AI for Education

Roberto Araya
Universidad de Chile
AI for Education

Students
Teachers
Families

Why?
The World as 100 People over the last two centuries

**Extreme Poverty**
- 94 living in extreme poverty in 1820
- 90 living in extreme poverty in 2000
- 99 not living in extreme poverty in 2015

**Democracy**
- 1 living in a democracy in 1820
- 44 living in a democracy in 2015
- 99 not living in a democracy in 2000

**Basic Education**
- 63 have not attained any education in 1820
- 14 have not attained any education in 2015
- 88 have basic education or more

**Vaccination**
- 0 vaccinated in 1820
- 85 vaccinated in 2015
- 14 not vaccinated

**Literacy**
- 82 are not able to read in 1820
- 15 are not able to read in 2015
- 85 are able to read

**Child Mortality**
- 43 die before they are 5 years old in 1820
- 57 survive the first 5 years of life in 2015
- 96 survive the first 5 years of life

*Data sources:
- Basic Education: UNESCO (calculations of global population share). Data are available for the period 1820 to 1880; UNESCO for 1880 and later.
- Vaccination: OPC-World Health Organization (WHO) (calculations of global population share). Data are available for 1820 to 2015.
- Literacy: UNESCO for the period 1820 to 1990; UNESCO for 2015 and later.
- Death: OPC-World Health Organization (WHO) (calculations of global population share). Data are available for 1820 to 2015.)

All these visualizations are from OurWorldInData.org, an online publication that presents the empirical evidence on how the world is changing.

*Licensed under CC-BY-SA by the author Max Roser.*
Walter Scheidel (2017) The Great Leveler: Economic inequality from stone age to the future
Inequality trends in Europe in the long run (TGL 87)

Walter Scheidel (2017) The Great Leveler: Economic inequality from stone age to the future
The Human Capital Century?

In recent decades the lion’s share of rising wage inequality can be traced to an increase in educational wage differentials.

**The Race between Education and Technology**

-Goldin, C.; Katz, L.
Disequalizing forces

Aging

Globalization

Inmigration

Automation
Super Smart Society

Your smartphone talks to you and make suggestions

Your smartphone takes the initiative

Your Smartphone learns autonomously

A second App in your smartphone also takes the initiative but has another opinion

Both Apps take the extra initiative to talk each other and discuss their arguments

You have 10 different Apps with different personalities

Welcome to a new fascinating world: the Super Smart Society
Imagine the future

<table>
<thead>
<tr>
<th>Society</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Society 1.0</td>
<td>Hunter-gatherer society</td>
</tr>
<tr>
<td>Society 2.0</td>
<td>Agrarian society</td>
</tr>
<tr>
<td>Society 3.0</td>
<td>Industrial society</td>
</tr>
<tr>
<td>Society 4.0</td>
<td>Information society</td>
</tr>
<tr>
<td>Society 5.0</td>
<td>Super-smart society</td>
</tr>
</tbody>
</table>

Source: The Government of Japan
AI for Education

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Families
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Example 1
Vehicles & robots

What **RULES** (code) are needed?
Vehicles & robots

Games

Trained with millions of examples:
NO RULES
Machine Learning
Example 2
Digital Humanities

Frequencies of appearance of the characters:

Granny 10
Mother 1
Little Red Riding Hood 5
Wolf 12
Woodcutter 2
Little Red Riding Hood
Natural Language
Example 3
Schelling segregation model

Schelling segregation model

Schelling segregation model

Agents
Example 4
Social Networks
Example 6
Artificial, Natural & Sexual Selection
Artificial, Natural & Sexual Selection
Computational Biology
Machine learning

Machine learning techniques mark a break with the classic algorithm.

In particular, as they mark the gradual transition from a programming logic to a learning logic

- C. Villani
  Fields Medal Mathematics
Machine learning

‘The end of the code’: in the future, we will no longer program computers, we will train them.

- Wired Magazine
AI is the new ELECTRICITY
Machine Learning (decision tres, VSM, games, diagnosis)

Natural Language (story summarization graphs)

Agents (Schelling segregation models)

Social Networks (identity dynamics)

Computational Biology (physical and behavioral traits, cooperation)
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Example 1
Smartphone ubiquity
Bienvenido!

SMART SPEECH

Observación COPUS

TERMINAR

PROFESOR

ESPERANDO

ESCRIBIR PIZARRA

HACER PREGUNTAS

RESPONDE PREGUNTA

DISCUSIÓN 1 A 1

ADMINISTRACIÓN

ESTUDIANTE

SEGUIMIENTO - FEEDBACK

PREGUNTA CLICKER

MOVERSE POR LOS GRUPOS

EXPERIMENTO

0:24
<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecturing</td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td></td>
</tr>
<tr>
<td>Asking open ended question</td>
<td></td>
</tr>
<tr>
<td>Waiting</td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td></td>
</tr>
<tr>
<td>Asking multiple choice question</td>
<td></td>
</tr>
<tr>
<td>Moving around groups</td>
<td></td>
</tr>
<tr>
<td>undefined</td>
<td></td>
</tr>
</tbody>
</table>

Real time feedback
Example 2
The number of different physics concepts and connected concept pairs had correlations with students’ learning gains

Data

- Data taken from Quality of instruction in Physics (QuiP) Project
- 25 Finnish teachers and their 9th grade students
- Content was Introduction to the relation between electrical energy and power
- Audio of teachers’ discourse (25 audios of 45x2 minutes)
- Pre and Post test of students (328 students)
**Greater the Diameter and the Degree Centrality, higher Learning Gain**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Std. Error</th>
<th>t – value</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>-0.343</td>
<td>0.248</td>
<td>-1.387</td>
<td>0.170</td>
</tr>
<tr>
<td>NODES</td>
<td>0.016</td>
<td>0.011</td>
<td>1.512</td>
<td>0.133</td>
</tr>
<tr>
<td>EDGES</td>
<td>-0.005</td>
<td>0.005</td>
<td>-0.991</td>
<td>0.324</td>
</tr>
<tr>
<td>DENSITY</td>
<td>-0.161</td>
<td>0.064</td>
<td>-2.519</td>
<td>0.013</td>
</tr>
<tr>
<td>DIAMETER</td>
<td>0.036</td>
<td>0.014</td>
<td>2.653</td>
<td>0.009</td>
</tr>
<tr>
<td>CLUSTERING</td>
<td>0.044</td>
<td>0.271</td>
<td>0.162</td>
<td>0.871</td>
</tr>
<tr>
<td>DEGREE</td>
<td>0.060</td>
<td>0.061</td>
<td>0.983</td>
<td>0.328</td>
</tr>
<tr>
<td>DEGREE_CENTRALITY</td>
<td>0.826</td>
<td>0.351</td>
<td>2.357</td>
<td>0.018</td>
</tr>
</tbody>
</table>

Residual standard error: 0.1924 on 320 degrees of freedom.

**Diameter**
The greatest distance between any pair of concepts of the network.

**Degree Centrality**
The average of the proportion of how many neighbors does a concept have.
Needs thousands of examples of the same lesson
Example 3
Automatic content analysis in collaborative inquiry-based

• Introductory thermodynamics course
• The participants ($N = 55$) were divided into groups of five students ($N_{\text{groups}} = 11$)
• The groups solved **face-to-face** an inquiry problem with a shared laptop computer
• Transcriptions of group work sessions based on video- and audio-recordings (on average, 180 utterances per group)

Lämsä, Espinoza, Araya, Viiri; Jiménez, Gormaz, Hämäläinen
Automatic content analysis in collaborative inquiry-based, ESERA 2019
Collaborative inquiry-based learning

Orientation
Getting familiar with the problem

Conceptualisation
Research questions (RQs) / hypotheses

Investigation
Collecting, analysing and interpreting data

Conclusion
Offering solution to the RQs / hypotheses

Discussion
Communication and reflection

Pedaste et al. (2015)
<table>
<thead>
<tr>
<th>Input</th>
<th>Process</th>
<th>Output</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics textbooks</td>
<td>Preprocessed textbooks pages</td>
<td>LDA training</td>
<td>1. Train LDA</td>
</tr>
<tr>
<td>CIBL group work sessions with utterances manually coded with IBL phases (n=11)</td>
<td>Preprocessed utterances with phase codes</td>
<td>Feature vectors with phase codes</td>
<td>2. Build feature vectors grouped by CIBL group work session</td>
</tr>
<tr>
<td>Feature vectors and phase codes grouped by CIBL group work session (n=11)</td>
<td>Training set (9 group work sessions)</td>
<td>Feature vectors with phase labels</td>
<td>3. Train SVM classifier</td>
</tr>
<tr>
<td></td>
<td>Test set (2 group work sessions)</td>
<td>Feature vectors</td>
<td>SVM training</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SVM</td>
<td>SVM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Predicted phase codes</td>
<td>Confusion matrix</td>
</tr>
</tbody>
</table>

Lämsä, Espinoza, Araya, Viiri; Jiménez, Gormaz, Hämäläinen
Automatic content analysis in collaborative inquiry-based, ESERA 2019
One session described by a topic model
Table 1. Comparison between the results of manual and automatic content analyses. The rows refer to the manual content analysis while the columns refer to the automatic content analysis.

<table>
<thead>
<tr>
<th></th>
<th>Predicted orientation</th>
<th>Predicted conceptualisation</th>
<th>Predicted investigation</th>
<th>Predicted conclusion</th>
<th>Predicted discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>16.3</td>
<td>0.4</td>
<td>1.1</td>
<td>0.0</td>
<td>6.8</td>
</tr>
<tr>
<td>Conceptualisation</td>
<td>2.8</td>
<td>2.2</td>
<td>0.8</td>
<td>0.0</td>
<td>5.7</td>
</tr>
<tr>
<td>Investigation</td>
<td>5.8</td>
<td>0.3</td>
<td>9.7</td>
<td>0.0</td>
<td>8.6</td>
</tr>
<tr>
<td>Conclusion</td>
<td>0.1</td>
<td>0.6</td>
<td>0.2</td>
<td>0.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Discussion</td>
<td>7.6</td>
<td>0.9</td>
<td>2.5</td>
<td>0.4</td>
<td>24.4</td>
</tr>
</tbody>
</table>

Overall accuracy 52.9% (sd = 4.8%) ≫ Baseline accuracy 34.9% (sd = 5.8%)

Lämsä, Espinoza, Araya, Viiri; Jiménez, Gormaz, Hämäläinen
Automatic content analysis in collaborative inquiry-based, ESERA 2019
Needs thousands of examples of the same lesson
Collaborative inquiry-based learning
Class observation and conceptual networks

Concepts connection and student learning

Collaborative inquiry-based learning
AI is the new ELECTRICITY
AI for Education

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Families
# What Parents Want: Education Preferences and Trade-Offs

A National Survey of K-12 Parents

Edited by Dora Zeehandelaar and Amber M. Winkler
Foreword and Summary by Chester E. Finn, Jr. and Michael J. Petrilli

## Figure 1: How K-12 Parents Prioritize Attributes

<table>
<thead>
<tr>
<th>School Characteristics</th>
<th>Student Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong core curriculum in reading and mathematics</td>
<td>Good study habits and self-discipline</td>
</tr>
<tr>
<td>Emphasizes science, technology, engineering, and math (STEM) education</td>
<td>Strong critical thinking skills</td>
</tr>
<tr>
<td>Strong education in life skills</td>
<td>Strong verbal and written communication skills</td>
</tr>
<tr>
<td>Extremely high academic standards</td>
<td></td>
</tr>
<tr>
<td>Programs for advanced students</td>
<td></td>
</tr>
<tr>
<td>High standards for student behavior</td>
<td></td>
</tr>
<tr>
<td>Technology used as a learning tool</td>
<td></td>
</tr>
<tr>
<td>Emphasizes character development, ethics, and/or morality</td>
<td></td>
</tr>
<tr>
<td>Instruction/project-based learning</td>
<td></td>
</tr>
<tr>
<td>Groups students by ability levels</td>
<td></td>
</tr>
<tr>
<td>Offers vocational classes or job-related programs</td>
<td></td>
</tr>
<tr>
<td>Offers programs for struggling or special needs children</td>
<td></td>
</tr>
<tr>
<td>Very traditional approach to learning</td>
<td></td>
</tr>
<tr>
<td>Average - 95</td>
<td></td>
</tr>
<tr>
<td>Variety of extracurricular activities other than sports</td>
<td>Prepared for college</td>
</tr>
<tr>
<td>Emphasizes importance of academic competition as much as collaboration</td>
<td>Strong social skills</td>
</tr>
<tr>
<td>Encourages parental involvement</td>
<td>Identifies interests and pursues their talents on their own</td>
</tr>
<tr>
<td>Emphasizes instruction in citizenship, democracy, and leadership</td>
<td>Strong self-esteem</td>
</tr>
<tr>
<td>Prepares students for taking state tests</td>
<td>A love of learning</td>
</tr>
<tr>
<td>High test scores</td>
<td>A strong moral code of conduct</td>
</tr>
<tr>
<td>Diverse student body</td>
<td></td>
</tr>
<tr>
<td>Curriculum is compatible with personal beliefs</td>
<td></td>
</tr>
<tr>
<td>Arts and music instruction</td>
<td></td>
</tr>
<tr>
<td>Small total student enrollment</td>
<td></td>
</tr>
<tr>
<td>Close to home (or workplace/other convenient location)</td>
<td></td>
</tr>
<tr>
<td>Supervised before and after school programs</td>
<td></td>
</tr>
<tr>
<td>Strong athletic program</td>
<td></td>
</tr>
<tr>
<td>Updated building facilities</td>
<td></td>
</tr>
<tr>
<td>Longer school day or school year of instruction</td>
<td></td>
</tr>
<tr>
<td>Does not have too much homework</td>
<td></td>
</tr>
<tr>
<td>School uniforms</td>
<td></td>
</tr>
<tr>
<td>Average - 35</td>
<td></td>
</tr>
<tr>
<td>Able to work collaboratively in teams</td>
<td></td>
</tr>
<tr>
<td>Accepted at a top-tier college</td>
<td></td>
</tr>
<tr>
<td>Finishes school w/ job skills that do not require further education</td>
<td></td>
</tr>
<tr>
<td>A love of country/patriotism</td>
<td></td>
</tr>
<tr>
<td>Fluency in a foreign language</td>
<td></td>
</tr>
<tr>
<td>An appreciation for nature</td>
<td></td>
</tr>
</tbody>
</table>
Harvard Family Research Project

Toyota Family Learning

An intergenerational program from the National Center for Families Learning.
What Library Leaders Recommend:

- Place puzzles, coloring books, and Legos openly out on tables.
- Designate a small space in the library where parents can talk with one another.
- Find ways to continually transform sections of the library into different “exhibits” so that the environment is fresh and gives families and children new areas to explore.
- Set aside a safe place for librarians and families to have private conversations.
- Design spaces that reinforce relationships between children and families. Place parenting collections near the children’s area, for example.
Example 1
In EdReports' First Review of Early-Reading Programs, No Materials Make the Grade

EdReports, the nonprofit curriculum reviewer, released its first reviews of foundational reading and writing skills programs—and all five of the materials assessed failed to reach the evaluator's highest standard. Read more.

https://www.youtube.com/watch?v=rcGikVdmBEo
Needs thousands of videos for the same strategy
Social Learning
Example 2
https://mapas.conectaideas.com/
Summer coloring books
Play and peer review
Feedback for tens of thousands of videos
Family and social learning

Activity books, play and peer review
AI is the new ELECTRICITY
Jevons Paradox
Literacy rate
Estimates correspond to the share of the population older than 14 years that is able to read and write. Specific definitions and measurement methodologies vary across countries and time. See the 'Sources'-tab for more details.
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Thank you