
Lisa Spiro
“IB in a Virtual World”
October 5, 2013
How can we know what students know (and thus help them learn)?

Timothy Dilich
How can we teach students with diverse knowledge and backgrounds?
“adaptive learning takes a sophisticated, data-driven, and in some cases, non-linear approach to instruction and remediation, adjusting to a learner’s interactions and demonstrated performance level and subsequently anticipating what types of content and resources learners’ need at a specific point in time to make progress.” (Learning to Adapt)
Forms of Adaptive Learning

- Clickers/ audience response systems (e.g. Contingent Pedagogies)
- Games (e.g. Refraction)
- Textbooks
- Computer Adaptive Testing
- Intelligent tutoring systems/ cognitive tutors
Some See Adaptive Learning As A Way to Improve and Personalize Learning

“Adaptive learning may prove to be exactly what we need most right now – practices and tools that enable maximum learning gains for a diverse and broad array of students irrespective of their prior educational performance and preparation.”

(Josh Jarrett and Rahim Rajan, Gates Foundation)

- >> Gates recently issued an RFP for “Adaptive Learning Market Acceleration Program”
“Computer adaptive learning systems are reductionist and primarily attend to those things that can be easily digitized and tested (math, science and reading). They fail to recognize that high quality learning environments are deeply relational, humanistic, creative, socially constructed, active and inquiry-oriented.” (Philip McRae)
How do we make sense of this debate?
Navigating the Territory: Map for Today’s Talk

I. Understanding adaptive learning systems

II. Case studies of 3 high profile adaptive learning systems
   I. Carnegie Cognitive Tutor
   II. Open Learning Initiative
   III. Khan Academy

III. Making an informed decision
   I. Benefits, challenges & risks

http://www.flickr.com/photos/electrichamster/96531540/
I. Understanding Adaptive Learning Systems

Thinking designed by Hedie Assadi Joulaee from The Noun Project
How do students learn best?

1. **Conventional class** with 30 students
2. **Mastery learning**: students master material through formative tests, feedback and correction
3. **Tutoring for 1-3 students**, followed by formative tests, feedback and correction
<table>
<thead>
<tr>
<th>Type of Learning</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional class</td>
<td>--</td>
</tr>
<tr>
<td>Mastery learning</td>
<td>1 std. deviation (average student above 84% of students in conventional class)</td>
</tr>
<tr>
<td>Tutoring</td>
<td>2 std. deviation (average student above 98% of students in conventional class)</td>
</tr>
</tbody>
</table>

**How might we scale the effectiveness of tutoring without facing the high costs?**
## Intelligent Tutoring Systems as One Solution to the Scale Problem

<table>
<thead>
<tr>
<th>Type of Learning</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Tutoring</td>
<td>.79 standard deviation</td>
</tr>
<tr>
<td>Step-based intelligent tutoring systems</td>
<td>.76 standard deviation (sigma)</td>
</tr>
</tbody>
</table>

Two key differentiators of human tutors & intelligent tutoring systems (VanLehn):

- **Feedback**: tutors help students identify errors and correct them
- **Scaffolding**: tutors help students think through problems, take on increasing responsibility

[VanLehn (2011)]
ICAP Hypothesis For Differentiating Levels of Engagement in Instruction (Chi)

interactive ≥ constructive > active > passive

Interactive: dialoguing with peer or expert

Constructive: producing outputs, e.g. concept map, hypothesis, questions

Active: “doing something,” e.g. highlighting, pointing

Passive: listening to a lecture

Via VanLehn (2011)
What Are Intelligent Tutoring Systems?

- “computer software designed to simulate a human tutor’s behavior and guidance.” (ELI)
- Based on research into artificial intelligence
- Provide exercises until mastery is demonstrated
- Offer customized instruction and feedback
- Collect detailed data about the learner
- Enable
  - Students to learn at their own pace
  - Instructors to monitor learning & intervene
II. Case Studies of Technologies Incorporating Adaptive Learning
1. Carnegie Cognitive Tutor
Overview of the Carnegie Cognitive Tutor

- Based on the ACT-R theory of knowledge ("learning by doing")
- Grew out of Pittsburgh Urban Mathematics Project Algebra Tutor (early 1990s)
- "Model tracing" tracks student’s steps in problem solving and provides feedback
- "Knowledge tracing" monitors learning across problems to select next problems
- Supports:
  - Mastery learning
  - Differentiation of instruction
Multiple Representations to Support Different Learning Styles

The image shows a screenshot of a software interface that appears to be part of the Carnegie Cognitive Tutor. The interface includes text and a table, and a graph. The table contains the following columns:

- Quantity Name
- Time (in days)
- Savings

The table includes questions and calculations related to savings over a period of time. The graph on the right side of the interface likely represents the data from the table, showing changes over time.
### Just in Time Feedback

Your savings increases by 2 each day, but remember that it starts at 10 dollars.

<table>
<thead>
<tr>
<th>Quantity Name</th>
<th>the time from now</th>
<th>savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>days</td>
<td>dollars</td>
</tr>
<tr>
<td>Expression</td>
<td>$x$</td>
<td>$2x$</td>
</tr>
</tbody>
</table>

**Questions:**
- Question 1
- Question 2
- Question 3
- Question 4
Skillometer (Assessment)

Enter given.
Identify unit.
Calculate input value.
Writing expression, any form.
Place points.
Set axis interval.
Set axis bounds.
Teaching with Cognitive Tutor

Integrated approach: text, software, training

Recommendation: classes spend

- 2 days/week using the software
- 3 days/week in face-to-face class using active learning techniques, e.g. problem solving, group work

Koedinger & Corbett, 2006
Out of 27 studies of *Carnegie Learning Curricula and Cognitive Tutor*, only 3 are fully eligible and 3 eligible with reservations. High standards for eligibility, e.g. randomized controlled trial. Found “mixed effects” on students’ math scores: one study showed statistically significant positive effect on student performance; one (Geometry) a statistically significant negative effect; four showed indeterminate effects.

Positive Effects in Large-Scale Effectiveness Trial of Cognitive Tutor Algebra I (RAND 2013)

Method:
- Randomized controlled effectiveness trial
- Involved 73 high schools and 74 middle schools
- Compared courses using Cognitive Tutor Algebra I (CTAI) + textbook to those using a traditional textbook

Findings: Use of CTAI led to
- “a significant positive effect in high schools in the second year of implementation” (but not in the first year)
- “equivalent to moving an algebra I student from the 50th to the 58th percentile”

Cf. Reich
2. Open Learning Initiative
Overview of the Open Learning Initiative

- Initiative launched by Carnegie Mellon U in 2002
- Open educational project (free/low-cost access)
- Focused on college and community college courses such as statistics, chemistry, French & economics (18 to date)
- Incorporates embedded “mini-tutors”: simple versions of cognitive tutors to provide feedback & assessment
- Collaboratively designed by subject experts, cognitive scientists, human-computer interaction experts, &c
- Collects granular data on learning
- Provides feedback to learners and instructors
Understanding the Structure of the Course and Learning Objectives

Module 1 / Examining Distributions

**Learning Objectives**

1. Summarize and describe the distribution of a categorical variable in context.
2. Generate and interpret several different graphical displays of the distribution of a quantitative variable (histogram, stemplot, boxplot).
3. Summarize and describe the distribution of a quantitative variable in context: a) describe the overall pattern, b) describe striking deviations from the pattern.
4. Relate measures of center and spread to the shape of the distribution, and choose the appropriate measures in different contexts.
5. Compare and contrast distributions (of quantitative data) from two or more groups, and produce a brief summary, interpreting your findings in context.
6. Apply the standard deviation rule to the special case of distributions having the "normal" shape.
Self-Assessment/ Metacognition through “Did I Get This?”

Here are the number of hours that 9 students spend on the computer on a typical day:

1 6 7 5 5 8 11 12 15

The mode number of hours spent on the computer is: 7.5

The data from the above 9 students forms a bimodal distribution.

Incorrect. Bimodal distributions contain two modes. Since there is only one mode, what type of distribution is it?
Tracking Student Learning via the Learning Dashboard

Module 2: Examining Relationships

View data for: All Students [Hide Options...]

- All Students
- Individual Student

Learning Objectives

- Classify a data analysis situation (involving two variables) according to the "role-type classification," and state the appropriate display and/or numerical measures that should be used in order to summarize the data.

Estimated Learning by Student

- 43 students
- A dot >= 3 students

Class Accuracy by Sub-Objective

- Categorical: 27
- Explanatory: 27
- Identifying case C >= C: 31
- Select appropriate: 13
- Select appropriate: 13

Compare and contrast distributions (of quantitative data) from two or more groups, and produce a brief summary, interpreting your findings in context.

Produce a two-way table, and interpret the information stored in it about the association between two categorical variables by comparing conditional percentages.

Graphically display the relationship between two quantitative variables and describe: a) the overall pattern, and b) striking deviations from the pattern.

Graphically display the relationship between variables using a scatterplot.
“Data Collection and Feedback Loops for Continuous Improvement”
## OLI Hybrid STATS Course Speeds Learning, Brings Equal or Better Performance

<table>
<thead>
<tr>
<th>OLI Accelerated</th>
<th>Average % Correct</th>
<th>Traditional Control</th>
<th>Average % Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>55</td>
<td>Pre</td>
<td>50</td>
</tr>
<tr>
<td>Post</td>
<td>73</td>
<td>Post</td>
<td>53</td>
</tr>
</tbody>
</table>

Increase: 18 percentage points
Increase: 3 percentage points

**Student performance on Comprehensive Assessment of Outcomes in a first [college-level] Statistics course**

“students in OLI-Statistics took half the time to learn as much or more than their traditional counterparts”

---

Comparing Traditional & Hybrid STAT Courses at Public Universities

- “No significant difference” in learning outcomes
- Students had a slight preference for traditional
- Hybrid took ~ 25% less time to complete

3. Adaptive Learning in the Khan Academy
Overview of Khan Academy

- Provides free access to educational materials, including videos, exercises, and assessment tools
- Founded 2006
- High level of use
  - 283 million views of YouTube channel
- Incorporates adaptive techniques
  - Creating a profile of the learner
  - Adjusting difficulty of exercises based on prior responses
  - Offering detailed assessment data to learner & coach
Marvin the gnome is running from a big, mean orc. Marvin is 2 feet tall, and the orc is 8 feet tall.

The orc is how many times as tall as Marvin?

The orc is a lot taller than Marvin. We want to compare their heights using multiplication. How many times does 2 go into 8?

\[ 2 \times ? = 8 \]
Monitor Your Own Learning

LisaMSpiro » Skill Progress

Shows which skills you’ve worked on and completed.

<table>
<thead>
<tr>
<th>Addition and subtraction</th>
<th>Attempts</th>
<th>Correct</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-digit addition</td>
<td>14</td>
<td>93%</td>
<td>Practiced</td>
</tr>
<tr>
<td>2-digit addition</td>
<td>0</td>
<td>-</td>
<td>Practiced</td>
</tr>
<tr>
<td>1-digit subtraction</td>
<td>10</td>
<td>100%</td>
<td>Practiced</td>
</tr>
<tr>
<td>2 and 3-digit subtraction</td>
<td>0</td>
<td>-</td>
<td>Needs Practice</td>
</tr>
<tr>
<td>Addition with carrying</td>
<td>0</td>
<td>-</td>
<td>Needs Practice</td>
</tr>
<tr>
<td>Addition and subtraction word problems</td>
<td>0</td>
<td>-</td>
<td>Needs Practice</td>
</tr>
<tr>
<td>4-digit addition with carrying</td>
<td>0</td>
<td>-</td>
<td>Needs Practice</td>
</tr>
<tr>
<td>Subtraction with borrowing</td>
<td>0</td>
<td>-</td>
<td>Needs Practice</td>
</tr>
<tr>
<td>4-digit subtraction with borrowing</td>
<td>0</td>
<td>-</td>
<td>Needs Practice</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Multiplication and division</th>
<th>Attempts</th>
<th>Correct</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number line 1</td>
<td>0</td>
<td>-</td>
<td>Needs Practice</td>
</tr>
<tr>
<td>Multiplying 1-digit numbers</td>
<td>5</td>
<td>100%</td>
<td>Practiced</td>
</tr>
<tr>
<td>Multiplying by multiples of 10</td>
<td>0</td>
<td>-</td>
<td>Practiced</td>
</tr>
</tbody>
</table>
Provide Coaching
Know What You Know: Khan Learning Flow

Converting mixed numbers to fractions

Next up...

Now you've unlocked your next set of tasks. We'll continue to fill these up and suggest new things to practice. Each one you finish will give you point rewards!

UP NEXT

Reading pictographs 2

YOU FINISHED!

Math Pretest
+1000 energy points
Preliminary Results of Khan Academy Blended Learning Experiments

- **Los Altos School District**
  - Blended learning model where Khan is just part of overall approach that also includes manipulatives, projects, etc.
  - More value in exercises & data than videos (best as supplement)
  - Increased student motivation & ownership

- **Envision Academy** (Oakland) small pilot
  - Enabled teacher to do more 1:1 & small group interactions
  - Teacher could examine learner data (but needed ask why)
  - Students appreciated instant feedback, became more responsible for learning, and coached each other

- SRI study due soon
Criticisms of Khan Academy

- “instructivist” approaches
- Inaccuracies in videos (Khan Mystery Science Theater)
- “do this then do this” pedagogy
- Distracting people from deeper problems with education, such as inequity
III. Evaluating Adaptive Learning

Employee Evaluation designed by Miroslav Koša from The Noun Project
Many Companies Are Developing Adaptive Learning Software, Including...

- Adapt Courseware
- Cerego Global
- CogBooks
- Jones & Bartlett Learning
- LoudCloud
- McGraw-Hill Education (LearnSmart)
- Open Learning Initiative
- Smart Sparrow

Education Growth Advisors
Advantages of Adaptive Learning Systems

- Allow for personalized learning
- More scalable than human tutors
- Available at any time, any place
- May be easier for reserved students to interact with
- Create low-stakes opportunities to practice and build towards mastery
- Provide detailed data on learning that the instructor can use to tailor teaching
Limitations of Employing Adaptive Learning Systems

- **Often require** the learner to be motivated and self-directed
- Work best in areas where there are clear answers *(procedural/fact-driven)*
- Expensive to develop
- Time to integrate into education: technical infrastructure, curriculum, teacher training
- Challenging for teachers to **make sense** of all the data
- We lack sufficient understanding of **effectiveness** and need better approaches to evidence *(US Dept. of Education, 2013)*)
Concerns That Adaptive Learning Systems Undermine Learning

- Mechanizes learning
- **At odds** with creativity, choice & social relationships
- Diminishes teacher’s autonomy
- Lack of clear research demonstrating benefits
- Enforces rigidity and conformity
- Too much screen time?
Potential Costs Associated with Adaptive Learning Systems

- Software licenses
- Professional development
- Support
- Hardware
- Maintenance
Concerns about Commercializing and Privatizing Learning

- Cost of adaptive learning systems are often higher than traditional textbooks

- Do we want to outsource core learning functions to private companies?

- Invest in teachers rather than technology?

- Lack of ownership of subscription-based resources
Do we want to become the NSA of learning?

“The purpose of school isn't to get people comfortable with life under constant observation. The endless efforts at data collection to capture what ‘works’ with learning have the potential to disrupt the learning they are trying to capture. Learning requires trust...” (Bill Fitzgerald)
Data that can be collected includes:
- Social Security numbers
- Disciplinary record
- Whether a student is homeless

Concerns about who can access the data:
- Employers?
- Marketers?

inBloom responses:
- Data is anonymized
- Data will not be sold
- School districts determine what data will be collected
Most advocates of adaptive learning also emphasize the need for human teachers (cf. VanLehn, Meyer/OLI, Khan)

- **Adaptive learning**: practice, hints, feedback, assessment, data on student performance
- **Human teacher**: facilitating groups, helping students communicate, providing context, coaching, designing learning activities (but not grading tests)

Adaptive learning is typically used in a blended setting

But I could see a scenario where fewer teachers are required
Some Questions to Ask in Considering Adaptive Learning Systems

- Is this software consistent with the school mission and identity?
- How will parents respond? Students? Teachers?
- What evidence is there that this technology works?
- How will the software be integrated into the curriculum?
- How will teachers be trained to use the software?
- What are the current and ongoing costs? What happens if the company goes out of business?
- Is there an adequate technical infrastructure (devices, networking, etc) to support the software?
- Who has access to student data? How will that data be protected?
Adaptive Learning Systems Bring Shifts In....

<table>
<thead>
<tr>
<th>Category</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>How class time is spent</td>
<td>Mix of computer-based interactions, individualized instruction &amp; group work</td>
</tr>
<tr>
<td>Role of the teacher</td>
<td>Coach, learning designer, facilitator</td>
</tr>
<tr>
<td>Pace of learning</td>
<td>More according to the student’s needs, not the school calendar</td>
</tr>
</tbody>
</table>
A Quick Poll: Raise your hand if...

- you think adaptive learning systems could improve learning
- you are concerned that adaptive learning systems could undermine learning
- you aren’t sure what to think
“If... each student has his or her own computer and he/she does an online course which adapts to the level and needs of the student, there will be a much greater degree of differentiation. They are all doing mathematics, but one student is doing statistics, another is starting to look at the arithmetic mean ... The teacher is still needed though, to clarify concepts, to set creative open-ended problems and to ‘steer the ship’.” (Dr Conrad Hughes, Director of Education in the International School of Geneva)
Leading Questions

- What impact might adaptive learning systems have on teaching and learning?
- What potential benefits do you see to adaptive learning systems? What about disadvantages?
- Are adaptive learning systems consistent with IB values?
- What strategy would you pursue with regards to adaptive learning systems? How would you explain this strategy to your teachers? Parents? Students? Board members?
- What are some effective approaches to differentiating instruction, with or without technology?
Download these slides

http://digitalscholarship.wordpress.com/
Thanks!

Get in touch:
lisamspiro@gmail.com
Resources

More Resources


- What Works Clearinghouse