system design and management

MIT SDM Systems Thinking Webinar Series

Strategy, Simulation, and Analytics for the Complex World of Education
By Dan Sturtevant, Ph.D., MIT SDM Alumnus
Jeanne Contardo, Ph.D., BHEF Senior Advisor
Who we are and why we care.

A partnership between a membership organization of Fortune 500 CEOs and university presidents dedicated to advancing solutions to U.S. education and workforce challenges, and a modeling firm that specializes in answering education questions by thinking about them as complex systems.

% of U.S. population with 2-year or 4-year degree

Source: U.S. Census Bureau, American Community Survey

U.S. Spending on Human Capital Development by Category (in billions of $)

- Federal employment and training programs
- Apprenticeships & industry-based certifications
- Employer-based training (formal)
- Employer-based training (informal)
- Elementary and secondary education
- Higher education

Carnevale and Smith, 2013

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More of the challenge: employers and the future workforce are worried.
Roadblocks to education reform.

- Attempts at reform often fail because policymakers typically cannot account for many of the internal tensions, delays, feedbacks, and unintended consequences.
- We don’t have complete direct causal data– and if we do, the methodology may be questioned.
- Various stakeholders see the world differently– and their implementation choices are influenced by their different world views.
Using modeling to drive education policy.

- **Quantitative**
  - Survey design, Large N data sets, Randomized control, Statistics
  - System dynamics modeling, Agent based modeling, Complex adaptive system modeling, Others

- **Qualitative**
  - Sociology, Ethnography, Case studies

- **Deductive**
- **Inductive**
Institution and policy design in education: the importance of understanding why something works.
How do we actually apply modeling in an education/policy setting?

- Bring diverse stakeholders to the table
- Identify holes in the research
- Build an online model
- Create simplified user interfaces
- Develop a suite of resources around the model
Modeling can be complicated.
(U.S. STEM Education Model—Dynamic Hypothesis)

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But with a little thought, and practice, we can communicate our findings simply.
And sometimes, you need a little complexity.
The Aligned Workforce Model is the most recent addition to BHEF’s suite of online simulation models.

BHEF is funded by the William and Flora Hewlett Foundation to “address the significant skills misalignment present between education production and business needs by mobilizing national business support for building improved deeper learning skills.”

The Aligned Workforce Model is designed to shed light on misalignment between education production and workforce needs, and to offer solutions that could improve the outcomes we all care about.
Current workforce demands indicate acute labor surpluses and shortages.

Current Workforce Surpluses and Shortages

Help (More or Less) Wanted
The industries with the most and least acute labor shortages

<table>
<thead>
<tr>
<th>Most competitive</th>
<th>Job seekers per online opening in December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farming, fishing and forestry</td>
<td>48.7</td>
</tr>
<tr>
<td>Construction and extraction</td>
<td>28.1</td>
</tr>
<tr>
<td>Building, grounds cleaning and maintenance</td>
<td>15.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Least competitive</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Life, physical and social science</td>
<td>1</td>
</tr>
<tr>
<td>Computer and mathematical science</td>
<td>0.4</td>
</tr>
<tr>
<td>Health-care practitioners and technical</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Note: Excludes duplicate job ads; Openings in some occupations may be posted online less frequently.

Source: Bureau of Labor Statistics; The Conference Board
And future workforce projections indicate ongoing shortages, especially in high growth career fields.

12th Grade Student Interest and Proficiency in High-Growth Career Fields

<table>
<thead>
<tr>
<th>Career Fields</th>
<th>Projected Annual Job Openings</th>
<th>Career Interested and Math Proficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>16%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Computer/Information Specialties</td>
<td>11%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Management</td>
<td>9%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Community Services</td>
<td>9%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Marketing/Sales</td>
<td>8%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>
What would happen if we created policies that align the education and workplace systems?
The Aligned Workforce Model

Simulating the effect of education and workforce policies

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We all have heard the stories…

“I can’t find a job”

“I’m bored at work”

“I can’t find the right employees”

“I hired someone, but he couldn’t do the job”

The Aligned Workforce Model explores why this mismatch happens and asks:

*What would happen if we created policies that align the education and workplace systems?*

How do various education and workforce changes affect:

- Unemployment and job turnover?
- Wage inequality and the middle class?
- Worker productivity and firm profitability?
The Challenge:

Hiring managers and human resource officers have long used inefficient methods to hire a skilled workforce.

Furthermore, today’s companies increasingly require employees with mastery of core academic knowledge in a given field as well as fundamental workplace competencies.

However, these abilities are difficult to measure.

Lacking good data, employers will use degrees and credentials as a proxy and base hiring decisions on the presence of one or more very specific skills (e.g., knowledge of a particular software program, experience grant writing, or facility in a particular sector) possessed by a candidate.
So what’s the problem with hiring this way?

Today’s jobs require an increasingly complex array of very specific skills.

Moreover, the rate at which these skills change or evolve is increasing rapidly, often leading to skill obsolescence.

The imprecise hiring practices created by hiring for these skills alone, with only credentials as a proxy for more complex abilities, create an inefficient system. Read more about demand for what the Hewlett Foundation calls “deeper learning”

Employers that can better align hiring with their workforce needs—including the need for complex abilities—will have better workforce outcomes.

Colleges and universities that produce the knowledge and skills needed by employers will drive the economy.

This model addresses the question: What would happen if we created policies that align the education and workplace systems?
When the model runs, it contains simulated people and firms who make choices and interact with each other. Fundamentally, the model simulates:

- People, life-long learning, and their career success
- Firms and their business outcomes
- The way educational institutions behave
- Innovation & the growth of human knowledge
The model functions like a board game in some respects. Simulated people learn new skills, seek work, use skills on the job, and mature.

During the simulation, people aim to have happy and productive careers. The goal of simulated firms is to be productive and lean.
In the model, the sum of human knowledge is represented as a network. Each node can be thought of as a specific piece of academic or workforce content – a potentially useful competency or skill. Connected nodes represent content similarity.

When someone has a skill, it is easier to pick up a related skill. Likewise, firms tend to need a workforce with knowledge of different but related skills.

In the model, this simulated network of human knowledge will change over time. The expansion of knowledge will add more nodes. Innovation will make new ones valuable, while rendering others obsolete.
Each simulated person has different types of core knowledge and is varied along other deeper-learning dimensions affecting the rate at which they learn and what they learn.

Sum total of all human knowledge

Each person knows a subset of this knowledge

... and has deeper learning competencies affecting how they learn additional competencies over time

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Firms have needs for specific competencies in their workforce. They hire people with these skills. If alignment is good, the firm is lean. If not, the firm is less productive.

Firms have specific needs for knowledge in different quantities.

Firms employ many people, the sum of whose abilities may meet these needs.

Aligned firms’ employees have skills (in the aggregate) that match the workforce competencies they require. These firms are profitable and lean – they can cover all bases with a smaller number of productive and motivated employees.

Misaligned firms have disparities between their labor needs and the skills of their workforce. These firms are less productive because they must either employ many extra people to cover all bases or will not be able to do everything they wish to. They will have higher costs or lower revenue than is desirable.
A person’s value to a firm is a function of the in-demand skills they bring to the job and their ability to rapidly learn other necessary skills.

Similarly, a person’s happiness at work depends on how well-aligned their own skills are, to the skills most in current demand at the company.

Skill alignment leads both to career success for the individual and profitability for the firm.

The calculated value of the individual to the firm impacts whether a person will be hired or laid off. Simulated people will try to find employment in firms where they are highly valued. Read more about how we calculate value.
In addition, as the model evolves...

People learn new skills

Firm needs change due to innovation

The body of human knowledge expands

The model is designed to allow you to test different policies and scenarios related to...

What is taught in school?
Is the hiring process aligned?
How do people learn on the job?
Opportunities for the unemployed?
Keeping up in times of major change?
The model will allow you to test the impact of simulated policy choices on important outcomes at multiple levels:

**Individual**
- Fraction of career gainfully employed
- Value placed on skills by employer
- Skills learned over lifetime

**Firm**
- Alignment between needs and workforce competencies
- Staff turnover
- Availability of needed skills in the labor market

**Societal**
- Unemployment rate
- Open positions that could not be filled
- Income distribution / strength of middle class
The Aligned Workforce Model

Simulating the effect of education and workforce policies

Start by learning about the model in ‘Introduction’ and ‘Overview’

Then click ‘The Model’ to run scenarios and to explore the system

Questions or Comments?
Contact us: bhef@bhef.com
Entering the simulation

**Education system**

What content is taught in school?
- Unrelated to market demand
- Weighted toward 'in-demand'

Is 'Deeper Learning' emphasized in school?
- □ Learning strategies □ Self-efficacy

**Post Education Learning**

Opportunities to learn while unemployed
- □ Education opportunities prioritized

Skills the unemployed learn
- □ Adjacent to those already possessed
- □ Adjacent and high market value
- □ Learning strategies □ Self-efficacy

**On The Job Learning**

- □ Employee learning prioritized

What employees learn
- □ Adjacent to those already possessed
- □ Adjacent and high market value
- □ Adjacent and valued by employer
- □ Learning strategies □ Self-efficacy

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### Inputs

#### Education system
- What content is taught in school?
  - 🗽 Unrelated to market demand
  - 🗽 Weighted toward 'in-demand'

- Is 'Deeper Learning' emphasized in school?
  - ☐ Learning strategies
  - ☐ Self-efficacy

#### Post Education Learning
- Opportunities to learn while unemployed
  - ☐ Education opportunities prioritized

- Skills the unemployed learn
  - 🗽 Adjacent to those already possessed
  - ☐ Adjacent and high market value

  - ☐ Learning strategies
  - ☐ Self-efficacy

#### On The Job Learning
- Employee learning prioritized

- What employees learn
  - 🗽 Adjacent to those already possessed
  - ☐ Adjacent and valued by employer

  - ☐ Learning strategies
  - ☐ Self-efficacy

### Firms & Hiring
- How firms evaluate and hire
  - 🗽 Consider only relevant skills
  - ☐ Also consider ability to learn

- Is candidate and employee job fitness evaluated well?
  - ☐ High quality assessments

### Innovation, Technological Change
- How rapidly do firms' knowledge requirements change?

### Other Inputs
- What is the probability that an unemployed person will seek work any given week?
  - 0 1

- What is the probability that an employed person will seek better work any given week?
  - 0 1

- What is the probability a firm will contemplate laying off some workers any given week?
  - 0 1

- Number of opportunities evaluated when picking between options at career start or during career change.

  - Occasional career changes

- Hiring threshold
  - 0 1 25

- Layoff threshold
  - 0 6 25

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Output: Employment
Output: Knowledge & Skills

![Graphs showing knowledge, skills, efficiency, and inequalities.]

- **Knowledge & Skills**: Bar charts and line graphs illustrating various statistical data points.
- **Efficiency** and **Inequalities**: Comparative analysis with bar graphs.
- **Skill Net**: Analysis of skill distribution with bar graphs.
- **Scatter Plots**: Graphs showing scatter plots for data analysis.
- **Advanced**: Indicates advanced features or settings for data analysis.

- **Numerical Skills**: Bar chart indicating percentage distribution.
- **Learning Strategies Score**: Bar chart showing score distribution.
- **Self Efficacy Score**: Bar chart showing score distribution.

- **Ave Value Employer Places on Curr Employees**: Line graph showing average value.
- **Value of Skills Across Economy**: Line graph showing value distribution.
- **Fraction Skills Used by Curr Employer**: Line graph showing usage distribution.
- **Fraction Skills Useful Somewhere in Econ**: Line graph showing utility distribution.

- **Everyone**, **Employed**, **Unemployed**, **Young (<30)**, **Experienced (>45)**: Different graph lines for various demographic groups.
Output: Efficiency

- Employment
- Knowledge
- Efficiency
- Inequalities
- Skill Net
- Scatter Plots

Fraction skill needs met
Fraction skills available somewhere

Underutilization: Skills firm does not value

Widgets produced across economy
Pct alignment between skills and demand

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Output: Inequality

- Gini coefficient: Measure of societal inequality
- Fraction of people employed
- Early career employed (<30)
- Later career employed (>45)
- Value curr employer places on skills
- Value of skills somewhere in economy

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Output: Network representing human knowledge
Output: The value placed on skills is a function of mismatch between supply and demand.
Output: Looking at individuals: Knowledge, skills and their current utility
Firms: Mismatch between labor supply and demand
Test 1: Increase rate of ‘Creative Destruction’, ‘Innovation’, ‘Technological Change’
Gaining skills over a career
Some skills valued, others not
Test 2: Better alignment between what is learned and what firms need

<table>
<thead>
<tr>
<th>Learning</th>
<th>Firms</th>
<th>Summary</th>
<th>Other</th>
</tr>
</thead>
</table>

**Education system**
- What content is taught in school?
  - **Weighted toward 'in-demand'**
  - Unrelated to market demand

- Is 'Deeper Learning' emphasized in school?
  - Learning strategies
  - Self-efficacy
  - **Education opportunities prioritized**

**Post Education Learning**
- Opportunities to learn while unemployed
  - **Education opportunities prioritized**

- Skills the unemployed learn
  - Adjacent to those already possessed
  - Adjacent and high market value
  - Learning strategies
  - Self-efficacy

**On The Job Learning**
- Employee learning prioritized

- What employees learn
  - Adjacent to those already possessed
  - Adjacent and high market value
  - Adjacent and valued by employer
  - Learning strategies
  - Self-efficacy

![Graphs showing before and after comparisons](chart.png)
Test 3: ‘Deeper Learning’ (Hewlett’s term)

Is 'Deeper Learning' emphasized in school?
- Learning strategies
- Self-efficacy

What employees learn
- Learning strategies
- Self-efficacy

Skills the unemployed learn
- Learning strategies
- Self-efficacy

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Test 4: Better knowledge & skill assessment

Is candidate and employee job fitness evaluated well?
✓ High quality assessments

- Fraction of people employed
- Early career employed (<30)
- Later career employed (>45)

Widgets produced across economy

- Fraction skill needs met
- Fraction skills available somewhere

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Test 5: Firms prioritize learning

Widgets Before

Widgets After
Interesting thought: In times of change, ‘disloyalty’ may be more economically efficient.

Other Inputs

- What is the probability that an unemployed person will seek work any given week? 1
- What is the probability that an employed person will seek better work any given week? 1
- What is the probability a firm will contemplate laying off some workers any given week? 0.01
- Number of opportunities evaluated when picking between options at career start or during career change? 25
- Occasional career changes

Hiring threshold: 6
Layoff threshold: 6

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Leadership, Innovation, Systems Thinking
Another interesting test: Let’s trigger a recession.
What this all means.

• Despite the wide perception of a broken education/workforce pipeline, we may have enough employers and employees… we just need to get them in the right place.

• Treat this as an inventory problem… by focusing on learning and alignment with the market, we can see better outcomes and more productive economy.

• By using modeling, we can visualize the dimensions of this debate and shape more effective strategies to address the issues at hand.
Contact Us:

Dan Sturtevant: dan.sturtevant@sloan.mit.edu

Jeanne Contardo: jeanne.contardo@bhef.com
Additional models to explore.

• **The U.S. STEM Education Model:** Asks how you can double the number of STEM graduates in the United States. [Run the model on Forio.](#)

• **The U.S. STEM Undergraduate Model:** Update of the U.S. STEM Education model suggests ways to scale the highest-leverage education strategies for increasing the STEM workforce. [Run the model on Forio.](#)

• **Learn and Earn Model:** Explores the effect of employer and postsecondary education partnerships, also known as "Learn and Earn" programs, on workforce outcomes. [Run the model on Forio.](#)