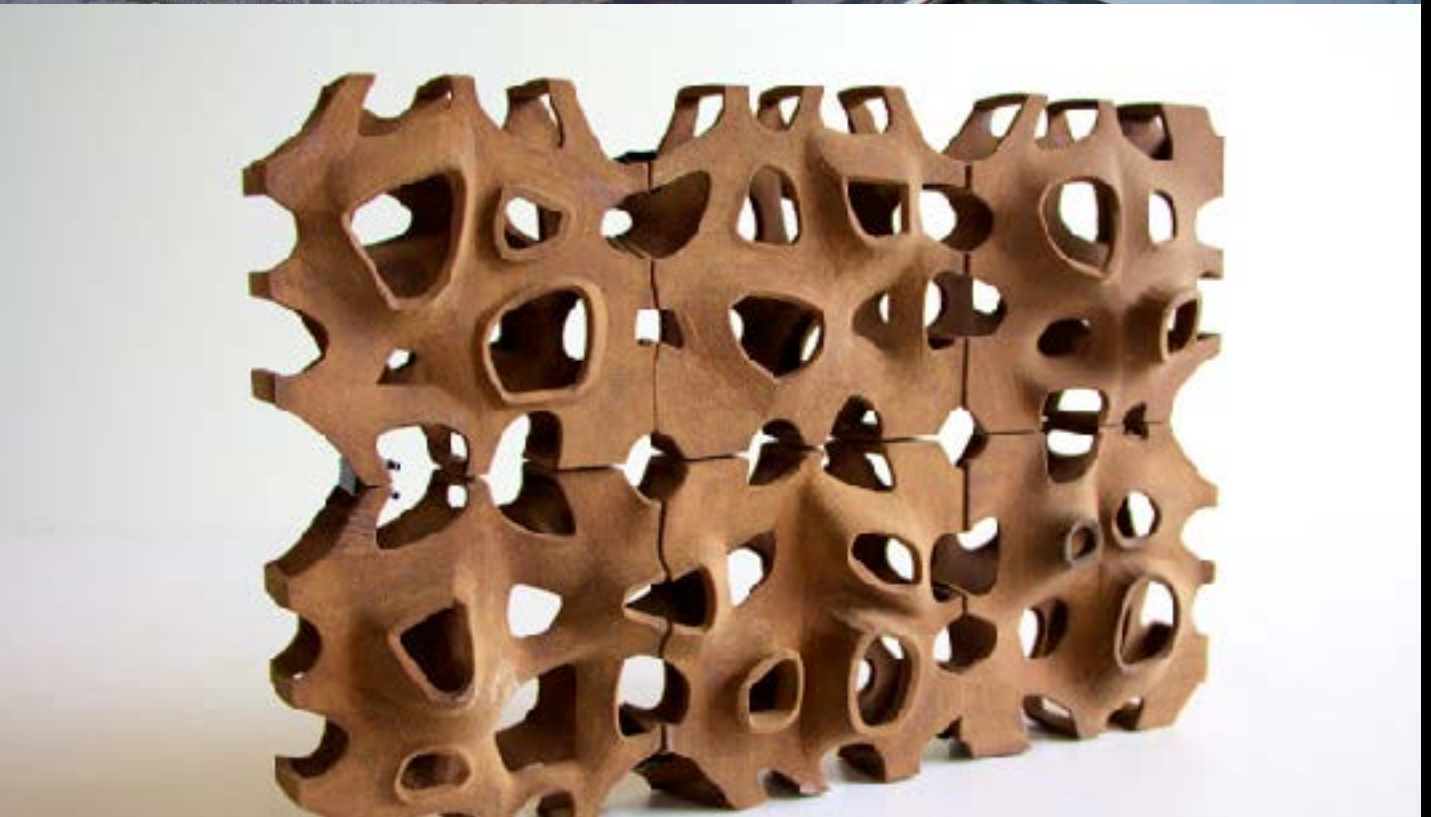
Makers spaces

Additive manufacturing

Sensors

IOT

Networks



Digital Kills

Computational thinking

Coding

Data analyses

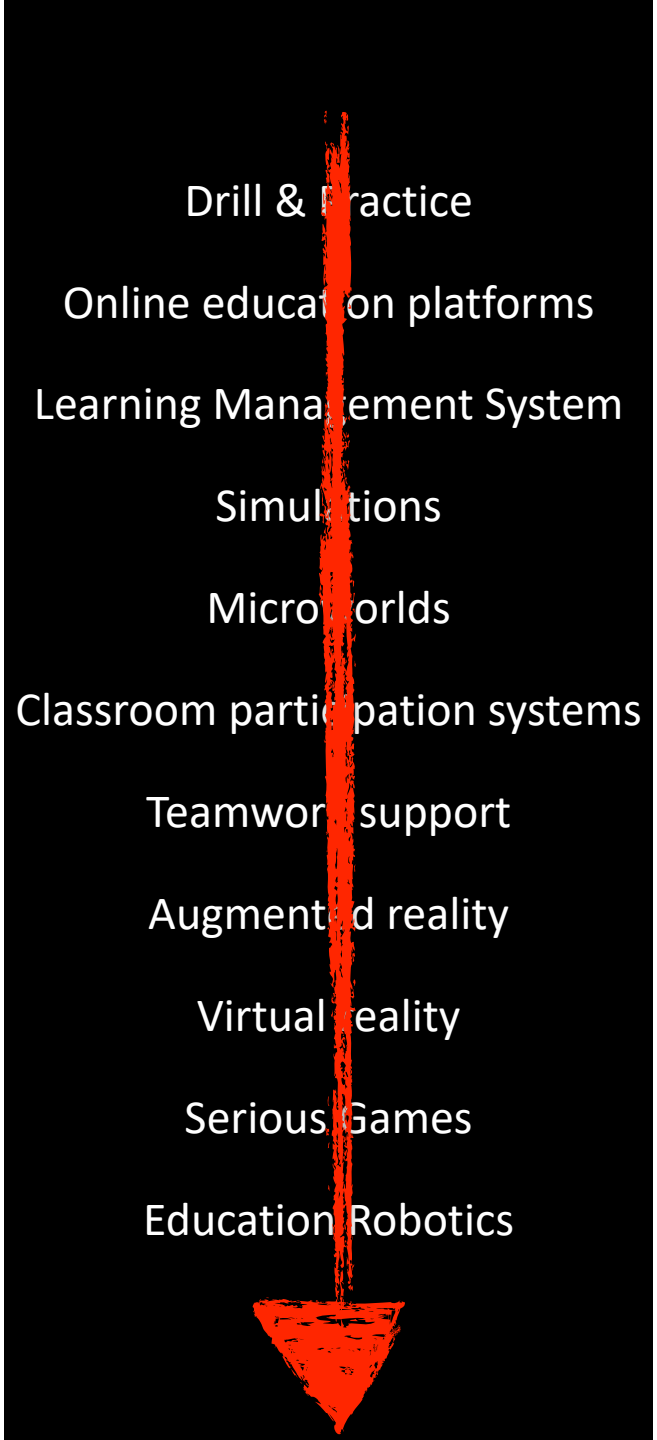
Makers spaces

Additive manufacturing

Sensors

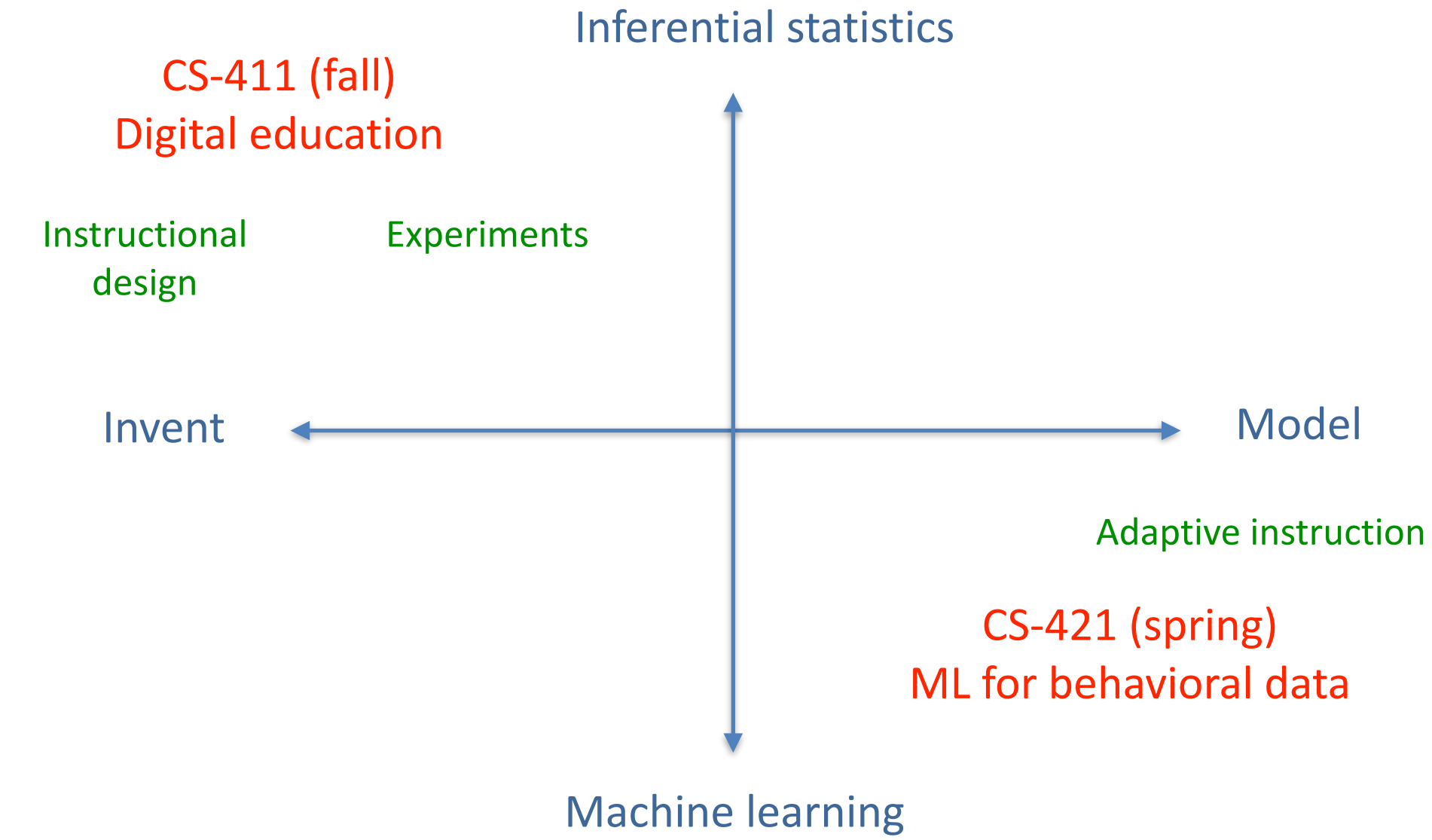
IOT

Networks



How people learn

what learners learn
does not depend on right specific technology
but on the cognitive activity they do
(with this technology)


Inferential statistics
CS-411 (fall)
Digital education
Instructional design
Experiments
Invent
Model
Adaptive instruction
CS-421 (spring)
ML for behavioral data
Machine learning

CS411 Fall 2025 Assignment and checkpoint due dates

	Exercises Tuesday, 08:15 - 10:00 MED 0 1418	Lectures Tuesday, 10:15 - 12:00 MED 0 1418		Due dates for check points and assignments
09.09	–	Overview of learning technologies	P. Dillenbourg & T. Käser	
16.09	Experimenting PS-I Defining learning goals	Human cognition	Pierre Dillenbourg	**Checkpoint 1 Due 18.09 (Thursday 23h59)** Form groups, choose topics, and submit on Moodle
23.09	Designing learning activities	Designing experiments	Chris Petre	**Checkpoint 2 Due 25.09 (Thursday 23h59):** Submit 1-2 page description of problem-solving activity and learning goals
30.09	Designing learning activities	Piaget, microworlds & simulations	Pierre Dillenbourg	
07.10	Designing learning activities	Inferential statistics (part 1)	Patrick Jermann	
14.10	Implementing learning activities	Inferential statistics (part 2)	Patrick Jermann	17.10 Milestone 1 (Pass) Submit 3-4 page summary of project plan including description of problem-solving activity and sketch.
~~21.10~~	*Break*			
28.10	Implementing learning activities	Skinner, Bloom & mastery learning	Pierre Dillenbourg	
04.11	Statistics	Student modelling, Adaptive Ed	Tanja Käser	
11.11	Statistics	Bayesian Knowledge Tracing	Tanja Käser	
18.11	Running Experiments	Vygotsky, social cognition	Pierre Dillenbourg	
25.11	Running Experiments	GenAI for Education	Tanja Käser	
02.12	Running Experiments	GenAI for Education	Tanja Käser	
09.12	Analyzing data	AR & VR For education	Pierre Dillenbourg	
16.12	Finalizing projects	Synthesis & project presentation	P. Dillenbourg & T. Käser	
				Submit final report 06.01.2026 (Tuesday)

Available in Moodle

CS-411 : 6 credits !!!

- Written Exam: see 2023 year exam on Moodle
- Project : Design an I-PS vs PS-I experiments
  - Teams of 3
  - Select a difficult topic to understand
  - Analyse de tasks
  - Design the PS and I learning Activities
  - Run the experiment
  - Run the statistical analysis
  - Write the report

All instructions on Moodle

This is not a coding test !

What will learners learn ?

(not something trivial)

Some of the topics you can choose from include:

1. Bayes' theorem
2. Recursion
3. Entropy in physics
4. Information entropy
5. Gradient Descent
6. Gerrymandering

Other topics are acceptable, but please discuss with one of the TAs first before submitting.

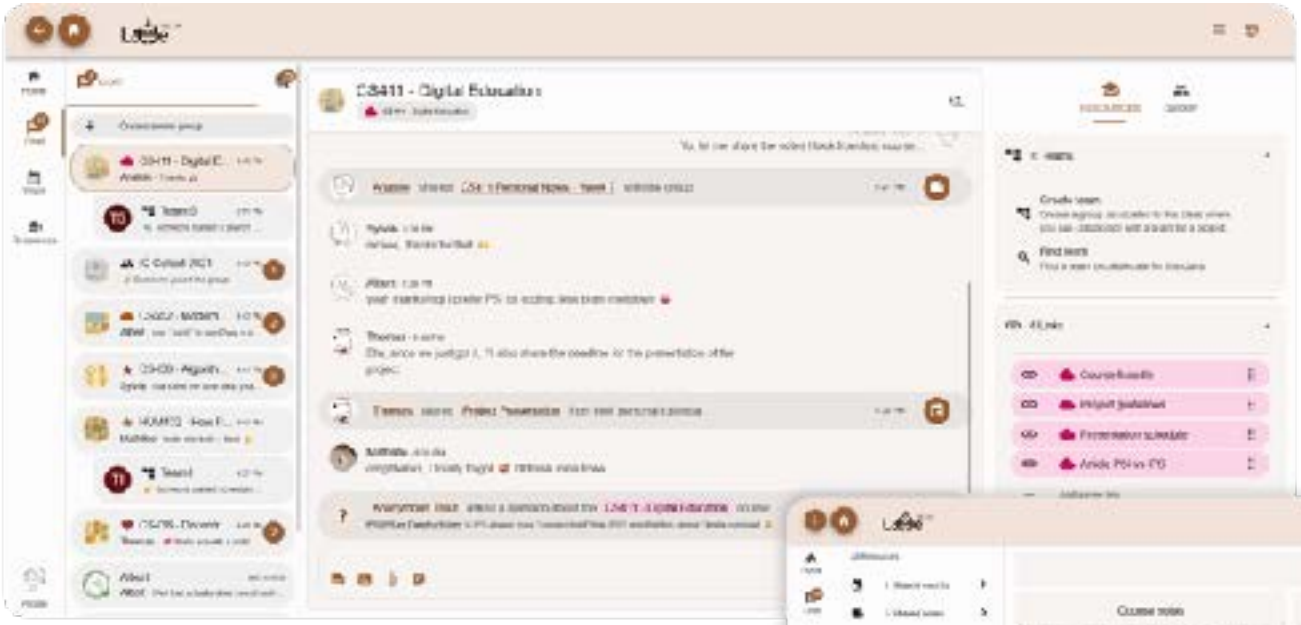
Final Report

1. Introduction (½ page)
    a. Introduce the topic
    b. Introduce the target audience as defined in the tasks
2. Learning Goals (½ page)
3. Task Analysis (1-2 pages)
4. Lesson Design and Activities (1-2 pages)
5. Experimental Design (1 page)
6. Implementation (1-2 pages)
7. Participants, Data, and Analysis (1-2 pages)
8. Conclusions and Reflection (½-1 page)

CS411 Fall 2025 Project Tasks (Detailed)

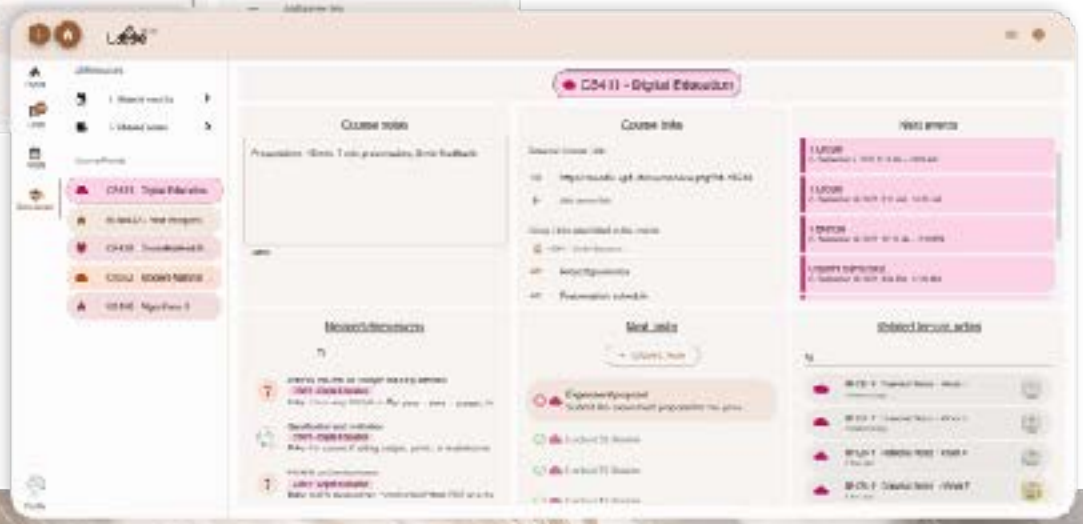
Week	Main Task	Deliverable with Due Dates	Detailed Description
1–2	Form groups & choose topic	Group registration + topic choice on Moodle (Sept 18, Checkpoint 1)	Form groups of three students and officially register your group on Moodle by Week 3. Decide on a topic for your digital lesson that connects with learning theories discussed in class. Choose a topic that at least one group member feels confident about to make lesson development easier. Submit both your group and chosen topic on Moodle for approval.
3	Define learning goals & learners	List of 3 specific, measurable goals + task analysis	Specify three specific and measurable learning goals using action verbs (e.g., calculate, explain, design, compare). Define your target students by considering their age, prior knowledge, and skills. Conduct a task analysis to break down each learning goal into the required knowledge and sub-skills, showing how prior knowledge connects to the new concepts. This may be represented as a graph or structured breakdown.
4–5		1–2 page activity description + goals (Sept 25, Checkpoint 2)	Design the main problem-solving activity that will form the basis of your PS-I lesson. Provide a 1–2 page description including the learning goals it addresses and the sequence of activities. Justify your design choices with learning theories (e.g., productive failure, preparation for future learning). Remember you may need to scale your goals to fit within a ~1 hour lesson (inc. pre and post tests). Submit this activity and integrate any feedback you receive.
5–6	Develop lesson designs (PS-I & I-PS)	Draft instructions + begin prototypes	Finalize both lesson versions: Problem Solving → Instruction (PS-I) and Instruction → Problem Solving (I-PS). Carefully consider how the sequence of activities must be revised for the I-PS version. Start implementing your lessons in your chosen digital platform (Moodle, JupyterNote, or another). Pending your own solution, ensure you have a working version ready by October, finalized by November to be ready for data collection. Draft the exact instructions students will receive for your PS activity.
7	Draft project plan & experimental design	Milestone 1 submission (Oct 17): 3–4 page draft plan	Start asking potential recruitments for 20 participants in your experiment (10 each condition). Develop a clear research question comparing the effectiveness of PS-I and I-PS designs. Outline your experimental design by identifying variables (independent, dependent, control etc), and decide whether to use a within-subjects or between-subjects design. Describe your participants and how you will recruit them. Submit a 3–4 page draft project plan that includes: topic, learning goals, participant recruitment plan, descriptions of both lesson designs, draft PS activity instructions, and a link to a working prototype. This Milestone 1 submission will be graded pass/fail.
8–9	Refine lessons & experimental setup	Completed prototypes + finalized experiment plan	Continue refining your two lesson versions in the chosen digital platform. Incorporate feedback from Milestone 1 and adjust activities or sequences as needed. Ensure your experimental design is finalized and prepare participant information sheets outlining study procedures and rights. By the end of this phase, you should have testable lesson prototypes and a ready-to-run experimental design.
10–11	Run experiment	Conduct experiment with ~20 participants	Schedule and confirm 20 participants to test your lessons (10 each condition). Distribute participant information sheets in advance to ensure informed consent. Run your experiment by implementing both PS-I and I-PS lesson versions. Document participant numbers, context, and the type of data you are collecting (e.g., performance scores, process data, surveys).
12–13	Analyze data & prepare presentation	Analysis results	Perform statistical analysis on the data collected, using ANOVA to compare PS-I and I-PS conditions. Interpret results clearly, ensuring they connect back to your research question. Prepare visuals such as graphs and tables to support your findings.
		Submit final report (Jan 6,	Complete and submit your final report (~10 pages) by January 6, 2026. The report should include: Introduction (topic, audience, goals), Lesson Design & Activities (PS-I and I-PS with screenshots/links), Experiment Design & Data (research question, design, participants, data), Data Analysis & Results, and Discussion & Conclusions. Reflect on what you learned, what worked well, and what you would change if running the

Available in Moodle



Your place to study.

Objective: Provide students with a centralized virtual environment where they can **chat, organize, collaborate and study** in the **clearest** and most **efficient** way.



See you next week here at 08:15