Adaptive Learning and the Power of Analytics

Colm Howlin, PhD
Principal Researcher

colm.howlin@realizetitlearning.com
www.realizetitlearning.com
@RealizeItLearn

Twitter : #NercompPDO1
Outline

• Adaptive Learning Framework in Realizeit
  • How we achieve adaptivity
• Learning Analytics
  • Integrated into learning
  • Student and instructor views
  • Academic analytics examples
• Predictive Analytics
  • Example of behavior based early warning system
• Questions
Product Vision

• Emulate a good teacher in one-on-one learning situation

• Provide an individualized learning experience
  • Deliver learning at an appropriate time
  • Deliver appropriate learning material
  • Learn about the learner
  • Manage and adapt to change: abilities, metrics, behavior etc.
  • Identify weaknesses and try to remedy

• Remain subject and content independent
The Realizeit Learning Model

- Target Knowledge (Curriculum)
- Determine Knowledge
- Learning Paths
- Profiling
- Ability Metrics
- Content
The Realizeit Learning Model
The Realizeit Learning Model
Content

• Learning Bits
  • Introduction
  • Learning Material
  • Example
  • Worked Example
  • Interactive Example
  • Questions
  • Summary
  • Review

• Questions

Template: $ax + bx = ?$

Conditions:

- $1 \leq a \leq 10$
- $1 \leq b \leq 7$

ILEWNQSR
LRQ
LSQNILQR
LSIWQR

2x + 7x = ?

x + 3x = ?

10x + 2x = ?
The Realizeit Learning Model
Adaptivity in Realizeit

• Tailor a student’s start position
• Alter a learner’s pathway in real-time
• Select the most suitable content
• Select the most suitable pedagogical elements
• Adapt the content in real-time
• Main source of adaptivity comes from the adaptive intelligence engine
• Adaptivity and personalization also come from the instructor or the student themselves
Learning and Academic Analytics

<table>
<thead>
<tr>
<th>TYPE OF ANALYTICS</th>
<th>LEVEL OR OBJECT OF ANALYSIS</th>
<th>WHO BENEFITS?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Analytics</td>
<td><strong>Course-level:</strong> social networks, conceptual development, discourse analysis, “intelligent curriculum”</td>
<td>Learners, faculty</td>
</tr>
<tr>
<td></td>
<td><strong>Departmental:</strong> predictive modeling, patterns of success/failure</td>
<td>Learners, faculty</td>
</tr>
<tr>
<td>Academic Analytics</td>
<td><strong>Institutional:</strong> learner profiles, performance of academics, knowledge flow</td>
<td>Administrators, funders, marketing</td>
</tr>
<tr>
<td></td>
<td><strong>Regional</strong> (state/provincial): comparisons between systems</td>
<td>Funders, administrators</td>
</tr>
<tr>
<td></td>
<td><strong>National and International</strong></td>
<td>National governments, education authorities</td>
</tr>
</tbody>
</table>
Learner and Instructor Analytics

• Go beyond the traditional summative metrics – adaptive analytics
• Based on both attainment and behavioral metrics
• Easily understandable
• Actionable
• Integrate analytics into the functionality and use of the system
• Makes use of data as it is gathered and generates real-time analytics
Instructor
Instructor – Analytics Examples
Instructor – Analytics Examples
Instructor – Analytics Examples
Course Review – Analytics Examples

Trend analysis

Trends
Values that have been generally increasing:
- Number of students
- Number of groups
- Number of instructors
- Percentage repeating
- Students per group
- Interactions per student
- Messages from students (per student)
- Messages to students (per student)
- Learning hours per student
- Questions per student
- Practices per student
- Revisions per student
- Calculated score
- Percentage retained
- Knowledge state
- % of students with grade D
- % of students with grade C
- % of students with grade B
- % of students with grade A

Values that have been generally decreasing:
- Number of new instructors
- Number of learning nodes
- Groups per instructor
- Percentage of questions queried
- Percentage of quoted questions without response
- Percentage with Determine knowledge
- % of students with grade F
- % of students with grade E

<table>
<thead>
<tr>
<th>Value</th>
<th>Slope</th>
<th>Correlation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revisions per student</td>
<td>0.420</td>
<td>0.962</td>
<td>4.860</td>
<td>4.860</td>
<td>5.460</td>
<td>8.950</td>
<td>8.060</td>
<td>8.250</td>
<td>8.580</td>
<td>7.830</td>
</tr>
</tbody>
</table>
Prediction of Student Success

• To build an early warning system to detect at-risk students

• Traditionally built on demographic - cannot change

• Focus on learner behaviour - one week of learning

• From the predictions and associated probabilities determine a list of at-risk students.

• Take action - Inform the appropriate stakeholders and provide appropriate remediation

• Monitor the impact of any intervention
Relationship between versions

- All fail → Most pass
- All pass → All pass
- Same proportion pass/fail each version
- Most pass → All fail

Relationship shown with correlation of 0.5791.
Dependant Variable

- **FinalGrade** - The average student grade across the course objectives at the final due date.

- **PassFail** - A binary version of FinalGrade

\[
PassFail = \begin{cases} 
1 & \text{if } \ FinalGrade \geq 60\% \\
0 & \text{otherwise}
\end{cases}
\]
Independent – Course Level

Behavior

- **Activity1** – First activity on course
- **Activity2** – Second activity on course
- **ActivitiesEachDay** – Total number of learning activities
- **AvgActivitiesEachDay** – Average number of activities each day
- **DayStarted** – Number of days before finish date that student started learning
- **Days** – number of days on which learning activities were delivered
- **NumPrevCourses** – The number of previous courses in which the student was enrolled.
Independent – Course Level

Attainment

- **Grade** – Final grade if calculated at this point in time
- **GradePF** – Binary version of Grade.
- **QuestionsAsked** – Num of questions
- **QuestionsCorrect** - Num correct
- **QuestionsIncorrect** – Num incorrect
- **PerQuestionsCorrect** – Percent correct
- **PerQuestionsIncorrect** – Percent incorrectly
Independent – Objective Level

Attainment

• **Obj\_i\_Grade** – The grade the student.
• **Obj\_i\_KC** – The knowledge covered.
• **Obj\_i\_KS** – The knowledge state.
• **Obj\_i\_Pass/Fail** – A binary version of the objective grade.

Behaviour

• **Obj\_i\_Learning Prop** – The proportion of activities that are learning activities (before mastery).
• **Obj\_i\_Revision Prop** – The proportion of activities that are revision activities (after mastery).
• **Obj\_i\_TimePerNode** – The average amount of time per node.
Model Accuracy – Unseen Data

<table>
<thead>
<tr>
<th>Predicted</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail</td>
<td>Fail</td>
</tr>
<tr>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>

Fit - 94.23%
Accuracy - 84.92%
Predictor Importance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>ActivitiesEachDay</td>
<td>8.1%</td>
</tr>
<tr>
<td>Days</td>
<td>7.2%</td>
</tr>
<tr>
<td>Obj 1 KC</td>
<td>4.9%</td>
</tr>
<tr>
<td>Obj 1 Grade</td>
<td>4.9%</td>
</tr>
<tr>
<td>Grade</td>
<td>4.8%</td>
</tr>
<tr>
<td>AvgActivitiesEachDay</td>
<td>4.1%</td>
</tr>
<tr>
<td>Obj 1 Pass/Fail</td>
<td>3.8%</td>
</tr>
<tr>
<td>Obj 1 Revision Prop</td>
<td>3.3%</td>
</tr>
<tr>
<td>DayStarted</td>
<td>3.0%</td>
</tr>
<tr>
<td>Obj 1 Learning Prop</td>
<td>3.0%</td>
</tr>
<tr>
<td>Obj 1 KS</td>
<td>2.9%</td>
</tr>
<tr>
<td>Obj 1 TimePerNode</td>
<td>2.8%</td>
</tr>
</tbody>
</table>
Simplified Model

Behavioural Metrics
- Activities Each Day
- Days
- Day Started
- Obj 1 Revision Prop
- Obj 1 Learning Prop
- Obj 1 Time Per Node

Attainment Metrics
- Obj 1 KS
- Obj 1 KC
- Obj 1 Grade

Accuracy

<table>
<thead>
<tr>
<th></th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fail</td>
</tr>
<tr>
<td>Observed</td>
<td></td>
</tr>
<tr>
<td>Fail</td>
<td>20.92%</td>
</tr>
<tr>
<td>Pass</td>
<td>6.73%</td>
</tr>
</tbody>
</table>

Unseen Data
- Full Model: 84.92%
- Simplified Model: 84.74%
Sample model

Course: Principles of Macroeconomics

Training: Version 8
Test: Version 9

Full model: 86.99%
Simplified model: 84.01%
Insights

- Model based on behavioural and attainment metrics.
- Models allows insights into what behaviours make a student successful and what puts them at risk.

- Behavioural Metrics
  - Activities Each Day
  - Days
  - Day Started
  - Obj 1 Revision Prop
  - Obj 1 Learning Prop
  - Obj 1 Time Per Node

- Attainment Metrics
  - Obj 1 KS
  - Obj 1 KC
  - Obj 1 Grade
Overall Prediction Accuracy

- All fail → Most pass
- All pass → All pass
- Same proportion pass/fail each version
- Most pass → All fail

Linear Correlation: 0.5791
Summary – three main takeaways

• Adaptive Learning can provide unique fine grained data which can power new insights and analytics

• Analytics in real-time, actionable and integrated into the use of the system

• Adaptive learning can power predictive analytics based on learner behavior
Realize It

Learn More

Visit us at www.realizeitlearning.com or on Twitter @RealizeItLearn

Colm Howlin, PhD
Principal Researcher
colm.howlin@realizeitlearning.com

Twitter: #NercompPDO1