Education as a computational science

Pierre Dillenbourg, EPFL
EPFL CAMPUS

EPFL MOOCs: 1'908'876
Hype is over but MOOCs continue to grow ....

1'815'471 Registrations
97'510 Passed

77 Courses Online
35 Courses In Preparation
EPFL Freshmen

MOOC Usage

EPFL Grade

Baccalaureat Level

- HI
- LO

Patrick Jermann, Francisco Pinto (EPFL CEDE)
Education
Technologies
Learning
Analytics
Teaching
CS
ED
CS
e-learning ?????????
Swarm Cellulo (Ayberk Ozgur, Wafa Johal, P. Dillenbourg)
learning Analytics

predict, classify, decide, ‘explain’

SVM, KMC, DNN, RNN, 2AM, POMDP

Computational Models

Education Research

Pierre Dillenbourg, EPFL
Adaptive systems

A

Score < 50%

B₁

Score > 50%

B₂
Bayesian Knowledge Tracing

Hidden State

\[ K_t \xrightarrow{} K_{t+1} \quad p(K_{t+1} \mid B_{t+1}, K_t) \]

Observable State

\[ B_t \xleftarrow{} B_{t+1} \]

\[
p(K_t = 'skill-x' \mid B_t = 'correct answer') = 1 - \text{Guess}
\]

\[
p(K_t = 'skill-X' \mid B_t = 'incorrect answer') = 0 + \text{Slip}
\]
Self-Improving systems

Find the best value for $X$!

- If Score $< X\%$, go to $B_1$.
- If Score $> X\%$, go to $B_2$. 
Improve the management of education systems

Computational Models

Education Research

Pierre Dillenbourg, EPFL
What about modeling learning outsider technology-based environments?
Campus Analytics

pre-requisites
\[ p(\text{Succeed (CS243)} \mid \text{Failed (CS201)}) \]

career
\[ p(\text{Salary} > T \mid \{\text{INF201, MA203, INF233,..]\}) \]

recommender
78\% of those who select CS243 also selected CS411

......

Pierre Dillenbourg, EPFL
how deep ?
Relevant Behavioral Abstractions (Features)

Education needs explainable AI
Relevant Behavioral Abstractions
(Features)

gaze(a) = f(gaze(b))
Gaze Recurrence
DUET - Dual Eye-Tracking
Pair programming experiment

Low gaze recurrence

P. Jermann, M.-A. Nüssli & P. Dillenbourg
© CRAFT – http://craft.epfl.ch/

Supported by the Swiss National Science Foundation
(grants #K-12K1-117909 and #PZ00P_126611)
DUET - Dual Eye-Tracking 
Pair programming experiment 

High gaze recurrence 

P. Jermann, M.-A. Nüssli & P. Dillenbourg
© CRAFT – http://craft.epfl.ch/

Supported by the Swiss National Science Foundation (grants #K-12K1-117909 and #PZ00P_126611)
Relevant Behavioral Abstractions

\[ \text{gaze}(\text{listener}) = f(\text{gaze}(\text{speaker})) \]

**Feature:** Gaze recurrence  
**Context:** Collaborative learning
Eye tracking experiment on MOOC Video

Following teacher’s references

Gaze of students’ watching Scala course by Prof. Martin Odersky (EPFL, Switzerland)

K. Sharma, P. Jermann, P. Dillenbourg
@ CHILI – http://chili.epfl.ch
Supported by the Swiss National Science Foundation (Grants CR1211_132996 and PZ00P2_126611)
gaze (learner) = \textcolor{red}{f} \text{ (reference (teacher))}

Feature: Withmeness
Context: Lecturing
No Visual Aid

Cirrocumulus Clouds
High & Puffy

Pointer

Cirrocumulus Clouds
High & Puffy

Gaze

Cirrocumulus Clouds
High & Puffy

“...they look like a bunch of little grains arranged together...typically a group of very small elements”
Do finger-based or gaze-based deictics enhance learning?

Sarah d’Angelo, Kshitij Sharma, Darren Gergle, Pierre Dillenbourg (2016)
Relevant Behavioral Abstractions

gaze (learner) = \( f \) (gaze (teacher))

**Feature:** ‘Withmeness’
**Context:** Lecturing
Modeling in the wild?

K_t

Raca, Tormey & Dillenbourg
Relevant Behavioral Abstractions

\[ \text{gaze (learner)} = f \text{ (location (teacher))} \]

**Feature:** Head rotations  
**Context:** Lecturing
activity (teacher) = f (gaze (teacher))

L. Prieto, K. Sharma, L. Kidzinsky, P. Dillenbourg
Education brings nice challenges

(1) Explainability

Computational Models

Education Research

Pierre Dillenbourg, EPFL
Education brings nice challenges

(2) Cold Start

Integrate expert’s knowledge

Use simulation with synthetic students
Education brings nice challenges

(3) Exploration Exploitation Tradeoff

Learner 1
Learner 2
Learner 3
Learner 4
Learner 5
Learner 6
Learner 7
Learner 8
Learner 9
Multi-Armed Bandit (MAB) for Exploration-Exploitation

➢ Selecting learning activities
➢ LFA model
➢ Tested with simulated students
➢ Will present and discuss this work at ECTEL in September

Louis Faucon, Pierre Dillenbourg, EPFL
Education is a computational science

EPFL Center for Learning Sciences
EPFL Digital Education Ecosystem
Social Sciences

Education
Psychology
Sociology
Ethnology
Anthropology
Economics
Political Sciences
Linguistics
History
Demography
Management

Humanities

Modern Languages
Old Language
Littérature
Philosophy
Religion
Art
Musicology
Museology
History

This is not one science !!!
Education
Docimology
Didactics
Instructional Psychology
Instructional Design
Learning Technologies
History of Education
Sociology of Education
Economy of Education
Special Education
Psychology
Cognitive psychology
Social psychology
Psychometry
Clinical psychology
Differential Psychology
Developmental Psychology
Sociology
And....