

Teaching a System Dynamics Approach (in a variety of “educational” settings)

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Teaching a system dynamics approach

ABSTRACT

The system dynamics approach has long been viewed as a powerful framework for building understanding and improving performance in dynamic systems. However, anecdotal evidence suggests that there may be challenges for would-be practitioners in developing facility with “best practices” necessary for effective use of the approach. One possible source of these challenges may be our approach to teaching and learning system dynamics.

In this presentation, I share one perspective on teaching and learning system dynamics. Drawing from over 35 years’ experience working in the field—in software support, in workshop design, development and delivery, in consulting, and as a university instructor—I describe elements of a learning-by-doing approach that supports the development of best practices. I show how the approach is used in a 10week undergraduate course at an Ivy League institution, and I illustrate how elements of the approach can be used to support thinking in systems in the context of a short, issue-focused workshop. Informal observations on learning outcomes in a variety of educational contexts are offered. These provide a context for focused discussion on how we might do a better job of helping people to learn how to use system dynamics approaches to think, learn, and improve their world.

Teaching a system dynamics approach

OVERVIEW

- My objectives for this session
- Some historical context
- How do people learn this stuff?
- Elements of an approach that seems to work
- A few examples
- Discussion

My objectives for this session

1. Share one perspective on teaching and learning a system dynamics approach
2. Create a space for discussion around how we might...
 - Do a better job of helping people to learn how to do this
 - Do a better job of helping people to use this stuff to think, learn, and improve their world

Some historical context

LOTS OF YEARS, LOTS OF EXPERIENCE, VERY GOOD MENTORS

- SD focus in grad school (Meadows, Meadows, Richmond, early 1980s)
- Multiple years in SD software business focusing on user support and training (Richmond, 1980s-2002)
- Independent consultant delivering workshops + projects in defense, pharma, not-for profit, national labs (collaborations with Lexidyne, Paich, others. 2003-Present)
- Semi-academic, teaching SD at Ivy League institution (2010-present)

How do people learn this stuff?

A FEW OBSERVATIONS

- Motivation for learning is often *instrumental* rather than *intrinsic*—capabilities are developed *in order to* achieve some other goal rather than simply because this stuff is extremely cool¹
- Developing significant expertise requires deliberate practice (often at the edges of one's comfort zone)²
- To get good at this, you need good coaches!²
- You *learn SD by doing SD*

(1) Schank, R.C., 1995. *What we learn when we learn by doing*. Northwestern University.

(2) Ericsson, K.A., Prietula, M.J. and Cokely, E.T., 2007. The making of an expert. *Harvard business Review*, 85(7/8), p.114.

Design considerations

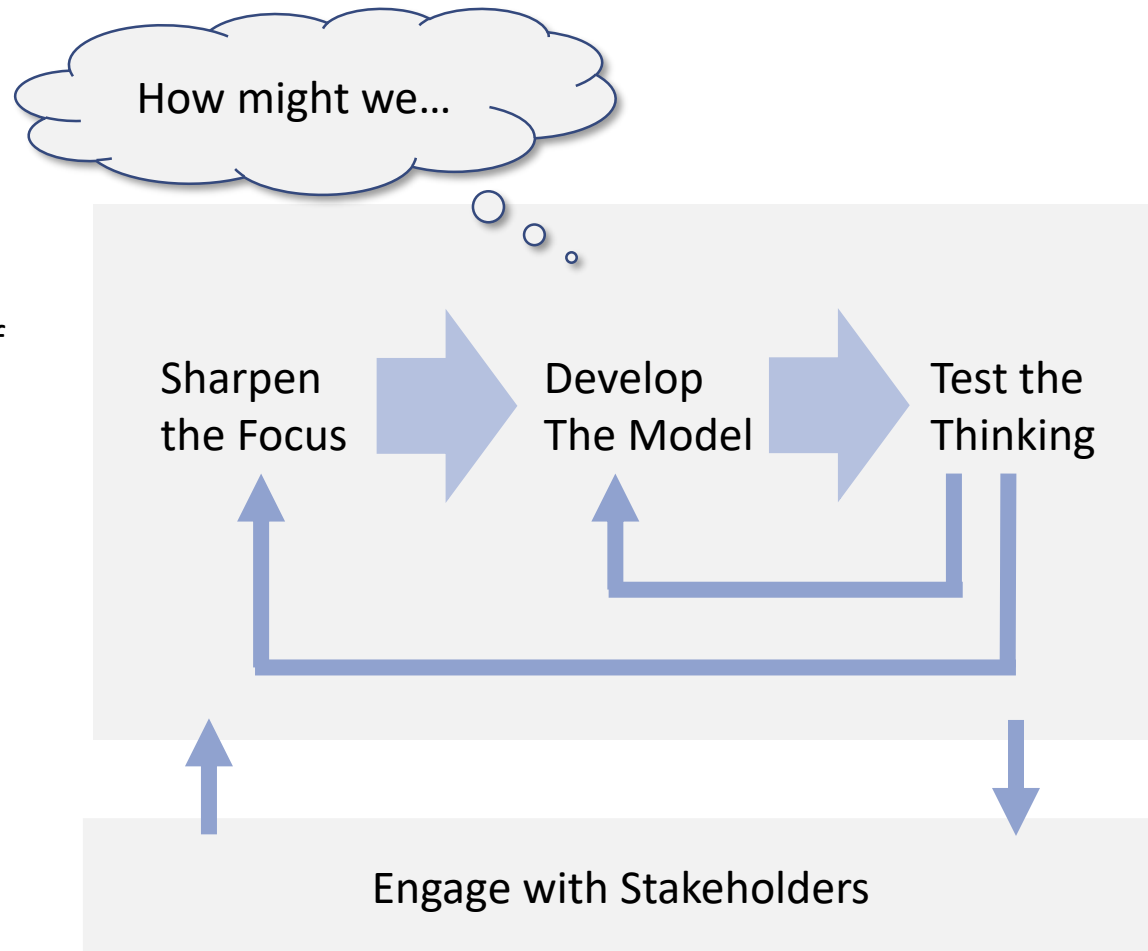
FOR WORKSHOPS, COURSES, CONSULTING ENGAGEMENTS, ETC.

- What goal(s) are being sought by the learner/client?
- What SD approaches/tools/techniques can be applied to help the learner/client achieve their goals?
- How might we create and take advantage of opportunities for hands-on, deliberate practice?
- What coaching strategies are likely to be most effective?

Elements of an approach that seems to work

MINDSET, PROCESSES, PRACTICAL SKILLS

- A design approach
- A set of practical skills
 - Dynamic thinking
 - Operational thinking
 - Expanding the boundary of inquiry
 - Feedback thinking
 - Seeking an evidence basis
- Productive processes for engaging stakeholders

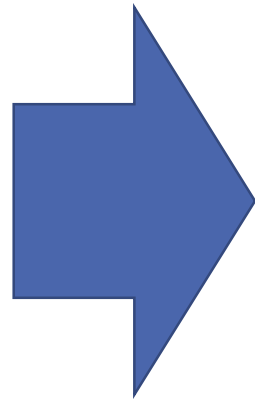


Sources:

Peterson, S. (2010) Systems Thinking for Anyone: Practices to Consider. In J. Richmond, et al (Ed.), *Tracing Connections: Voices of Systems Thinkers* (pp. 31-51). ISBN 978-0-9704921-2-8
<https://hbr.org/2008/02/make-better-decisions> (accessed 2016-07-15)

Shifts in teaching emphases

- Lectures
- Readings
- Theory
- Exams
- Teacher
- Curriculum-driven (direct skill instruction)



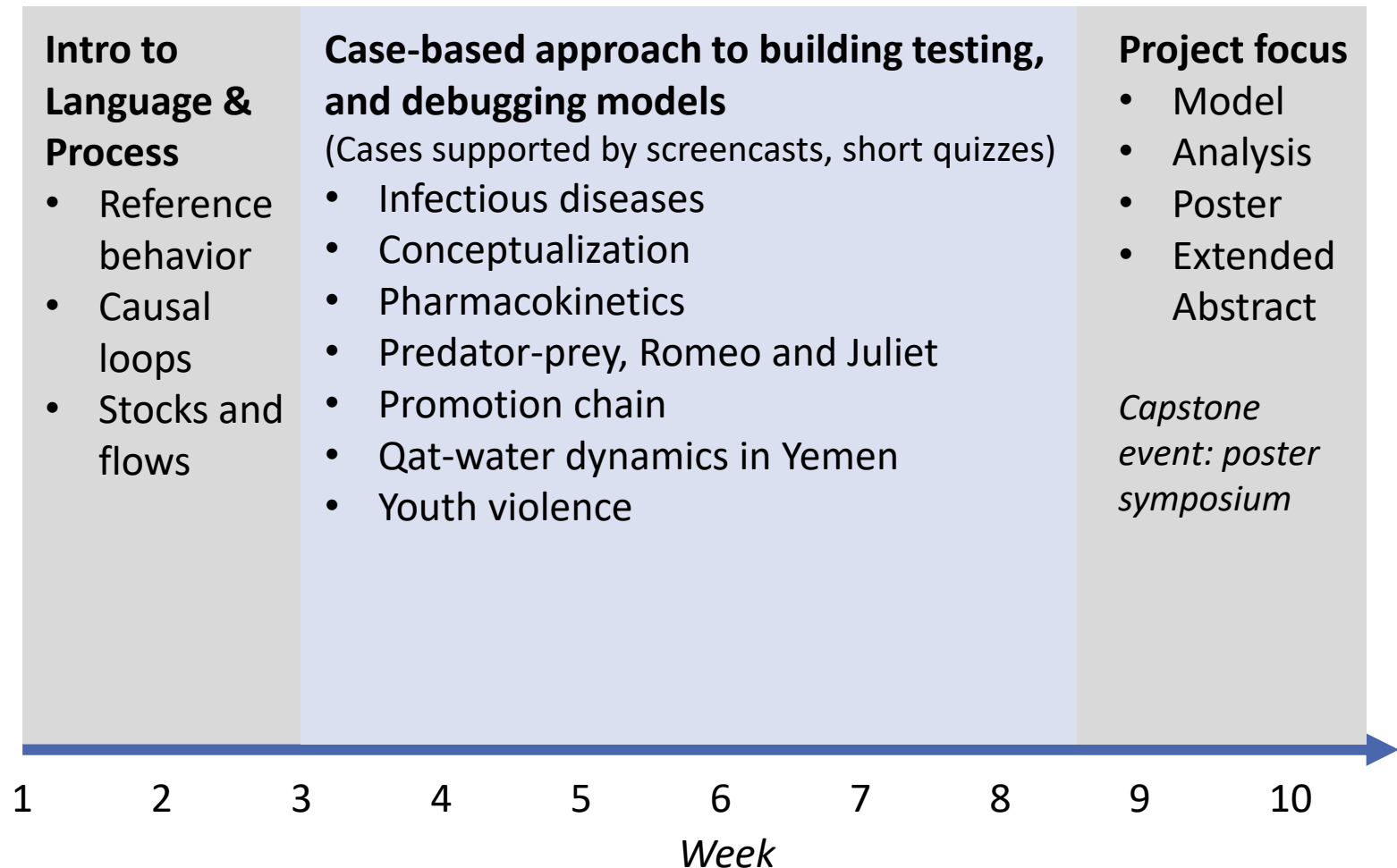
- Hands-on
- Screencasts
- Short Case Studies
- Individualized Projects
- Co-creator
- Just-in-time; just-what's needed (JITJWN)

A few quick examples

- College context: 10-week Ivy League undergraduate course
- Public health context: Access and affordability of care

10-week Ivy League undergraduate course

WHAT'S POSSIBLE IN AN INTRODUCTORY COURSE WITH LESS-QUANTITATIVE STUDENTS?



10-week Ivy League undergraduate course

STUDENT PROJECTS FROM 2018 COURSE

- Gentrification and Bus Ridership Decline in Los Angeles
- Chronic Pain Management and the Opioid Epidemic
- Improving AYUDA's Efforts and Knowledge of Type 1 Diabetes in the Dominican Republic
- Modeling Gentrification and Homelessness in an Urban Center
- Optimizing Pollution Tax Policies in Rural China
- The Internet Divide Between Rural and Urban Areas (A Vermont Case Study)
- Impact of Dairy Migrant Workers in the Upper Valley
- Alzheimer's Disease Population Dynamics in the United States
- Bush, Hussein, and Coupled Cognitive Biases in the Lead-Up to the Iraq War
- Deconstructing Social Entrepreneurship : Exploring Impact and Efficiency Across Strategies
- Exploring Migration Dynamics in Puerto Rico
- How Might Consumer Choice Precipitate an Electricity Death Spiral?
- Retribution vs. Rehabilitation for Drug-Related Crimes in the United States
- Startup growth dynamics
- Business Dynamics at Poona Indian Restaurant
- Mass Incarceration and the Prison Industrial Complex
- Increasing Female Participation in Software Engineering through Technological Artifacts
- Towards Environmental Justice: Balancing Greenspace and Gentrification
- Measuring the Benefits and Risks of the Hard Alcohol Ban at Dartmouth States
- Hosting the Olympics: opportunity or catastrophe?
- The Political Economy of Reproduction: Motherhood in the United States
- Addressing the New Hampshire Housing Crisis
- High-Risk HPV Transmission in College-Aged Women

10-week Ivy League undergraduate course

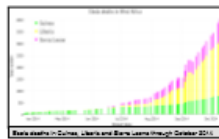
WHAT'S POSSIBLE IN AN INTRODUCTORY COURSE?

Epidemiology of Ebola in Guinea, Liberia, and Sierra Leone

Sara Peterson | Thayer School of Engineering at Dartmouth College | Hanover NH USA

Problem and Purpose

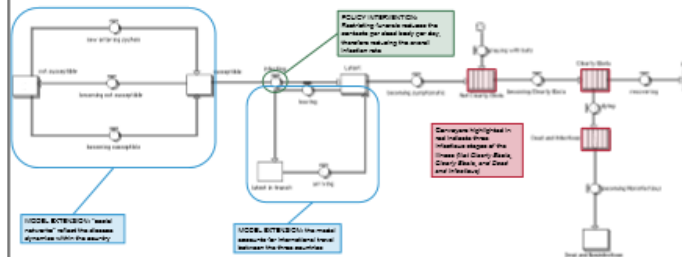
Epidemiologists have traced the origins of the 2014 Ebola outbreak in West Africa to Guinea, where a 2-year-old boy contracted the disease through contact with a fruit bat.¹ The Ebola virus spread rapidly throughout the region, striking Sierra Leone, Guinea, and Liberia particularly hard.



In September 2014, the CDC suggested that the disease could lead to some 1.4 million deaths in Sierra Leone and Liberia by the end of January 2015.² My goal for this project was to gain a better understanding of the dynamics surrounding the spread of this infectious disease, with the ultimate objective of understanding how various policies might be effective in curbing similar outbreaks in the future.

The Model

The model extends a simple SIR (Susceptible, Infectious, Recovered) model of disease dynamics. Extensions to the traditional model reflect spatial, probabilistic, and scalar aspects of the spread of the disease.

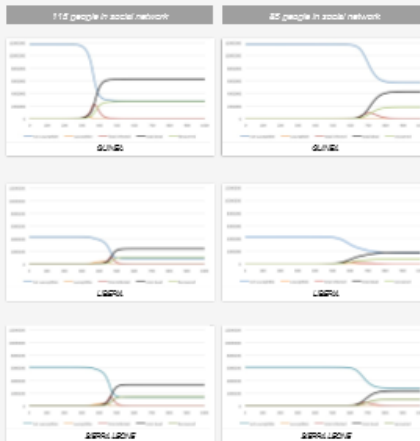


Key features of the model:

- Three Countries
 - Guinea, Liberia, and Sierra Leone
- International travel between countries
- Discrete, stochastic movement between countries (vs. continuous, deterministic)
- "Social Networks"
 - The number of people who move from being Not Susceptible to Susceptible by virtue of a person becoming infected
- Three probabilistic drivers of infection
 - Based on level of viral load from three different stages of illness
 - sick but Not Clearly Ebola
 - sick and Clearly Ebola
 - Dead and Infectious

TIPPING POINT DYNAMICS

Impact of an individual's social network decreasing from 115 to 85 people



The first series of graphs presents a baseline situation in which each individual's social network is composed of 115 people. In this case, a significant majority of each country's population becomes susceptible and a significant fraction of its population dies.

The second series of graphs presents a situation in which each individual's social network is comprised of 85 people. The smaller social network significantly reduces the number of people who become susceptible to the disease and, ultimately, the number of deaths in each country.

These results suggest that domestic policies that inhibit interpersonal interactions, such as quarantines, may be effective in curtailing the spread of the disease.

POLICY INTERVENTION: FUNERALS

Policy reducing contacts per dead per day by 25%, implemented after 100, 300, or 500 deaths (note change in scales)



These series of graphs review the efficacy of funeral policies (cutting the contacts per dead per day by 25%), given the baseline situation of 115 people in a social network. The first series of graphs indicates that implementing the policy after 500 total deaths reduces the spread of the disease, resulting in fewer than 3,000 total fatalities in each country. The second series of graphs indicates that implementing the policy after 300 total deaths is even more effective; the spread of disease in Guinea is halted, and the disease does not spread to Liberia at all. The first series of graphs indicates that implementing the policy after 100 deaths would greatly reduce the confinement of the disease within Guinea's borders, cutting the death toll to under 500 fatalities, and furthermore would prevent the disease from spreading beyond Guinea's borders.

These graphs suggest that the implementation of funeral policies could be highly effective in curtailing the international and somewhat spread of the disease. The earlier the adoption of such policies, the greater their efficacy.

Conclusions and Implications

- Methodological insights:
 - Traditional SIR models can't capture the spatial aspects of the disease
 - Disaggregation allows for simple representation of the dynamics within and across countries
 - This extended SIR model provides a simple alternative to a highly disaggregated Agent Based Model
- The size of social networks is a key leverage point within the system; even slightly smaller networks can be enough to greatly reduce the spread of disease
- Implementing a funeral policy could be a useful measure in preventing the spread of Ebola, as the viral load in dead bodies is very high
- Such a measure reduces the number of new infections within a country and therefore the number of sick people traveling internationally

Next Steps

- Speak with experts and learn more about parameters for the model
- Test hypothesis regarding the efficacy of border restrictions in curtailing the spread of the disease
- Find more detailed information regarding border crossings in and out of the affected countries in order to more accurately reflect international travel
- Further disaggregate the populations to better reflect the urban / rural divide
- Explore the impact of timing on the efficacy of various policy implementations such as border restriction, health awareness campaigns, and the restriction of domestic travel

Resources

1. [Shepelev, Barar. "Ebola: Patient Zero" How Outbreak Started from a Single Child. LiveScience. 30 Oct 2014.](#)
2. [http://www.cdc.gov/eid/content/20/14/2805a120140001.htm](#)
3. [Zahran, Doha. "Ebola: Patient Zero." Reality Time. Time, n.d. Web. 10 Mar 2014.](#)

Acknowledgments

I could not have completed this project without the guidance of my professor Steve Peterson and the financial support of Dartmouth Professor Phil Zanion. Thank you.

10-week Ivy League undergraduate course

STUDENT OBSERVATIONS ON STUDENT OUTCOMES

- On inverted classroom:

I think learning through screencasts instead of lectures was really effective, since we each got to watch at our own pace and re-watch some areas that may have needed clarification. Similarly, using class time as practical hands-on time was really great.

- On workload:

This course had the heaviest workload of all of my courses, but not in a bad way. There were just a lot of deliverables between the in-class projects (which I never finished in class) and the quizzes. I'm glad that these came in with less frequency as the term went on.

- On individualized project and symposium:

I think the final project was great--I loved picking my own topic and being able to break it down and use STELLA to explain my impression of the system behind the problem. The symposium is a great way to share, because it is a much more lively environment than in-class presentations, which can get repetitive.

Access and affordability of care

CONVERSATIONAL APPROACHES IN BRIEF FACILITATED SESSION

- 1.5 day session held at a place whose name you'd recognize
- ~10 experts brought in from academe, host institution, health systems, not-for-profits, and school systems
- Multiple “back bench” participants from host institution

Disclaimer:

Funding for the workshop was made possible by the Centers for Disease Control and Prevention and ChangeLab Solutions under Cooperative Agreement Number 6NU38OT000141-04-03. The views expressed in written workshop materials or publications and by the speakers and moderators do not necessarily reflect the official policies of the Department of Health and Human Services, nor does the mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government.

Access and affordability of care

CONVERSATIONAL APPROACHES IN BRIEF FACILITATED SESSION

- Objective: come to clearer and shared understanding of how to improve accessibility and affordability of care
- Strategy:
 - Help participants develop initial level of facility with stock-flow mapping
 - Facilitation team charged with doing heavy lifting of map creation/revision
 - Participants charged with critiquing/improving map
 - Revised map served as basis for policy-focused discussion during day 2 of session

Access and affordability of care

SOME OUTCOMES FROM FACILITATED SESSION

Short-term...

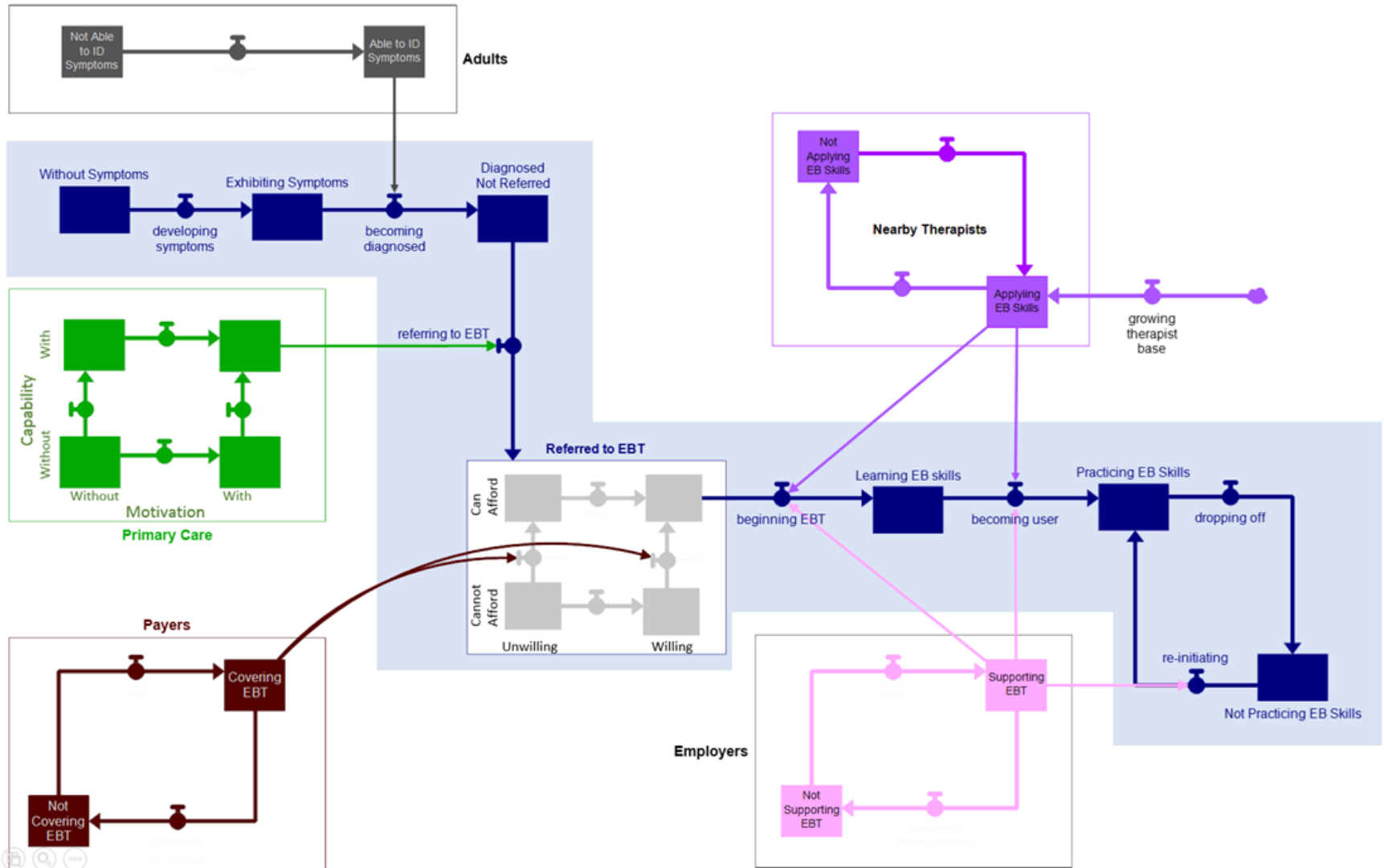
1. Ownership of map effectively transferred from facilitators to clients during workshop
2. Post-workshop, client team worked *on its own* to revise map
3. Map in use to help identify high-impact areas for improving access and affordability

Longer-term...

1. Map expected to play essential role in development of “children’s mental health research agenda”
2. Continued collaboration with external participants

Access and affordability of care

“FINAL” MAP



Common outcomes from facilitated sessions

ANECDOTAL, BASED ON >125 SESSIONS IN THE CURRENT MILLENNIUM

1. Significant progress in understanding and improving problem performance
2. Enthusiasm for the toolset and approach
3. Initial level of practical skills in “best practices”
4. (Typically) follow-on opportunities

Discussion