RESEARCH ARTICLE

# Reshaping How Educators View Student STEM (Science, Technology, Engineering, and Mathematics) Learning:

## Assessment of the SENCER Experience

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## Introduction

There are innumerable government-commissioned reports documenting the need for improved STEM (science, technology, engineering and mathematics) education. These are exemplified by *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2007)* and the *National Action Plan for Addressing the Critical Needs of the U.S. Science, Technology, Engineering and Mathematics Education System (2007)*. In 2010 the National Science Board report *Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation's Human Capital* emphasized the urgency of the issue: "to ensure the long-term prosperity of our Nation, we must renew our collective commitment to excellence in education and the development of scientific talent."

Complementing the need for improved STEM education identified by government-commissioned reports is the range of reports and studies focused on undergraduate learning experiences carried out by educators. Overviews of issues related to undergraduate education include *How College Affects Students* (Pascarella and Terenzini 2005), a synthesis of what is currently known about how college impacts students, and *Academically Adrift: Limited Learning on College Campuses* (Arum and Roksa 2011) an assessment of undergraduate student learning. There are also those focused on collegiate STEM experiences such as *Scientific Teaching* (Handelsman et al. 2004), *Vision and Change in Undergraduate Biology Education: A Call to Action* (Brewer and Smith 2011), *Inside the Schooled Mind: Review of Applying Cognitive Science to Education-Thinking and Learning in Scientific and Other Complex Domains* (Stern 2009) and others that report on how to improve science learning from both the student and educator perspective.

Science Education for New Civic Engagements and Responsibilities (SENCER) has supported a community of faculty, students, academic leaders, and others to improve undergraduate STEM education using an approach that connects learning to critical civic questions. [1] A SENCER description

1 This material is based upon work supported by the National Science Foundation under Grant No. 0717407. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

notes that the courses and programs "…explicitly embrace pedagogical strategies that reflect the recent scholarship of cognitive scientists on how we actually learn. These strategies emphasize learning that is active, authentic, inquiry-based, and connected to research" (SENCER Viewbook 2009). To put it succinctly, SENCER's dictum is "applying the science of learning to the learning of science" (SENCER Viewbook 2009). Specific SENCER goals are targeted to student outcomes: (1) get more students interested and engaged in learning in STEM courses, (2) help students connect STEM learning to their other studies, and (3) strengthen students' understanding of science and their capacity for responsible work and citizenship. (About SENCER http://www.sencer.net/About/projectoverview.cfm)

A 2006 report, *Evaluation of Science Education for New Civic Engagements and Responsibilities (SENCER) Project* (Weston, Seymour, and Thiry, 2006) describes a SENCER program evaluation that focused on students and the development and validation of the survey instrument for Student Assessment of Learning Gains (SALG). [2] In a summary of the SALG data from more than 10,000 students in 345 SENCER courses the authors found it significant that: (1) students gained most in the areas of science literacy, followed by general course skills; (2) women gained more than men and non-science majors gained more than science majors on many of the items and composite variables; (3) the patterns of gains were in line with efforts by SENCER to encourage awareness of the link between civic issues and scientific content. The 2006 evaluation also included a survey and interviews with faculty selected from 135 instructors teaching SENCER courses.

In 2010 the SENCER Impact Assessment Survey was designed to find out from all program participants whether or not SENCER was meeting its objectives. Rather than test specific hypothesis, the research goal was to describe participants' views of their SENCER experience and use this information for future planning. In April 2011 SENCER eNews published a descriptive overview of the survey results. [3]

## Methods

### *Participants*

The 1,685 SENCER program participants who attended at least one national or regional event between 2001 and 2010 were contacted by e-mail to participate in a web-administered survey. Of these, 346 were returned due to bad e-mail addresses and five were not eligible evaluators associated with SENCER. Among the 1,334 eligible, 602 (45%) responded. Comparisons between respondents and all participants are limited. The only available SENCER administrative data that can be directly compared to survey respondents is the number of events program participants attended. This comparison shows that those who responded are more likely than all participants to have experienced more than six SENCER events (11.9% to 2.0% respectively) and 3 to 6 events (33.5% to 8.0% respectively) and less likely to be those participating in 1 or 2 national or regional SENCER events (54.3% to 89% respectively).

### *Survey Instrument*

The survey instrument for the SENCER Impact Assessment Survey was developed by Stephanie Knight, Professor of Educational Psychology and Teacher Education at Penn State University and SENCER Director of Evaluation and Assessment; Richard Duschl, Chair in Secondary Education at Penn State University; and the SENCER Assessment and Evaluation Advisory Team.[4] The questionnaire covered multiple topic areas related to SENCER objectives: (1) the value of specific SENCER programs and resources; (2) professional and personal career development; (3) pedagogical practices (4) image of students as science learners; (5) student achievement; and (6) institutional change. Questions to categorize respondents included institution type (two or four year; public or private), role on campus, and number of national and regional SENCER events attended. Open-ended items gave respondents opportunities for verbatim answers to expand on the Likert-type close-ended choices. [5] Respondents were given the option to respond anonymously or to give their names and personal contact information.

2 Information about the Student Assessment of Learning Gains (SALG) can be found at http://www.sencer.net/Assessment/independentevaluation.cfm

3 The overview can be found at http://serc.carleton.edu/sencer/newsletters/52534.html .

4 Members of the SENCER Assessment and Evaluation Advisory Team included William E. Bennett, Stephen Carroll, Matthew Fisher, Jeannette Haviland-Jones, and Terry McGuire.

5 The questionnaire is available by contacting the SENCER national office.

### *Data Collection*

Data collection using a web-administered questionnaire was conducted between October 13, 2010 and November 30, 2010. The e-mail request said the purpose of the survey was "to garner information about SENCER's impact, influence, and effectiveness to help us plan for the future." Five e-mail reminders, approximately a week apart, were sent to encourage survey participation. As noted above, 602 (45%) responded to the survey.

### *Data Analysis Plan*

The focus of the analysis is descriptive. Using the survey data we can learn about respondents' perceptions of SENCER objectives related to: (1) using active learning—the SENCER foundation for pedagogical practice; (2) viewing students as science learners; and (3) achieving 21st Century learning goals. The data for this analysis is based on answers to the Likert-style response choices. [6]

Each of these core objectives has components associated with the SENCER approach. A review of the frequency distributions for the components identifies the areas where SENCER participation is perceived to have had more or less influence and provides planning information for potential areas where future SENCER programming needs to focus.

Cross tabulations were used to analyze respondent subgroups. These sub-group categories are the number of national or regional SENCER events attended and the respondent's role on campus. Comparing the data for those who attended different numbers of events answers the question of whether or not SENCER attendance has a cumulative effect on meeting SENCER objectives. The role on campus analysis compares answers of those who identify as faculty to responses from academic administrators, a group that includes a variety of positions such as program directors, department chairs, deans, provost, vice president, and chancellors. The faculty member viewpoint is expected to be primarily based on the application of his or her SENCER program experience in the classroom. Looking at the academic administrators' responses provides the perspective of institutional decision makers whose experience can be used to facilitate the institutional classroom adoption of the SENCER approach.

The open-ended questions related to these SENCER objectives described as being included in the survey instrument have not been analyzed. The development of a coding frame and a systematic process to categorize the text of the verbatim responses is a future research objective.

6 Individuals or teams interested in using the survey data for their own analysis should contact the SENCER national office.

## Results

### *Profile of Survey Respondents.*

Survey respondents were primarily faculty (66.7%) with about one-in-five reporting an administrative role on campus such as department chair (11.5%), dean (5.2%), and provost, vice president, president, or chancellor (2.5%). Fourteen percent had other roles on campus primarily in other administrative positions such as program directors. Most were from four-year (85.5%) compared to two-year (14.5%) institutions, and somewhat more were from public (55.2%) than private (44.8%) institutions. A majority of respondents participated in one or two national or regional SENCER events (54.3%), a third participated in three to six events (33.5%), and 1-in-10 experienced more than six SENCER events (11.9%). Examples of these "events" are the intensive SENCER Summer Institute, the three-day Washington, DC Symposium and Capitol Hill Poster Session, and various regional training programs and workshops. (Table 1)

**TABLE 1.** Profile of Survey Respondents

| | PERCENTAGES | NUMBER |
|---|---|---|
| **ROLE ON CAMPUS** | | |
| Faculty Member | 66.7 | 349 |
| Department Chair | 11.5 | 60 |
| Dean | 5.2 | 27 |
| Provost, Vice President, President, Chancellor | 2.5 | 13 |
| Other | 14.1 | 74 |
| **INSTITUTE TYPE** | | |
| 2 Year | 14.5 | 76 |
| 4 year | 85.5 | 447 |
| **INSTITUTE TYPE** | | |
| Public | 55.2 | 285 |
| Private | 44.8 | 231 |
| **NUMBER OF SENCER EVENTS** | | |
| 1-2 | 54.3 | 284 |
| 3-6 | 33.5 | 175 |
| More than 6 | 11.9 | 62 |

Source: 2010 SENCER Impact Assessment Survey

### *Educators' Views of SENCER Influence on Student STEM Education*

The SENCER Impact Assessment Survey had three questions related to SENCER objectives focused on students. These are the use of active learning—the SENCER foundation for pedagogical practice; perception of students as science learners; and student achievement of 21st Century learning goals.

### Pedagogical practice

To learn whether or not SENCER participation influenced their pedagogical practice respondents were asked to strongly agree, agree, disagree, or strongly disagree if it increased student learning opportunities to: (1) identify scientific problems and questions; (2) conduct measurements and/or observations to develop data sets; (3) analyze data sets to determine evidence or the need to conduct more measurements and observations; (4) analyze evidence to determine patterns; (5) analyze evidence to construct models; (6) use evidence patterns and/or models to generate or evaluate explanations; (7) make connections between science and civic problems/topics; and (8) make interdisciplinary connections.

Overall, about 8-in-10 or more strongly agreed or agreed that SENCER participation influenced instruction that increased student opportunities to experience all eight of these components of pedagogical practice. (Table 2) When the eight are rank ordered, the highest percentages of agreement are for respondents' perceptions of increased student opportunities to make connections between science and civic problems/topics (95.2%), make interdisciplinary connections (94.7%), and identify scientific problems and questions (91.4%). The other five student learning opportunities are ranked as follows: analyze evidence to determine patterns (84.1%), conduct measurements and/or observations to develop data sets (84.0%), analyze evidence to construct models (83.6%), analyze data sets to determine evidence or the need to conduct more measurements and observations (80.9%), and use evidence patterns and/or models to generate or evaluate explanations (79.3%).

**TABLE 2.** SENCER Influence on Pedagogical Practices to Increase Student Opportunities (Strongly Agree/Agree Percentages)

| | | NUMBER OF SENCER EVENTS ATTENDED | | | ROLE ON CAMPUS | |
|---|---|---|---|---|---|---|
| PEDAGOGICAL PRACTICE | Total (n=485) | 1-2 (n=256) | 3-6 (n=168) | More than 6 (n=60) | Faculty (n=332) | Academic Administrator (n=135) |
| Make connections between science and civic problems/topics | 95.2 | 91.7 | 98.7 | 100 *** | 93.9 | 97.9 |
| Make interdisciplinary connections | 94.7 | 91.4 | 100 | 100 *** | 93.1 | 98.0 * |
| Identify scientific problems and questions | 91.4 | 88.9 | 93.6 | 96.1 *** | 90.1 | 94.3 * |
| Analyze evidence to determine patterns | 84.1 | 77.5 | 90.2 | 94.4 *** | 82.3 | 88.5 * |
| Conduct measurements and/or observations to develop data sets | 84.0 | 79.1 | 88.6 | 91.7 *** | 81.4 | 90.3 * |
| Analyze evidence to construct models | 83.6 | 78.0 | 87.9 | 94.3 ** | 87.7 | 76.3 * |
| Analyze data sets to determine evidence or the need to conduct more measurements and observations | 80.9 | 74.7 | 87.0 | 89.8 *** | 77.9 | 87.8 * |
| Use evidence patterns and/or models to generate or evaluate explanations | 79.3 | 73.4 | 83.3 | 92.1** | 80.8 | 89.9 * |

Source: 2010 SENCER Impact Assessment Survey

Note: Due to item nonresponse, the number answering each of these items varied. The numbers on the table represent the maximum of the following ranges: Total 485-401; Number of SENCER events: 1-2 events 256-211; 3-6 events 168-138; more than 6 events 60-48; Role on Campus: Faculty 332-279; Not Faculty 153-122.

Pearson Chi -Square significance test
*P<.01
**P<.001
***P<.0001

### *Perceived SENCER influence by event attendance*

The more SENCER events a respondent attended the more likely he or she was to strongly agree or agree that SENCER participation influenced pedagogical practice. A comparison of the three groups illustrates the extent of SENCER influence varies depending on the number of events attended.

**Attended more than six events.** All eight student learning opportunities were perceived to have had SENCER program influence by 9-in-10 or more of this attendee group. Of particular note, is unanimous agreement that SENCER had an influence on increasing student opportunities to make connections between science and civic problems/topics and to make interdisciplinary connections.

**Attended three to six events**. Four of the eight student learning opportunities received agreement from 9-in-10 of the respondents in this group. Making interdisciplinary connections stands out with unanimous strongly agree or agree responses.

**Attended one or two events.** Two of the eight student learning opportunities were perceived by 9-in-10 of these attendees as being influenced by SENCER participation. These are to: make connections between science and civic problems/topics (91.7 %) and make interdisciplinary connections (91.4 %).

### *Perceived SENCER influence by role on campus*

Overall, about 8-in-10 or more faculty and academic administrators strongly agreed or agreed that SENCER participation influenced pedagogical practice to increase student opportunities for the eight components of this SENCER objective. Nine in ten academic administrators agreed with five of the eight components of student opportunities compared to three of the eight perceived to be influenced by 9-in-10 faculty. Academic administrators were more likely than faculty to report agreement to all these activities except increasing student opportunities to analyze evidence to construct models (76.3% to 87.7 % respectively).

These results are overwhelmingly positive and suggest that the SENCER program is perceived by respondents to be meeting its objective to influence pedagogical practice. Of particular note is the core SENCER objective to make connections between science and civic problems is perceived as influencing almost all respondents. The rank order of the eight components is instructive for identifying those that may need more attention in future SENCER programs. The data showing the perception of influence increases with the number of events attended illustrates SENCER's cumulative effect on attaining its objectives. SENCER influence on pedagogy is perceived similarly by faculty and academic administrators suggesting a consensus that can aid in moving the SENCER approach from individual classrooms to an institutional focus.

## Image of students as science learners

A SENCER objective is to transform perceptions of students as science learners. Respondents were asked if they strongly agree, agree, disagree, or strongly disagree that involvement in SENCER influenced their image of students as science learners who are able to: (1) ask scientifically oriented questions; (2) use evidence to develop and evaluate explanations to address scientifically oriented questions; (3) formulate explanations from evidence to address scientifically oriented questions; (4) evaluate their explanations in light of alternative explanations; (5) respond to criticism from others; (6) formulate appropriate criticism of others; (7) seek criticism of their own explanations; (8) reflect on alternative explanations/phenomena that do not have unique resolutions; (9) translate the knowledge gained to other courses; and (10) take the knowledge gained and apply it in a civic/community setting.

For all ten components of this SENCER objective, 3-in-4 or more strongly agreed or agreed SENCER participation changed their perceptions of students' abilities as science learners (Table 3). The rank order of science abilities suggests where SENCER is having more or less influence. Eight-in-ten or more agreed SENCER changed their perceptions that students are able to: take the knowledge gained and apply it in a civic/community setting (92.2%); translate the knowledge gained to other courses (89.6%); use evidence to develop and evaluate explanations to address scientifically oriented questions (88.7%); ask scientifically oriented questions (88.1%); formulate explanations from evidence to address scientifically oriented questions (87.4%); reflect on alternative explanations/phenomena that do not have unique resolutions (86.9%); and evaluate their explanations in light of alternative explanations (86.3%). Fewer, agreed that SENCER influenced their image of students' abilities to: formulate appropriate criticism of

**TABLE 3.** SENCER Influence of Image of Students as Science Learners Able to do the Following (Strongly Agree/Agree Percentages)

| | | Number of SENCER Events Attended | | | ROLE ON CAMPUS | |
|---|---|---|---|---|---|---|
| **STUDENT SKILL INFLUENCED** | TOTAL (n=452) | 1-2 (n=237) | 3-6 (n=155) | More than 6 (n=59) | Faculty (n=310) | Academic Administrator (n=144) |
| Take knowledge gained and apply it in a civic/ community setting | 92.2 | 88.6 | 96.1 | 96.6 ** | 90.9 | 95.1 |
| Translate knowledge gained to other courses | 89.6 | 84.1 | 96.1 | 94.6 *** | 88.1 | 92.8 |
| Use evidence to develop and evaluate explanations to address scientifically oriented questions | 88.7 | 82.9 | 95.3 | 94.8 *** | 87.1 | 92.2 |
| Ask scientifically oriented questions | 88.1 | 83.0 | 93.4 | 94.8 *** | 86.3 | 91.7 |
| Formulate explanations from evidence to address scientifically oriented questions | 87.4 | 82.1 | 92.8 | 94.9 ** | 85.9 | 90.8 |
| Reflect on alternative explanations/phenomena that do not have unique resolutions | 86.9 | 81.7 | 91.7 | 94.8 ** | 85.9 | 89.0 |
| Evaluate their explanations in light of alternative explanations | 86.3 | 80.4 | 94.0 | 95.7 *** | 84.7 | 89.4 |
| Formulate appropriate criticism of others | 77.2 | 71.4 | 81.7 | 87.5 * | 75.8 | 79.9 |
| Respond to criticism from others | 76.5 | 71.1 | 80.2 | 87.2 * | 74.1 | 81.5 |
| Seek criticism of their own explanations | 75.9 | 70.3 | 79.2 | 89.1 * | 73.7 | 80.2 |

Source: 2010 SENCER Impact Assessment Survey
Note: Due to item nonresponse, the number answering each of these items varied. The numbers on the table represent the maximum of the following ranges: Total 452-410; Number of SENCER events: 1-2 events 237-213; 3-6 events 155-139; more than 6 events 59-55; Role on Campus: Faculty 310-274; Not Faculty 144-134.
Pearson Chi -Square significance test
*P<.01
**P<.001
***P<.0001

others (77.2%); respond to criticism from others (76.5%); and seek criticism of their own explanations (75.9%).

### *Perceived SENCER influence by event attendance*

Similar to the data described for the pedagogical practice objective, the more SENCER events a respondent attended, the more likely he or she was to strongly agree or agree that participation had an influence on the image of students as science learners who are able to accomplish STEM related activities.

**Attended more than six SENCER events.** Among those who attended the most SENCER events, about 9-in-10 agreed that SENCER had influenced their image of students for all ten components of this SENCER objective. Take knowledge gained and apply it in a civic/community setting (96.6%) and evaluate their explanations in light of alternative explanations (95.7%) had the highest percentages of agreement. The student science abilities related to criticism were least likely to be perceived as influenced by SENCER involvement: seek criticism of their own explanations (89.1% ); formulate appropriate criticism of others (87.5%); and respond to criticism from others (87.2%).

**Attended three to six SENCER events.** Seven of the ten abilities had agreed answers from 9-in-10 of the respondents in this group. Similar to the group who attended more than six events, the abilities related to criticism were least likely to be perceived as being influenced: formulate appropriate criticism of others (81.7%); respond to criticism from others (80.2%); and seek criticism of their own explanations (79.2%).

**Attended one or two SENCER events.** None of the ten components related to the image of students as science learners had agreement from 9-in-10 of those who attended the fewest number of events. However, 8-in-10 agreed with seven of the ten abilities. As with the other attendee groups, the lowest percentages of

agreement were for the image of student's ability to: formulate appropriate criticism of others (71.4%); respond to criticism from others (71.1%); and seek criticism of their own explanations (70.3% )

### *Perceived SENCER influence by role on campus*

For all ten components related to the SENCER objective of influencing the image of students as science learners, academic administrators were more likely than faculty to strongly agree or agree. Nine in ten academic administrators strongly agreed or agreed with five of the abilities compared to faculty who only had 9-in-10 agree with one. For both faculty and academic administrators the highest percentage of perceived influence was on the image of students being able to take the knowledge gained and apply it in a civic/community setting (90.9 % and 95.1% respectively). As with the attendee groups, the lowest percentages of agreement for faculty and administrators were for the image of student's ability to: formulate appropriate criticism of others (75.8% and 79.9 % respectively); respond to criticism from others (74.1% and 81.5 % respectively); and seek criticism of their own explanations (73.7% and 80.2% respectively )

As these robust results show, SENCER is perceived as meeting the objective of influencing participants' views of students as science learners. It is informative that among the ten components of this image of students, the abilities fewer perceive as being influenced are those related to criticism. Again the cumulative impact of SENCER attendance is observed with more SENCER experience being related to higher perceptions of influence for more of the components of this objective. And, those with faculty and administrative roles have similar perceptions on whether or not SENCER participation influenced their image of students as science learners.

## Student achievement of 21st Century learning goals

Facilitating student achievement of 21st Century learning goals is another SENCER program objective. Respondents were asked if SENCER participation had helped student achievement a great deal, some, not much, or not at all with these components of 21st Century learning goals: (1) quantitative literacy; (2) ability to engage in critical thinking; (3) capacity to collaborate or engage in group work; (4) ability to discern good information from fraudulent claims; (5) cultivation of a global perspective; and (6) problem solving.

Overall 8-in-10 or more respondents answered that all six components of 21st Century learning goals had helped a great deal or some (Table 4). The top ranked 21st Century learning goals respondents perceived as being influenced by SENCER were: ability to engage in critical thinking (91.8%);

**TABLE 4.** Perceived SENCER Participation Help for Student Achievement of 21st Century Learning Goals (Great Deal/Some Percentages)

| | | NUMBER OF SENCER EVENTS ATTENDED | | | ROLE ON CAMPUS | |
|---|---|---|---|---|---|---|
| **21ST CENTURY ACHIEVEMENT GOALS** | TOTAL (n=463) | 1-2 (n=239) | 3-6 (n=166) | More than 6 (n=58) | Faculty (n=317) | Academic Administrator (n=146) |
| Ability to engage in critical thinking | 91.8 | 86.5 | 96.4 | 100 *** | 88.9 | 97.9 * |
| Capacity to collaborate or engage in group work | 90.4 | 85.0 | 97.0 | 94.7 *** | 88.9 | 95.2 * |
| Problem solving | 88.7 | 83.2 | 93.9 | 96.5 *** | 86.2 | 94.5 * |
| Cultivation of a global perspective | 82.5 | 77.3 | 83.8 | 100 *** | 79.1 | 89.9 * |
| Ability to discern good information from fraudulent claims | 82.3 | 76.6 | 85.8 | 94.8 *** | 79.3 | 89.0 * |
| Quantitative literacy | 80.5 | 73.2 | 86.6 | 92.8 *** | 79.0 | 83.9 |

Source: 2010 SENCER Impact Assessment Survey
Note: Due to item nonresponse, the number answering each of these items varied. The numbers on the table represent the maximum of the following ranges: Total 463-436; Number of SENCER events: 1-2 events 239-222; 3-6 events 166-156; more than 6 events 58-55; Role on Campus: Faculty 317-300; Not Faculty 146-136.
Pearson Chi -Square significance test
*P<.01
**P<.001
***P<.0001

capacity to collaborate or engage in group work (90.4%); and problem solving (88.7%). Somewhat fewer were influenced by SENCER programs a great deal or some to help students achieve: cultivation of a global perspective (82.5%); ability to discern good information from fraudulent claims (82.3%); and quantitative literacy (80.5%) (Table 4).

### *Perceived SENCER influence by attendance*

Similar to the other two SENCER objectives, the more events a respondent attended, the more likely he or she was to answer this participation helped their students a great deal or some to achieve six 21st Century learning goals.

**Attended more than six SENCER events.** All six components of 21st Century learning goals for students were perceived by 9-in-10 of these attendees to have been helped a great deal or some by SENCER participation. Most noteworthy, is the unanimous view that their SENCER experience helped their students' ability to engage in critical thinking (100%) and cultivation of a global perspective (100%) a great deal or some.

**Attended three to six SENCER events.** Among these attendees, 9-in-10 answered a great deal or some for three of the 21st Century learning goals: students' capacity to collaborate or engage in group work (97.0%), ability to engage in critical thinking (96.4%), and problem solving (93.9%) received the highest percentage of a great deal or some answers.

**Attended one or two** SENCER **events.** None of these 21st Century learning goals had great deal or some answers that exceeded 90 percent from this group of attendees. Three components of this SENCER objective had 8-in-10 who perceived the SENCER experience helped students learn to: engage in critical thinking (86.5%), collaborate or engage in group work (85.0%), and solve problems (83.2%).

### *Perceived SENCER influence by role on campus*

About 8-in-10 or more faculty members and academic administrators view SENCER participation as an aid to preparing students to achieve 21st Century learning goals. For all six components of this SENCER objective academic administrators were more likely than faculty to perceive students were helped a great deal or some because of SENCER participation. The components that rank highest for both academic administrators and faculty are ability to engage in critical thinking (97.9 % and 88.9% respectively) and capacity to collaborate or engage in group work (95.2% and 88.9% respectively).

Respondents clearly perceive that SENCER participation has helped students attain 21st Century learning goals. Again, SENCER planning can benefit from the descriptive rank order of the components to target possible revisions in this program objective. In addition, knowing that there is an increase in perceived SENCER influence related to event attendance is encouraging to overall incorporation of the SENCER approach to student STEM education.

SENCER events provide participants with learning theories and the methods to apply them. The survey results are testimony to how successful this approach is in practice and illustrate the extent of influence on student accomplishments.

## Discussion

The urgency for improved undergraduate STEM education can not be overstated. The message that there is a need to transform how students learn and to broaden inclusion comes from government and academic leaders. *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* was commissioned by Congress and challenges the status quo and points to necessary changes. Answering this challenge, the National Science Foundation Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES) provides support "to transform undergraduate STEM education, for example, by bringing about widespread adoption of classroom practices that embody understanding of how students learn most effectively."

At the core of student learning is how they are taught. Studies such as *How People Learn: Bridging Research and Practice, Enhancing the Instructional Environment* and others illustrate how active learning as a pedagogical approach to teach science is gaining support. However, as suggested in *Scientific Teaching*, "reports generally do not offer a guide to learning how to do scientific teaching" and *Creating the Future of Faculty Development: Learning from the Past, Understanding the Present* provides suggestions for improving teaching. SENCER program participation is viewed as addressing this issue by influencing pedagogical skills such as using active learning for student experiences such as identifying problems,

using scientific methods, and making connections to apply scientific knowledge to current social issues.

Other research to identify ways to improve STEM education looks at expectations for student learning. Scholars such as Rhona Weinstien, *Reaching Higher: The Power of Expectations in Schooling*, and others point to a more ecological/ holistic view of how students learn that is anchored in perceptions, expectations, and self- fulfilling prophecies in schooling. This field of pedagogy looks at the influence of learning expectations based on how teachers view students, teacher/student relationships, and the culture and environment where learning takes place. Applying this to STEM learning, the typical "perception" that non-science majors and women are least likely to "succeed" in science courses may become a self-fulfilling prophecy.

The SENCER objective to influence how educators view students addresses this approach to student learning. The survey results clearly indicate there is a perception that SENCER attendance influences participants' image of students as science learners. For this objective the SALG results summarized in a prior section indicate how changing educators' views can influence students as science learners. The SALG results show that among these students who were taught by SENCER program participants women gained more than men and non-science majors gained more than science majors on many of the items and composite variables. The SALG evaluators note this as "encouraging evidence given that females and non-science majors have traditionally been underserved or overlooked in many university science programs."

Transforming undergraduate STEM education is the core objective of the SENCER program. The SENCER Impact Assessment Survey was conducted to find out whether or not SENCER program attendance influences the various objectives related to this goal. As the robust descriptive results show, overall respondents perceive their pedagogical practice, perception of students as science learners, and ability to help students achieve 21st Century learning goals was influenced by attending SENCER programs. The description of the components of these objectives and the types of participants where there is more or less consensus on perceived SENCER influence can inform SENCER planning and contribute to addressing the challenges related to improving STEM education.

## About the Author

*Janice Ballou* is a nationally recognized survey research methodologist with more than 40 years of experience. Currently an independent consultant, before retirement Ballou was a Vice President and Senior Fellow at Mathematica Policy Research, Inc. Her prior position was Director of the Rutgers University Center for Public Interest Polling. Her publications include "Survey Data Collection Methods" a chapter in *Counting Working-Age People with Disabilities: What Current Data Tell Us and Options for Improvement*, and "Web of Caring: Development of Web-Survey Best Practices" and "Diversity of Methods: Assessment of Quantitative and Qualitative Research Multiplier Effect" in *Proceedings of the American Statistical Association Section on Survey Research Methods*. She has held multiple American Association for Public Opinion Research elected offices and served on the *Public Opinion Quarterly* Advisory Committee and the *Survey Practice* Editorial Board.


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