SRMN

STEM Research and Modeling Network

SRMN Meeting Summary
February 9, 2009
Miami, FL

The second convening of the STEM Research and Modeling Network (SRMN) on February 9, 2009, brought together more than 50 researchers, modelers, policy makers, education and business leaders, foundation officers, and program directors. Participants reviewed the progress made, delved into emerging research components of the model, and discussed requirements for future model developments and a user interface.

The proposed meeting outcomes were to

- explore how best to incorporate proposed changes into the official model;
- introduce users to the idea of interacting with the model;
- learn about user-interface options and discuss the community's desired usability features;
- solidify plans for in-network and open source release of the model;
- ensure users know how to stay involved following the meeting.

A summary of important themes follows and concludes with a review of the next steps for the SRMN.

Update on SRMN Activities

Since the last meeting of the SRMN in November 2008, SRMN partners made significant strides in a) developing the internal infrastructure needed to support the network, b) facilitating the development of the research and modeling community through face-to-face meetings, c) vetting the research underpinning the model and identifying areas that require further attention, d) establishing an interactive platform on Google Groups for the SRMN to exchange ideas and documents, and e) crafting an external Web presence in the form of www.STEMnetwork.org.

Raytheon Chairman and CEO Bill Swanson commended the progress that the SRMN made and reminded the group in Miami that any model is just a tool, with utility and limitations. As he explained, "All models are wrong. Some are useful." He asked the SRMN to consider how to make the model as high-fidelity as possible in order to serve as a useful instrument for policymakers, educators, and others who are involved in strengthening STEM education in the United States.

Addressing Some of the Major Issues Raised at Kauffman

At the November 2008 convening of the SRMN at the Kauffman Foundation in Kansas City, participants identified research areas within the model that required closer examination. These topics are described in the meeting proceedings. The February SRMN meeting responded to these issues by convening several experts to discuss specific topics:

- Russell Hulse (UT-Dallas), informal learning
- Patrick Shields (SRI International), teacher influences on student learning
- Steve Robbins (ACT), student interest and proficiency in STEM

Russell Hulse, a University of Texas at Dallas professor and Nobel laureate in physics, discussed his history with science and engineering, which began when he was a young child. He shared examples of his desire to build things as a way of illustrating the point that young children have a natural curiosity that should be "harnessed rather than stifled." Citing the importance of out-of-school learning experiences in inspiring students and involving families, he expressed a desire to move away from the label of "informal" science education because it can be equated with "unimportant, underappreciated, and undersupported." He mentioned a study released in January 2009 by the National Academy of Sciences about learning science in informal environments that might be of interest to the SRMN.

Dr. Hulse also emphasized the value of project-based learning (PBL)—open-ended, self directed projects where students are challenged to solve a problem—in inspiring students and in building functional integrated knowledge. In his view, increasing PBL or inquiry based-learning (IBL) opportunities in college can reduce attrition from STEM majors. As an example, he pointed out that freshman engineers do not get to build anything in their first couple of years of college, causing them to leave the field. Because PBL and IBL are delivered in ways that are hard to measure with standardized testing, Dr. Hulse recommended developing better assessment methods that capture the value of PBL and informal science education programs, especially their influence on inspiration and problem-solving skills.

In his remarks, Dr. Hulse also stressed the importance of career awareness. He noted that students can be interested in STEM, but unable to visualize a career based on that interest. Or, they might be able to visualize a career but they do not think that it is a viable one. As he explained, "Someone has to make the connections for [STEM-interested students]" to STEM-based careers.

He also suggested some alternate ways to label parameters in the model:

- STEM interested in the current model = STEM tracked students (students who are going into stem careers)
- STEM literate = People who are familiar with and understand STEM, not intending to be STEM professionals, but are nonetheless key to our citizenry
- STEM non-literate = People who are not familiar with STEM and who are not intending to pursue STEM majors or STEM careers

Discussing the notion of separating STEM interest and proficiency in the model, Dr. Hulse identified three factors which should be coupled together but are decoupled in our current education system. He thought it would be worthwhile to track these issues:

- interest and engagement as critical source of motivation
- academic achievement represented by content knowledge as revealed by standardized testing
- real-world problem solving skills (functional integrated knowledge)

Further reflecting on his considerations for the STEM model, Dr. Hulse encouraged the group to keep in mind that interest and aptitude have intrinsic and acquired components. He said that even as we are trying to model the ways to increase the number of STEM graduates, it is important to remember that a lot of people end up in STEM careers because of their "dogged, intrinsic determination. It's not because we did anything good to help them out."

Dr. Hulse also discussed the importance of mathematics and its role in the model. "Arguably, he said, the best way to teach math is to integrate it into other subjects because most students are not interested in math." He explained that teaching math in context also helps students to retain the mathematic learning and makes it more learning. He closed by saying that proficiency in math is a necessary step to a STEM career, but no matter how critical math is, he encouraged the SRMN to not rely on math as a proxy for other attributes.

Patrick Shields, director of the Center for Education Policy at SRI International, summarized the current state of knowledge on teachers. Noting that teachers are the "single most important non-home factor on student achievement," he pointed out that studies from different states (TN, NY, CA, NC, FL, TX) show varying degrees of teacher impact on student achievement. He said that there appears to be a relationship between the nature of the state test and these effect sizes: the more the test is oriented toward basic skills, the smaller the effect size for teacher impact. Dr. Shields suggested that this variation simultaneously points to the need to incorporate several studies on teacher effectiveness into the model and highlights the importance of considering the state test and its properties when estimating coefficients for teacher impact.

Dr. Shields further explained that the variation in teacher impact is greater within schools than across schools, and that the variation of teacher quality in low-performing schools is greater than in high-performing schools. For these reasons, he encouraged the SRMN to consider modeling different populations of students in different kinds of schools. In California, for example, english language learners are having the hardest time entering and staying in the STEM pipeline. As a result, Dr. Shields suggested that a California model might include strands for the general population and for english language learners.

According to Dr. Shields, administrators "can't tell [who will be an effective teacher] when they arrive at the schoolhouse door," which is driving the policy push for pay-for-performance. He explained that the research shows a generally weak relationship between the characteristics of teachers—their subject area experience, qualifications, test scores, etc.—and student achievement. He noted, however, that there is a relationship between teacher characteristics and student achievement in high school math. For that reason, he suggested that it might be worthwhile to use the model to look more closely at 9th or 10th grade math. Such an examination might result in different coefficients for certain variable at different grade levels.

In a similar vein, Dr. Shields explained that the research overall shows a weak relationship, if any, between a teacher's credentials and student achievement. Because teacher credentials are politically important, he recommended including credentialing in the model but leaving it as neutral (i.e., expect no impact).

Addressing the recommendation from the Kauffman meeting to identify the components of a "good" teacher, Dr. Shields concluded by noting that there is robust literature on what constitutes a good teacher. Among other things, a good teacher builds on students' prior knowledge, develops language skills, and creates a culture of learning. He explained that it is not possible to acquire data on all of these factors in an aggregate way for use in the model. Nonetheless, he said, the issue is not irrelevant and does have important policy implications. Dr. Shields suggested a need for multiple measures of teacher effectiveness beyond value-added hits on achievement, including some kind of measure of what transpires in the classroom.

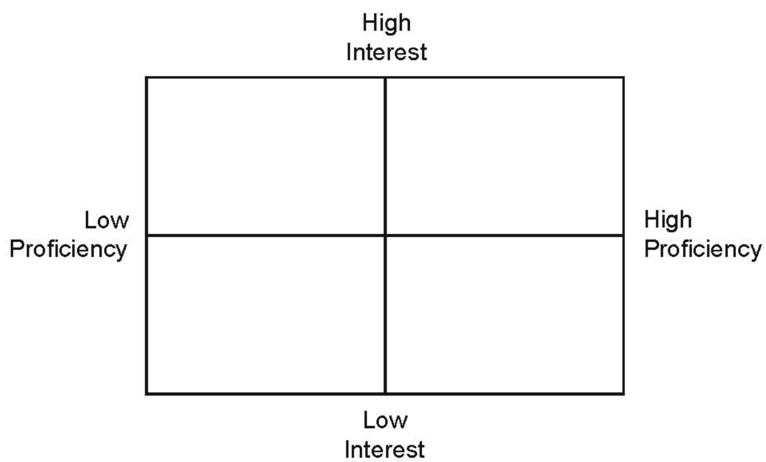
Steve Robbins, assistant vice president of Applied Research at ACT, explained the nature of the data that ACT collects. ACT conducts a national curriculum survey every three years that identifies key standards for success in college algebra, college English, and first-year college science. The Educational Planning and Assessment System (EPAS) is an 8th, 10th, and 12th grade system that lines up academic achievement in math, science, reading, and English to monitor how students are progressing toward those key standards of college readiness and success. At the same time, ACT studies career and educational planning with UNIAC, its career assessment system. Since the 1960s ACT has tested 45 million students with career interest inventories tied to its academic achievement system. The system maps measured interests (who students are or their dispositions) to expressed or chosen college major and career preferences and goals.

According to Dr. Robbins, these systems provide ACT with robust longitudinal systems of data related to academic achievement over time and career interest that can be used in the STEM model. For example, in any year, ACT has

- linked files of 140,000-150,000 students who took ACT assessments in the 8th, 10th, and 12th grades;
- data on 2 million students who took the ACT in grade 12;
- data on the ACT test takers who enter postsecondary education (as the result of a partnership with the National Student Clearinghouse, which manages 92% of all postsecondary enrollment in the country).

Dr. Robbins drew on his analysis of ACT's student interest data to recommend a research question that the model might address. He explained that the fit between students' dispositions (measured interest) and what they want to do (expressed interest) is low in 8th grade, goes up between 8th and 10th grade, then drops in 12th grade. He pointed out that in 12th grade, students move away from being interested in ideas and things—which are associated with STEM-related careers and majors—to being interested in people, which correlate with service and social-related careers and majors. Dr. Robbins suggested that "we need to figure out what is scaring off people who like doing activities associated with science and math but who are moving away from those professions."

Continuing his discussion of student interest, Dr. Robbins also recommended a key change to the model. The recommendation is based on his important finding that math and science success and math and science interest are independent from each other. In discussing the implications of this finding, Dr. Robbins described the potential to develop a two-by-two matrix that depicts high and low ability and high and low interest in STEM-related activities—a Latin square (see graphic below).



He explained that the needs and interventions will be different for the students in each square:

- High-proficiency, high-interest students need to be identified and supported to maintain their commitment to STEM.
- High-proficiency, low-interest students might need more exposure to STEM careers or programs to increase their interest.
- High-proficiency, low-ability students should be targeted for academic interventions.
- Low-proficiency, low-ability students likely require more general, non-STEM related supports to help them succeed.

Dr Robbins concluded with four points:

1. School and class-level effects on achievement are critical. The key to increasing rigor in the classroom is teacher development and training.
2. There are parallel paths in terms of career and college readiness and interest. It is critical to identify expectations and activities that must take place for youth to be successful.
3. Aligned, coherent systems are essential to track and use data. ACT prides itself on the use of data to inform decisions, which is why the organization's leadership is interested in contributing to the model.
4. Students need help selecting the right major when entering college because the fit between a person's measured interest (disposition) and their expressed interest (college major) is highly predictive of major stability, time to degree attainment, and career earnings.

The Model's User Interface

User interfaces are tools that are designed to facilitate sound decision making with a model. Such tools give users the ability to interact with the model and drive policy discussions, while better understanding the dynamic nature of the issues at hand. During the February SRMN meeting, Jim Middleton of Arizona State University gave a brief video and presentation of the ASU Decision Theatre, a laboratory that combines advanced methodologies in visualization, simulation, and cognitive science to inform policy decision making. In subsequent discussion among participants about the creation of the user interface for the STEM model, it was pointed out that the substance of the model ultimately should drive the user interface. Moreover, because different users will have different purposes and needs for interacting with the model, it was suggested that it might be necessary to consider developing different user interfaces targeted at different audiences.

Next steps

1. Future Model Developments

Based on material presented by the panelists and on ensuing discussions, the community agreed to pursue the following model changes:

- Research and data on student interest in STEM will be added as well as data on math proficiency.
- Data will also include the impact of teachers on both interest and proficiency.
- Ways to include out-of-school influences will be developed at some point in the future, such as family and peer-group influences and after-school programs.

2. Other Future Considerations

Discussion revealed many important areas that warrant further thought from the SRMN community:

- Methods to highlight informal learning will be considered in order to avoid the trap that "informal=unimportant."
- Inclusion standards for the studies underpinning the model will be further defined, clearly identifying when a piece of research has become too dated for inclusion in the model.
- The possibility of state-level models based on the national model will be discussed.
- Parameters in the model that are undefined or poorly defined will be elaborated upon.
- Financial aspects of programs and policies explored in the model will be considered.
- Reviews of current research on programs and efforts to improve STEM education will be conducted in case we already know what works but lack scalability.

3. Building the SRMN Community

A robust research and modeling network is vital to the success of this endeavor. Over the next several months, SRMN partners will be calling on community members to join in a variety of activities. For example, SRMN members can

- participate in conversations regarding the role of the user community;
- assist in the design and development of a user interface;
- identify areas in the model where greater support or clarification is needed to aid the development of a user handbook;
- identify areas of research that they would like to lead and/or in which they would like to participate;
- provide extant research for inclusion in the model.

4. Upcoming SRMN Events

- American Educational Research Association (AERA), San Diego CA, April 16, 2009. In a 2-hour session, Alex Sanchez and Natalie Nielsen will introduce AERA members to the idea of system dynamics modeling, demonstrate the model, and discuss some of the underlying research.
- An SRMN meeting will be offered in conjunction with the Systems Dynamics Annual Conference Systems Dynamics Society in Albuquerque, NM on July 31st. At the same meeting (July 26-30,

2009), Alex Sanchez of Raytheon will present a paper to this audience of system dynamics modelers.

- American Institute of Aeronautics and Astronautics, Arlington, VA, May 12-13, 2009. Chris Roe from BHEF will present “Engaging with Future Generations in K-12.”