BHEF BUSINESS-HIGHER EDUCATION FORUM®

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Modeling the Role of Community Colleges in Increasing Educational Attainment and Workforce Preparedness

Prepared by

Business-Higher Education Forum
&
Emtect Solutions

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EXECUTIVE SUMMARY

BHEF BUSINESS-HIGHER EDUCATION FORUM®

In light of recent data showing that educational attainment rates in the United States have stagnated, the Obama administration and others have called for renewed efforts to bolster higher education outcomes. Strengthening the role of community colleges is undoubtedly an important component of any plan to dramatically increase the number of students earning postsecondary credentials.

This project was undertaken by the Business-Higher Education Forum (BHEF) with support from the Bill & Melinda Gates Foundation. The project uses a system dynamics modeling approach to develop a framework that can help stakeholders understand the role and potential of community colleges in increasing postsecondary degree attainment and workforce preparedness, either through the lens of a region or an industry sector. It also begins to examine strategies that the community college system could use to increase degree attainment and increase the capacity or efficiency of the community college system to accommodate this growth both generally, and specifically in science, technology, engineering, health and mathematics (STEHM) related disciplines.

This report describes the results from a system dynamics modeling approach that was used to examine the community colleges "ecosystem," including the K-12 education system, employers, four-year institutions, government, and local communities. Through this approach, a range of problems, factors of interest, and policy levers were identified and clustered to generate two broad model frameworks. The first, **a regional model**, focuses on a community or region and a community college (or colleges). It allows users to explore interactions among government, education, and workforce as they contribute to increasing the number of students earning credentials or degrees with workforce value over time. A second model – **a sectoral model** – focuses on the labor market dynamics of a single workforce or profession (e.g., the allied health fields) and articulates the relationships between employers and the community college that fuels the future workforce for a particular industry.

The model framework incorporates a number of components that are of interest to policymakers and other stakeholders as they relate to the flow of students and adults through the community college system and into either the workplace or four-year institutions. It includes both demand and supply side factors that influence these outcomes. For example, the model includes factors such as employer demand for community college graduates and employer support for specific programs at community colleges. It also includes factors affecting the supply of students into the community college system, such as the quality of the K-12 education system, financial incentives, community support for education, and employment outcomes of graduates from these programs. In addition, the interactions among various factors were identified and analyzed to better understand the complex, interrelated

and systemic forces that affect the entry and persistence of students through the community college system and beyond. This process also helped enumerate potential solutions available to policymakers and other stakeholders as they attempt to solve a range of system-wide problems.

The insights from this project provide a valuable tool for community college administrators, faculty and students, policymakers, funders and other concerned stakeholders as they undertake systemic reform efforts focused on community colleges such as the Completion By Design project, or design and implement particular strategies that address education and workforce goals.

In addition, the model framework that was developed provides a foundation and road-map to build a fully functioning simulation model that would allow researchers and policymakers a number of additional benefits and opportunities to explore program and policy design options and scaling scenarios prior to their implementation.

Introduction

U.S. educational attainment rates have stagnated during the last decade, during which time a number of countries have surpassed our nation's performance on this critical benchmark[1]. This fact led President Obama to call for efforts to bolster educational attainment rates, stating that: "By 2020, America will once again lead the world in producing college graduates."

Bolstering community college pathways is thought to be an important component of any plan to increase U.S. educational output and meet the projected shortfall of workers needed who possess at least some postsecondary education[2]. According to President Obama, "I believe community colleges will play a huge part in meeting this goal, by producing an additional five million degrees and certificates in the next 10 years."

Community colleges play a central role in producing an educated citizenry and skilled workforce[3]. In 2007, community colleges conferred nearly 1.5 million degrees, about equally split between associate's degrees and certificates[4]. They serve a vast and diverse set of learners, with nearly 12 million students enrolled in 1,200 community colleges[5].

Students attend community colleges for a number of different reasons related to academic, vocational or personal goals and interests. Among these are two large groups of students: those who attend to earn a certificate or terminal associate's degree that equips students with the necessary skills needed for the workforce, and those intending to complete introductory level courses that will allow them to transfer into a bachelor's degree program at a four-year institution.

While community colleges hold the potential to contribute to rising educational attainment and increased workforce preparedness, a variety of systemic problems and barriers contribute to disappointing outcomes—just 15 percent of those students who began at a community college had earned either a certificate or associate's degree after three years and only 11 percent of students had transferred to a four-year institution.[6]

The purpose of this project is to better understand the role and impact of community colleges on degree attainment and workforce preparation and to examine strategies that community colleges could use to:

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1 On average, university-level graduation rates in United States dropped from Rank 2 in 1995 to Rank 14 in 2007 among all OECD countries.
Organization for Economic Cooperation and Development, Education at a Glance 2009: OECD Indicators; Table A-3.2

2 Projections show that by 2018, there will be demand for 22 million new workers with college degrees but projects a shortfall of at least 3 million postsecondary degrees produced.
Carnevale A. et al, 2010. Help Wanted: Projections of Jobs and Education Requirements Through 2018. Center on Education and the Workforce, Georgetown University.

3 Community Colleges enroll more than 40 percent of all undergraduate students.
Horn, L., and Nevill, S. (2006). Profile of Undergraduates in U.S. Postsecondary Education Institutions: 2003–04: With a Special Analysis of Community College Students (NCES 2006-184). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, D.C.

4 See National Center for Education Statistics 2009 report *Changes in Postsecondary Awards Below the Bachelor's Degree: 1997 to 2007.*

5 See American Association of Community Colleges, http://www.aacc.nche.edu/AboutCC/Pages/fastfacts.aspx

6 Horn L, Wecko T (2009) *On Track to Complete? A Taxonomy of Beginning Community College Students and Their Outcomes 3 Years After Enrolling: 2003–04 Through 2006* National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, D.C.

- Increase the number of students earning postsecondary credentials such as associate's degrees and certificates.
- Increase the capacity or efficiency of the community college system to accommodate this growth, both generally, and specifically in science, technology, engineering, health, and technology (STEHM) related disciplines.

A System Dynamics Approach to Understanding the Challenges of Community Colleges

In light of these goals, a system dynamics modeling[7] approach was selected as the methodology for understanding these challenges. In contrast to traditional analytic methods that tend to focus on an isolated problem with limited interactions, system dynamics modeling takes a holistic view of the problem under study[8] and accounts for a much larger number of interactions among different components that comprise a system[9] (See Figure 1). When applied to study complex problems, and combined with the use of modeling and simulation, this approach has proved to be valuable in helping different stakeholders see the "big picture" or entire "ecosystem" as opposed to simply their role in it.

In comparison to traditional analytical methods that often involve solving an isolated problem by a subject matter expert, system dynamics modeling engages all stakeholders and subject matter experts to utilize their own expertise in a knowledge-building process to identify system-wide challenges that affect community colleges and its environment. Understanding both the big picture and connection among a number of interrelated problems allows policymakers and other stakeholders develop collective solutions that have long term success. For a more detailed description about the systems dynamics modeling approach and the terminology, please see Appendix A.

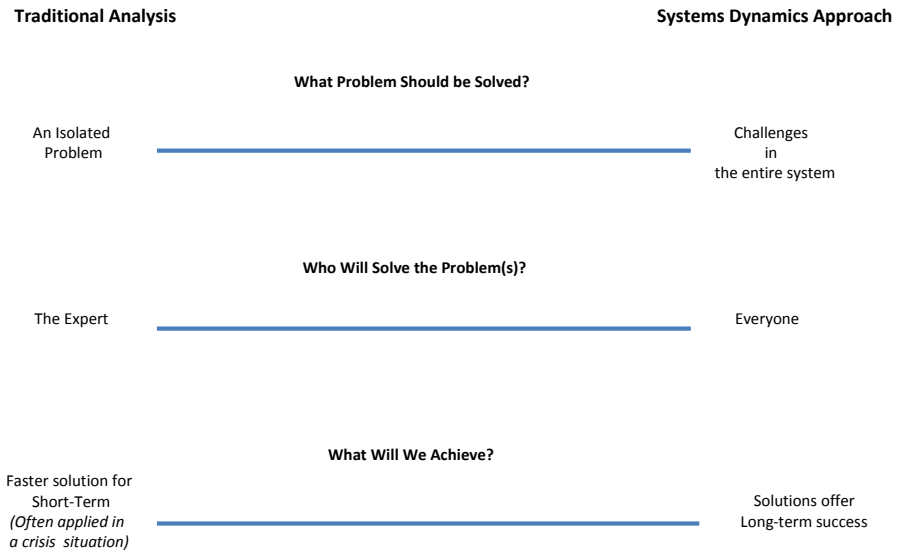

Figure 1: Comparison of System Dynamics Approach to traditional approaches used for analysis

7 Sterman JD (2000) *Business Dynamics: Systems Thinking & Modeling for a Complex World.* Irwin/McGraw-Hill.

8 Weisbord, Marvin R. (1987). *Productive workplaces: Organizing and managing for dignity, meaning, and community.* San Francisco: Jossey-Bass.

9 A system is defined as a *collection of individual units that interact to function as a whole.* In this case, the system under study is Community Colleges and its environment.

Louisville: A Case Study

The first step in building a system dynamics model is to assemble a group of stakeholders and subject matter experts who understand the challenges in the community college education system[10]. Based on initial discussions with policy experts, it became apparent that most forces affecting a community college ecosystem are local in nature. Therefore, it was decided to apply the system dynamics modeling approach to understand the various forces that affect community colleges at a local level as a first step.

In selecting a community or region to study, it was important to identify one that:

- was currently grappling with ways to strengthen the community college role in increasing education attainment and workforce preparedness; and
- had already established good working relationships among key stakeholders in the ecosystem.

One such region is Louisville, Kentucky. In May 2010, after more than two years of work, the main groups in the region signed the "The Greater Louisville Education Commitment"[11], a comprehensive strategy to increase the region's college degree attainment rates[12]. BHEF was instrumental in helping the community craft the plan, which was co-signed by Louisville's Business Leaders for Education (BLE) and by the Mayor's Education Roundtable (MER), comprised of educators, business and community leaders, and civic government representatives.

When asked if they would be interesting in using a system dynamics modeling approach to examine their challenges and potential strategies, key stakeholders quickly agreed to participate, and two workshops were set up to convene key stakeholders and develop a prototype model framework. While a majority of workshop participants and interviewees were members of the Louisville community, a few representatives of national organizations were also included to provide national perspectives.

This diverse set of individuals agreed to come together to look at the community college system from their unique perspectives with the understanding that they were interested in collectively thinking about ways to move a greater number of community college students into programs in economically important fields and to provide the support students need to succeed.

Although at the centerpiece of this analysis are community colleges, a variety of interrelated factors such as the K-12 education system, industry demand, institutional capacity at community colleges affect the number of students achieving post-secondary credentials. Therefore, various stakeholders from community colleges (students, faculty and administrators) as well as potential employers, K-12 schools, four-year educational institutions, the mayor's office, local governing boards and community-based organizations were included.

During a series of two workshops, participants worked with system dynamics modelers to collectively define the problem statement to be analyzed, capture and aggregate their individual knowledge and devise a qualitative system dynamics model. For a more detailed description about the process of building a qualitative system dynamics model, please see Appendix B.

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10 Vennix J (1996) *Group Model Building: Facilitating Team Learning Using System Dynamics.* Wiley: Chicester. Chapter 5.

11 See http://www.greaterlouisvilleproject.org/Default.aspx?tabid=64&EntryID=51 for more information.

12 The goal of the Louisville region is to increase the total number of degrees by 55,000 including 40,000 Baccalaureate degrees and 15,000 Associate's degrees.

What Did We Learn?

As a result of the workshops and interviews with stakeholders, we were able to identify a range of problems of interest to different stakeholders, understand challenges in the entire system, and enumerate potential strategies and solutions through which collective goals could be achieved.

During this process, it was found that most stakeholders are interested in solving specific problems, and implementing policies to independently solve an isolated problem. The workshops provided a platform where they could externalize their assumptions about the problems that had to be addressed in order to increase enrollment, persistence and graduation of students from community colleges. It also helped them better understand the concerns of other actors and develop collective solutions and strategies that could be used to solve a range of different problems identified by different stakeholders (See Appendix C, Table C1).

For example, a concern of potential community college students is to understand the "value proposition" of postsecondary education as it relates to future workforce outcomes; while employers were concerned that the type of skills and training offered by community colleges may not meet their workforce needs. Community college administrators, meanwhile, identified resource constraints as a limiting factor to increase enrollment of students at community colleges.

In addition, a number of stakeholders discussed the challenges unique to increasing the number of graduates in STEHM fields that are in high demand and contribute to regional growth and economic competitiveness (See Appendix C, Table C2).

A number of policy choices were identified as having the potential to solve these challenges (See Appendix C, Table C2). One unique solution, the "Learn and Earn"[13] program, aims to increase the number of postsecondary degrees, design or adapt the curriculum to meet industry demand, and provides an alternative model for financing education at community colleges.

13 The Learn and Earn programs combine career-oriented academic curriculum, (Learn component) with financial aid (Earn Component) allowing students who might not be able to afford to study to remain in school. The students gain relevant work experience at firms while taking courses at postsecondary institutions.

Resulting System Dynamics Model Design

Through this process, a framework for two broad qualitative system dynamics models was developed that contains elements that could be incorporated in either a **regional** or **sectoral** model.

Two Proposed Model Frameworks

Regional Model: This model framework explores the flow of students into and out of community colleges and into the workforce. This model allows users to explore issues of alignment between government, education, and workforce. It also allows users to:

- Examine the impact of community college institutional reforms, such as those aimed at improving remedial education.
- Explore how interactions among community colleges and others stakeholders, such as government funders, universities, employers, and other community colleges, contribute to improved outcomes.
- Understand the impact of a community college's ability to expand capacity, become more efficient, and innovate.
- Examine the impact of issues such as quality of life, community beliefs about the value of education, and government support for colleges and the K-12 system.
- Explore the overall economic health of the region.
- Explore the impact of shifts in demographics, as well as migration in and out of the region

Sectoral Model: This model focuses on the labor market dynamics of a single workforce or profession and articulates relationships between employers, the workforce, and the community college that provides the current and future workforce for a particular industry. Examples could include the market for nurses, the market for STEHM skills generally, or the labor force of a single company that interacts with a community college for training its workforce. This model incorporates the stock of students earning related degrees or credentials and could be used to:

- Examine the impact of community college institutional reforms, such as those aimed at improving remedial education.
- Explore how interactions among community colleges and others stakeholders, such as government funders, universities, employers, and other community colleges, contribute to improved outcomes.
- Understand the impact of a community college's ability to expand capacity, become more efficient, and innovate.
- Examine the impact of issues such as quality of life, community beliefs about the value of education, and government support for colleges and the K-12 system.
- Explore the overall economic health of the region.
- Explore the impact of shifts in demographics, as well as migration in and out of the region.

At the core of both model frameworks are community college students (see Figure 2A). Both frameworks track students as they enter the pipeline from either the K-12 system or as adults, and differentiates among them by whether they are on an academic or vocational track. It further disaggregates students on the academic track by levels of preparedness (e.g., developmental vs. credit-earning).

The model then tracks students as they persist (or drop out) of either pathway and transfer to four-year institution or into the workforce. Successful outcomes include graduation with a certificate or an associate's degree, or matriculation to a four-year college, while unsuccessful outcomes include not graduating with a degree or graduating with a degree that does not increase a student's labor market earnings potential.

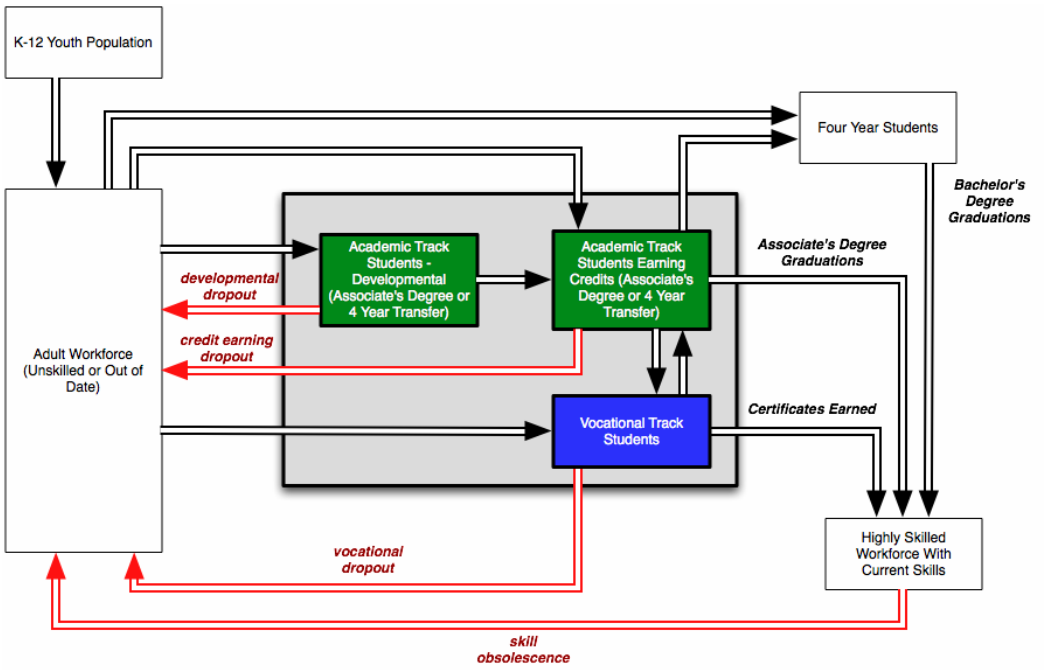


Figure 2A: Student Flows in the Model Framework

The model framework also includes a number of components that are of interest to stakeholders (see Figure 2B for a simplified version of the framework), including the flow of students and adults through the community college system described above (labeled "A"), interaction among factors[14], and a number of individual contributing factors. Some of these factors can be characterized as affecting the **demand** of graduates from community colleges include (indicated in blue):

- **Demand for community college workers by employers (labeled as "B"):** Student enrollment in community colleges may also be affected by the needs of employers for particular credentials and skills.
- **Employer support for community college students (labeled as "C"):** These factors include employer perception of the value of a certificate or associate's degree, the alignment between curriculum and employer needs, the quality of past graduates relative to others, and the increased productivity of workers who went through those programs.

14 It should be noted that this is not a complete set of factors, but those determined by a number of participants to be the most important ones.

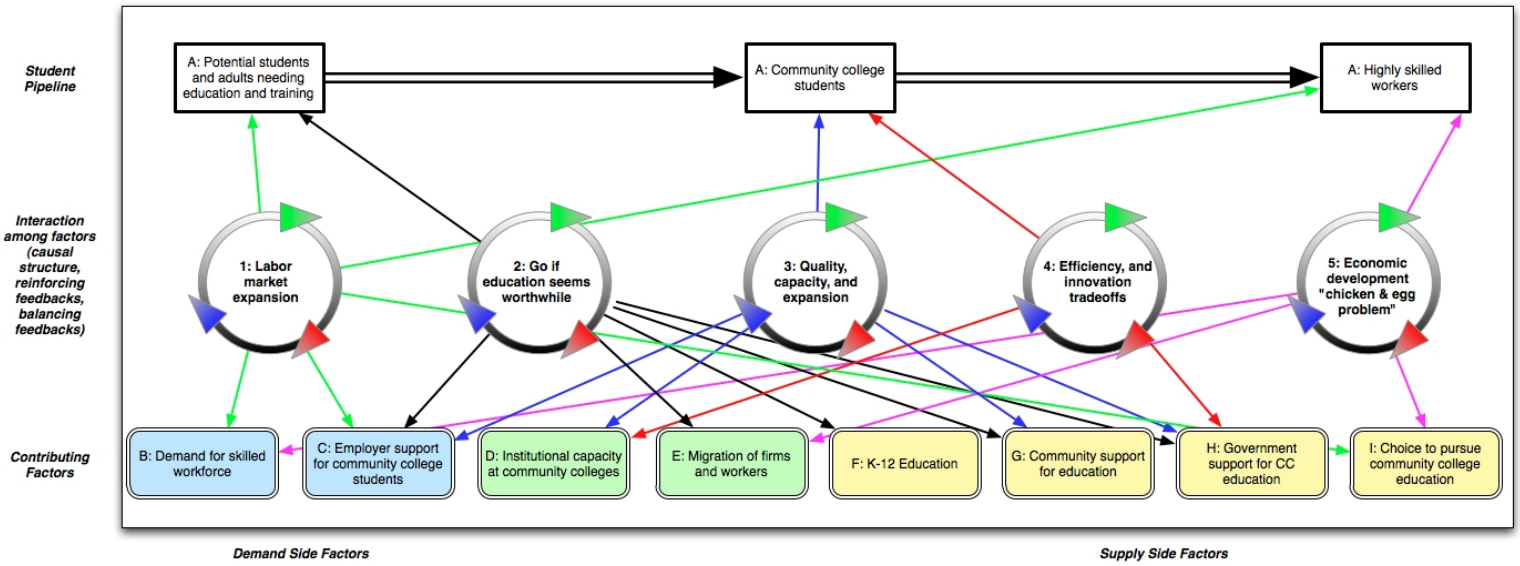


Figure 2B: Simplified Model Framework

In addition, the framework includes a number of factors that affect **supply** of graduates into community colleges (highlighted in yellow):

- **K-12 Education (labeled as "F"):** The quality of K-12 education is an important factor in determining whether students choose to pursue postsecondary education and if they are prepared to enroll in credit-bearing courses or need remedial education, which can slow or impede their success.
- **Community support for education (labeled as "G"):** Many social and economic factors affect the decision of students to gain post-secondary education. For example, support from peers and family members may influence whether students pursue postsecondary education. Other factors that contribute to a student's decision include economic support such as scholarships for students and grants for community colleges to support expansion of specific programs (e.g., remedial courses).
- **Government support for community college education (labeled as "H"):** Financial support through scholarships such as Pell Grants or loans for students as well as grants that support institutions can increase enrollment of students in community colleges. In addition, government revenues often provide support for specific programs such as workforce training.
- **Choice to pursue community college education (labeled as "I"):** The labor market outcomes and personal experiences of graduates often provide a signal for other students who are deciding to enroll in community colleges. Other factors such as the economic downturn could affect both enrollment and persistence of students in community colleges. For instance, adults pursuing community college education might "drop out" to take care of their families during challenging economic times.

Two additional mitigating factors that affect both supply and demand include institutional capacity at community colleges and the migration of firms in or out of the region (highlighted in green):

- **Institutional capacity at community colleges (labeled as "D"):** Increasing the number of students enrolling in community college would require increasing capacity of community colleges or introducing innovations to improve efficiency by improving utilization of available resources.
- **Migration of firms in or out of the region (labeled as "E"):** Firms may choose to locate to or leave the region based on a number of different factors, including the quality and quantity of skilled workers.

The flow of students into and through the community college pathway and the various factors described above are interrelated and interact in a number of ways. Some of the interactions among these components are depicted in the middle row of circular "loops." The loops connect different components of the community college system and its environment and help policymakers understand the "dynamics" of interaction among various components including how (1) different policies and programs that are implemented in one part of the system affect other parts and (2) policies and programs that work in the short-term might have unintended consequences in the long term and vice-versa.

1. **Labor market expansion loop:** This loop analyzes the interaction between demand for skilled workforce and community college graduates. It helps understand how increasing the output of specific types of skilled workers could meet or potentially saturate a specific labor market. The interactions analyze employer perception of the value of a certificate or associate's degree, the alignment between curriculum at community colleges and employer needs, the quality of graduates from the program relative to others and the increased productivity of workers who went through those programs. It also helps analyze if doubling the number of graduates in a program in one community would undermine the labor market value of that credential.

2. **Go if education seems worthwhile loop:** This loop connects community colleges to community support for education and the K-12 education system. It helps assess decision of students to enroll in community colleges based on factors such as feedback received from their peers and mentors about their past experiences, market value of the degree as compared to a high school degree alone. It helps assess how sudden changes such as an economic downturn may affect decisions of students to enroll or persist in community colleges or institutions of higher education or whether they will try to find employment to support their families. Some strategies that may be analyzed in the model include student financial aid policies, tuition forgiveness programs, and work-study programs. In addition, users could assess tradeoffs to increase success rate of students, such as whether to direct resources towards improving quality of K-12 education or remedial courses at community colleges.

3. **Quality, capacity and expansion loop:** To increase the number of students earning postsecondary degrees, policies and programs that impact **enrollment** and **persistence** need to be tested against resource and capacity constraints at community colleges. The relationship between quality of education, capacity constraints at community colleges and innovations to improve efficiency are explored by connecting potential students in community colleges to demand factors such as workforce demand and employer support to their employees who may be interested in enrolling in community colleges as well as government and community support for education.

4. **Efficiency, innovation and tradeoffs loop:** Community colleges often face tradeoffs between performing immediate tasks such as investing in increasing capacity—changes that may be effective in the **short term**—versus introducing innovations such as creating partnerships between colleges and firms or investments in educational technology that may prove to be beneficial in the **long term**. A number of such strategies can be explored within this loop to improve efficiency of the community college system.

5. **Economic development "chicken and egg problem" loop**: A balance between the demand for specific set of skills from employers and availability of trained workers is required to establish and maintain economic competitiveness of a region. If a mismatch between jobs and employees persists over time, then either skilled workers or firms will leave a region. However, this mismatch may induce workers or firms to enter a region as well. The model allows exploring policies for coupling economic development and education in such a way that jobs and workers grow in parallel to support regional clusters of innovation[15].

Using Modeling to Examine Impact of Specific Policies under Different Scenarios

One benefit of the system dynamics modeling approach is that we can use the model to examine the impact of specific interventions on improving student outcomes under different scenarios prior to implementation (Figure 3). For example, we can explore alternative scenarios that may result from improvements to remedial, or developmental, education.

The blue line shows the current situation for students as they progress toward degree completion, with a significant number of them dropping off the pathway to completing a degree. Alternatively, we could imagine two different scenarios. In one, we could increase resources to support the expansion of remedial courses. This approach could result in improved student persistence and graduation (green line in Figure 3). Alternatively, if support for or quality of remedial instruction is increased (red line in Figure 3), it could improve the retention of students early on, but might compromise the quality of education for other courses due to capacity constraints and higher enrollment of students. This could result in a decrease in graduation of students in the long-term. This hypothetical example shows how system dynamics modeling can be used to examine the effectiveness of different policies and programs under different scenarios prior to implementation to determine the short-term and long-term consequences.

15 This approach was examined by a different team of modelers and workshop participants under the direction of The Ohio State University.

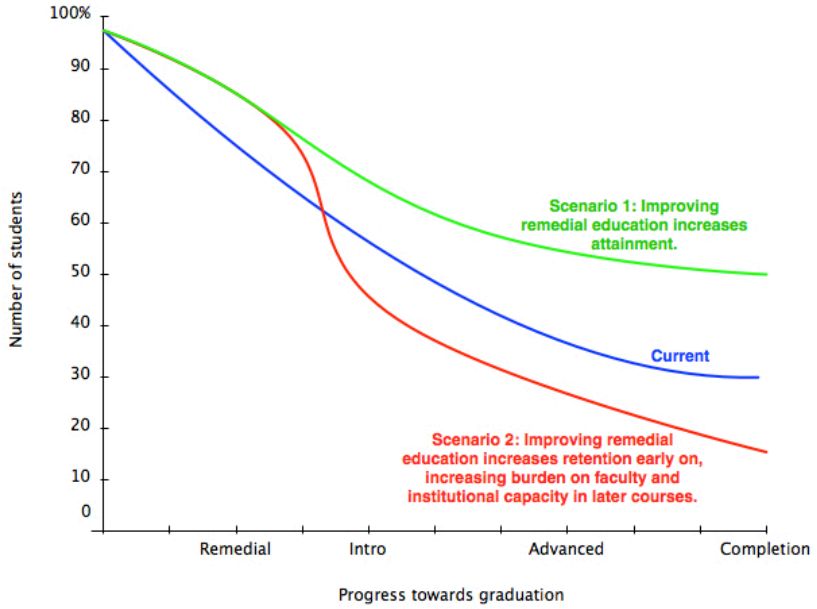


Figure 3: Scenario Testing of Impacts Resulting from Remedial Education Improvements

Conclusion and Future Directions

The system dynamics modeling approach and the resulting model structure enhanced the ability of various stakeholders to capture the complex, interrelated forces that affect the entry and persistence of students through the community college system and beyond. It also resulted in the development of a qualitative system dynamics model of the community college ecosystem that, if fully built, would allow analyzing the effectiveness of different policies to improve educational attainment of community college students. In essence, this process provided a holistic view of the challenges and various factors that affect the community college "system."

The next step in building a complete model is to incorporate data and research in the model framework developed above. The goal is to build a quantitative model that allows users to explore in real-time the impact of different strategies for increasing the number of postsecondary degrees and strengthening workforce outcomes. Generating a quantitative model using computational methods provides policymakers the ability to compare and contrast a set of assumptions about the problems in the entire community college system and simulate the impact of specific policies and programs over time. In addition, it allows users to explore the potential effectiveness of multiple options and devise non-obvious solutions. Finally, a complete model would allow testing the effectiveness of various programs and policies before costly implementation. For a full description of the process, see Appendix A.

The model framework that resulted from engaging the various stakeholders in Louisville can act as a template that can be used by other communities to understand the systemic challenges in the community college pathway to attaining educational goals and meeting demands of the workforce. By repeating the process in a selected sample of different communities, the commonalities and differences affecting the community college education system can be identified. The common problems can then

be used to build a "national" model to represent the problems faced by community colleges at a national level. In addition, results from this effort can also be adapted to populate a community college portion within the BHEF U.S. STEM Education Model, which was developed by Raytheon Company and donated to BHEF in 2009[16].

Together, the insights and model framework developed as part of this project provide a valuable tool for community college administrators, faculty and students, and with policymakers, funders and other concerned stakeholders as they undertake systemic reform efforts focused on community colleges, such as the Completion By Design project, or design and implement particular strategies that address education and workforce goals.

16 For more information about the BHEF U.S. STEM Education Model, see *"Increasing the Number of STEM Graduates: Insights from the U.S. STEM Education & Modeling Project"* (BHEF 2010) or visit www.STEMnetwork.org.

APPENDIX A - System Dynamics Modeling

A system dynamics approach is used for framing and understanding complex issues and problems, such as those facing the U.S. education "**system**." The method helps explain "**dynamics**" of interaction among various components, including how changes in one part of a system, such as K-12 education, affect other parts, such as a community college education system, both in time and space. The approach provides a lens through which systemic challenges can be examined simultaneously, thereby proving to be complementary to existing methodologies where specific issues are often studied independently[17,18]. The interaction among different components often is explained in terms of ***feedback*** within the system. That is to say, factor A causes factor B, and over time B affects A through factor C. The steps for building a complete system dynamics model are shown in Figure A. Although the entire process is iterative and most steps build on each other, even in the initial stages, this method can start providing useful information and insights for users. For this report, steps 1-3 were completed.

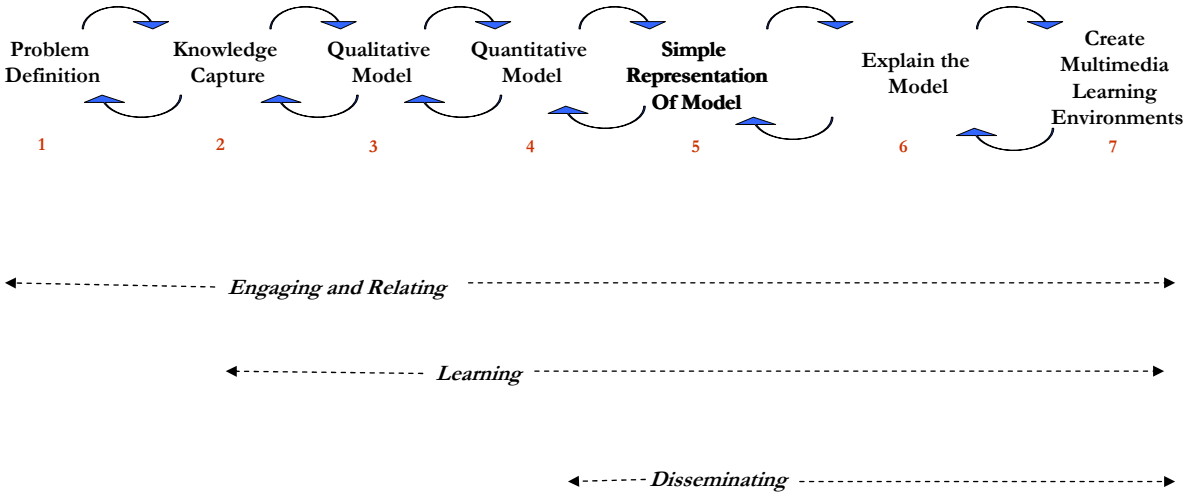


Figure A: The System Dynamics Modeling Process

Source: Wolstenholme E., (1998), Qualitative v Quantitative Modeling: The EvolvingBalance, International System Dynamics Conference.

1. Problem Definition: This stage involves defining the problem(s) of interest to various stakeholders engaged in the model building process.

2. Knowledge Capture: This stage involves capturing the knowledge of various stakeholders and subject matter experts on the problem(s) under study. This is done through model building sessions that help understand ways in which actions of different stakeholders affect each other, and how these interact to determine the **behavior**[19] and performance of the system as a whole. This stage also involves creating **causal loop diagrams** by incorporating various **variables** and policy levers to understand the relationships among various parts of the system. These stages help develop a **structure** representing the various elements of interest to different stakeholders.

17 Watkins, KE & Marsick, VJ 1993. *Sculpting the learning organization: Lessons in the art and science of systemic change.* San Francisco: Jossey-Bass.

18 Wolstenholme EF. 1999. Qualitative vs quantitative modeling: the evolving balance. *Journal of the Operational Research Society* 50: 422-428.

Wolstenholme EF. 1992. The definition and application of a stepwise approach to model conceptualization and analysis. *European Journal of Operational Research* 59: 123-136.

19 Behavior of a system determines how certain variables (factors) change over time.

3. Qualitative Model: The output from the first two stages is combined to create a conceptual framework that incorporates a number of problem(s), variables, policy levers comprising a system and the relationship among them.

4. Quantitative Model: This stage incorporates data collection and development of computer models to test problems and potential solutions identified during the previous stages. A computer model is needed because humans do not have the capability to independently visualize and manage the behavior of these complex **structures**. A system dynamics computer model is the result of an iterative process of comparing and contrasting a set of assumptions about the ***system structure*** and the known **behaviors** of it. Translating qualitative descriptions into quantitative models allow policymakers to understand how a system could respond to various interventions; explore different programmatic and policy options under a variety of scenarios prior to costly implementation in the real world; understand the potential "unintended consequences" that may result from policy choices and avoid mistakes in the real world as a result; understand the impact of policies that are effective in the short-term but could have unintended consequences in the long-term or vice-versa and demonstrate the capacity of the system to support the desired outcomes.

A number of insights are generated in the first four stages that need to be disseminated to gain insights.

The stages include:

5. Simple Representation of Model: In order to explain the model to people who were not involved in the model building process, the output should be converted to a simplified representation with the core components.

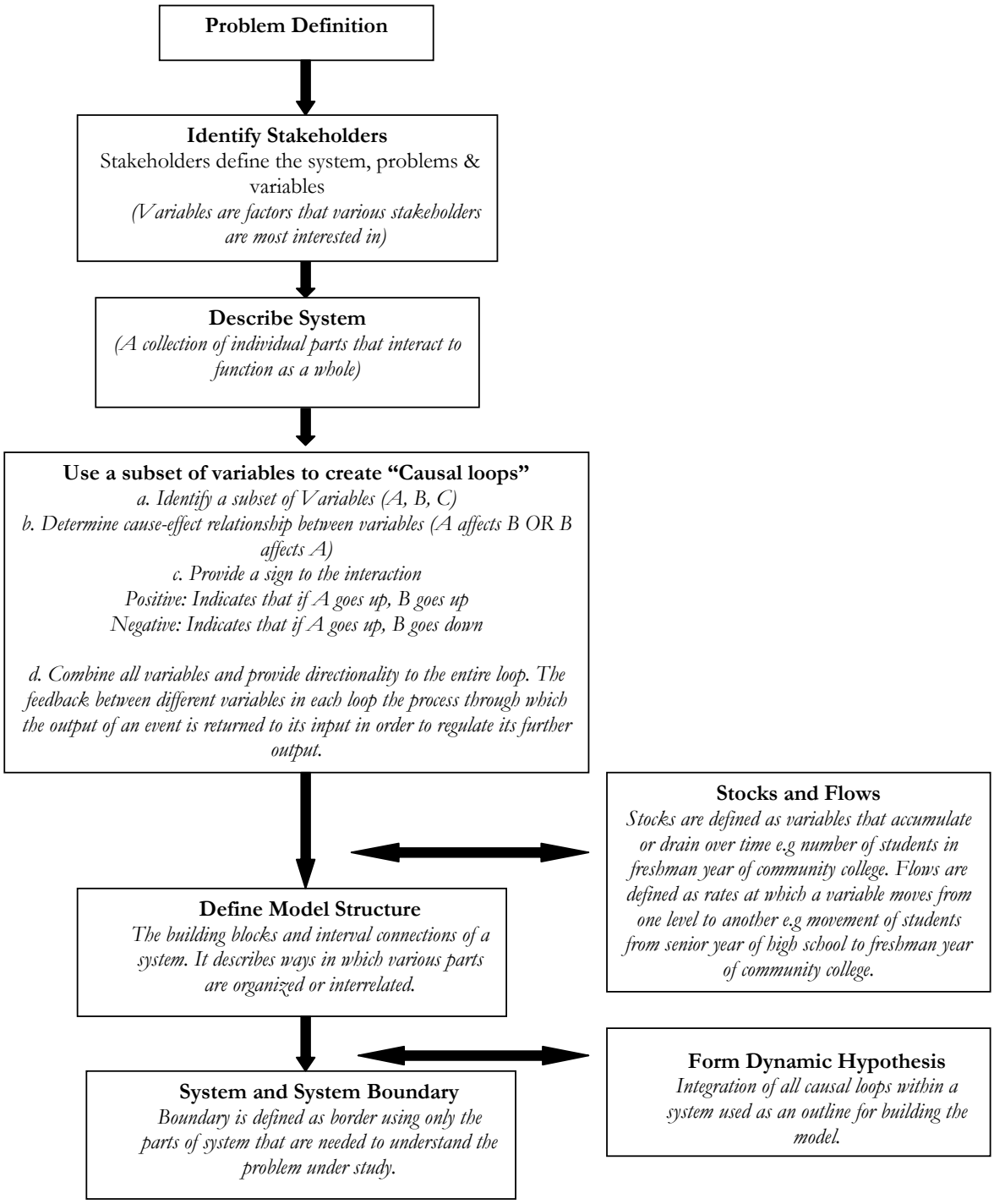
6. Explain the Model: Convert the model into an interface that can be used for learning and providing feedback on the model.

7. Creating Multimedia Learning Environments: This is an extension of the previous stage where the resulting model is embedded into multimedia learning environments for use by a wider community. For example, the BHEF U.S. STEM Education Model was converted to a Forio interface[20] to make it accessible to the wider public and experts who were not involved in the modeling process.

20 http://forio.com/simulate/bhef/u-s-stem-education-model/overview/

APPENDIX B

Detailed Description of Building a Qualitative System Dynamics Model



APPENDIX C

Table C1: Various Problems and Concerns of Different Stakeholder(s)

Stakeholder	Problem(s) of Interest
Potential Community College Students	a. Level of preparation necessary for post-secondary education. b. Effect of previous work experiences and education on academic success at community colleges. c. The wage differential between students with a postsecondary degree and high school graduates. d. Opportunity cost and value of credentials from community college education. e. Quality of curriculum and availability of support services at community colleges that allow successful transfer to four-year institutions.
Employers	a. Quality of K-12 education system and how a number of high school graduates are not ready for the "job" market. b. Curriculum at community colleges does not prepare students for the workforce, but is rather influenced by the knowledge base of faculty. c. Labor pool is too small and employees have a low morale and poor attitude.
Community Colleges	a. Lack of resources to increase capacity to meet increased student enrollments. b. Challenges to introduce institutional innovations to improve efficiency of the community college education system. c. Difficulties in changing the curriculum as community colleges often offer courses that their faculty have expertise in, rather than changing curriculum to meet the needs of the workforce. d. Changes in hiring policies to employ more faculty and staff e. to meet the increased enrollments. f. Governing bodies and accreditation boards often use the same metrics as universities to assess community colleges. g. Competition with for-profit institutions for resources.
Local, State and Federal Government	a. High drop-out rates of community college students. b. Employers often do not invest in building a talent pool that can contribute to regional development in the long-term.
Universities	a. Quality of training at community colleges does not prepare them for university education. b. Students coming from the K-12 education system often c. not prepared for university education.
Workers	a. Firms might relocate. b. Few employment opportunities and low pay.

APPENDIX C

Table C2: Illustrative Examples of Challenges and Solutions in STEHM

Stakeholder	Problem(s) of Interest
Community College Students, Community Colleges	Ease of transfer between academic disciplines
Community Colleges, Community College Students	Subject specific financial support
Community Colleges, Employers, Community College Students	Faculty training to teach STEHM courses
Community Colleges, Students, Employers	Changes in core curriculum, remedial courses in Mathematics.
Potential Community College Students, Four Year Institutions	Quality of core curriculum and if it prepares students for successful transfer to four-year institutions.
Community College students	Study time required for STEHM relative to non-STEHM programs.

A number of potential strategies, such as introducing mathematics courses in the main curriculum, providing hands-on research opportunities to students, offering mentorship programs for community college students, facilitating partnerships between community colleges and four-year institutions, and providing research experiences for faculty could be assessed to increase enrollment of students in STEHM-specific courses.

Table C3: Illustrative Examples of Solutions and Strategies to Increase Enrollment of Students in Community Colleges

Stakeholder(s) with the Policy Levers	Solution(s) & Policy Levers
Government, Foundations	Financial aid
Government	Tuition forgiveness programs
Community Colleges, Employers	Internship programs
Community Colleges, Employers	Work-study programs
Community Colleges, Proprietary Educational Institutions	Partnerships with proprietary educational institutions to improve delivery of content.
Community Colleges, Foundations, Government	Institutional innovations, including online courses, use of technology in education.
Employers, Community Colleges	Learn and Earn Programs