Infusing Demographic-Specific Applications into a Digital Logic Adaptive Learning System

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1) Motivation – The STEM Workforce & Pipeline

2) Personalized Learning

3) Demographic-Specific Content Can Stress Value
Motivation – The STEM Workforce

• What is STEM anyway?
  – Defined as “people who create knowledge”.
  – This doesn’t include health practitioners.

• Who are these STEM people?
  – In 2013, there were 142M jobs in the US.
  – Of these, 8M were in STEM (1 of ~18).
    • 3.8M in Computers & Math
    • 2.85M in Architecture & Engineering
    • 1.35 in Science
  – That’s 25% of the professional workforce.
  – That’s 5% of the overall workforce
Motivation – The STEM Workforce

• **STEM Fuels the US economy**
  – STEM innovations account for 50% of the growth in U.S. economy.
  – Predicted growth rate through 2018 in STEM jobs (20.6%).
  – Predicted growth rate through 2018 in non-STEM jobs (10.1%).
  – Jobs are shifting from non-STEM to STEM.
• **Are We Producing Enough STEM Grads To Meet the Demand?**
  – There are 8M STEM workers in the U.S. right now.
  – 9M+ by 2022.
Motivation – The STEM Workforce

• **The Question requires looking at the entire pipeline**
  - Data can be difficult to find.
  - Different sources define STEM professions differently. We use NSF def.

![Diagram showing K-12, U.S. STEM Higher Ed, and U.S. STEM Workforce (8M) with 287 STEM Openings.](image-url)
Motivation – The STEM Workforce

- The STEM Pipeline
  - Who enters U.S. higher education system?
Motivation – The STEM Workforce

- **The STEM Pipeline**
  - Who obtains a STEM degree?

- **Infusing Demographic-Specific Learning…**
Motivation – The STEM Workforce

• The STEM Pipeline
  – Including retirement completes the flow diagram.  Looks like we are fine?

- K-12 (3M/yr)
  25% STEM
  60% entering choose STEM
  40% Don’t Enter College

- U.S. STEM Higher Ed
  287k BS
  92k MS
  25k PhD
  40% Don’t Persist to Graduation

- U.S. STEM Workforce (8M)
  287 STEM Openings
  65k – 80k H1B

- Retire
  235k ~3%

- International
  35% Don’t Enter College
  40% non-STEM
Motivation – The STEM Workforce

- The STEM Pipeline – The off roads are the concern.
  - Some STEM graduates don’t enter the field after getting a degree.

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Infusing Demographic-Specific Learning...
Motivation – The STEM Workforce

- The STEM Pipeline – The off roads are the concern.
  - People leave the workforce at an alarming rate.

Infusing Demographic-Specific Learning...
• The off-roads impact certain demographics more than others

  – The fastest growing fields have the most severe underrepresentation of women.
• The off-roads impact certain demographics more than others

  – The fastest growing fields have the most severe underrepresentation of women.

  – Growth in the area of computers accounted for over 90% of the job growth in STEM occupations between 2003 and 2013.

    • Yet only 26% of jobs in this area were held by women.

    • The percentage of BS degrees awarded to women in this area decreased from 23% to 18% between 2004 and 2014.
Motivation – The STEM Workforce

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– Growth in the area of computers accounted for over 90% of the job growth in STEM occupations between 2003 and 2013.
  • Yet only 26% of jobs in this area were held by women.
  • The percentage of BS degrees awarded to women in this area decreased from 23% to 18% between 2004 and 2014.

– Women are 45% more likely than their male peers to leave the STEM industry within their first year. By age 35, 52% of women employed in STEM leave the field (Hewlett, 2008).
Why do people leave STEM? It depends on the student.

1) COGNITIVE
- Our intellectual skills.
- The first thing we think of when we talk about “learning”.

2) AFFECTIVE
- Our feelings (attitudes, motivation, willingness to participate, value of what is being learned).
- Heavily influences success of cognition.

3) PSYCHOMOTOR
- Motor skills.
- Cognition is underlying component, but practice-makes-perfect.
Personal Learning

- Why do people leave STEM? It depends on the student.

Motivation = Expectancy x Value

More than just wanting good grades & lots of money…

- Will a student “choose” a STEM degree
- Will the student put in the time necessary to achieve graduation.
- Will the person “choose” a STEM profession.
- Will the professional “choose” to stay in STEM.

(Atkinson 50’s 60’s, Eccles 80’s)
Why do people leave STEM? It depends on the student.

Motivation = Expectancy x Value

Beliefs about one’s own ability and chances for success.

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AGENTIC (self)

COMMUNAL (others)

Simple interventions can make a big difference.
E-Learning Systems Have Big Potential

- Personalized instruction without instructor resources
- Address background deficiencies
- Challenge top students
• **They are becoming practical**
  - Course management systems support the creation.
  - Publishers are providing more sophisticated e-learning environments.
Our Contribution - Demographics

• If we have the attention of the student, why not make the material “relevant”.
  – Wording of problems and choice of examples can make material “relevant”.

• “Relevance” varies between students
  – Agentic vs. Communal value systems.
  – Values often track demographics.

• But it’s a lot of work to make material relevant to many different student groups!
  – That’s where the e-learning system has great potential.
  – The system automatically tailors the material based on the individual.
A simple example: The traditional question format

<table>
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<tr>
<th>Example 1. Calculating How Long a Battery Will Last</th>
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</thead>
<tbody>
<tr>
<td><strong>Concept</strong></td>
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<td>• DC Power Consumption</td>
</tr>
<tr>
<td><strong>Problem Statement</strong></td>
</tr>
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<td>• A 9v battery is has a capacity of 500 mAh. If you are driving a circuit that consumes 20mW of power, how long will the battery last?</td>
</tr>
</tbody>
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• **A simple example:** *More relevant to the millennials.*

<table>
<thead>
<tr>
<th>Example 2. Calculating How Long a Battery Will Last</th>
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**Personal Learning**

- **A simple example:** *More relevant to communal value systems.*

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Current Status of our Work

- **Year 1 (now)**
  - Defined 13 broad learning objectives across two courses in digital logic.
  - Defined 60 specific learning outcomes to be measured.
  - Developed over 600 assessment tools (i.e., homework questions).
  - Implemented in course management system as auto-graded assignments.
  - Collected baseline data on student performance across 3 semesters (n=220).

- **Year 2 (next)**
  - Implement adaptive learning modules. Collect data.

- **Year 3 (final)**
  - Implement demographic-specific examples and implement in adaptive learning modules. Collect data.
Lessons Learned

• **Consent Forms**
  – Difficult to obtain demographic information.
  – We learned if coded sufficiently, we can pull data from university data base.

• **Auto-grading leads to poor students impacting results.**
  – Failing students are able to login and turn in assignments at the last minute.

• **Assessment measures need to match learning outcome category.**
  – If the learning outcome targets “synthesis”, the assessment tools can’t ask questions about “analysis”.

• **Labs are rich with assessment data, but hard to grade.**
  – Most learning in engineering occurs in the lab. But lab demonstrations are typically pass/fail.
  – Lab reports graded with rubrics give great assessment data, but scaling becomes impractical.
Questions

Thank you
**References**

17. ”Southern Regional Education Board’s (SREB) Electronic Campus Principles of Good Practice Checklist”, 2002.
References


Infusing Demographic-Specific Learning…
A. Plugging the leaks in the STEM pipeline, Complete College American, March 2014