# Engaging Young People in 21st Century Community Challenges: Linking Environmental Education with STEM

June 30, 2013

NewKnowledge Report #PRCO.106.110.06

NewKnowledge Publication #PRCO.106.110.06

Prepared for:

Underwriters Laboratories
333 Pfingsten Road
Northbrook, IL 60062

National Association for Environmental Education
2000 P St., NW, Suite 540
Washington, DC 20036

These research results were produced in support of the UL and NAAEE project entitled Blueprint for Success: Engaging Young People in 21st Century Community Challenges: Linking Environmental Education with Science, Technology, Engineering, & Math. The authors were the independent research partners for the project and are solely responsible for the content of this report.

Recommended Citation:

Fraser, J., Gupta, R., Flinner, K., Rank, S. & Ardalan, N. (2013). *Engaging Young People in 21st Century Community Challenges: Linking Environmental Education with Science, Technology, Engineering and Mathematics, NewKnowledge Report #PRCO.106110.06*. New York: New Knowledge Organization Ltd.

*The North American Association for Environmental Education (NAAEE) is a pioneering membership organization dedicated to accelerating environmental literacy through education. NAAEE supports a network of more than 16,000 educators, researchers, and organizational members working in environmental education across more than 30 countries through direct membership and 54 regional affiliate organizations. Through sponsored community networks, publications, and employment development opportunities, NAAEE provides resources for educators, professionals, volunteers, and researchers. NAAEE's tentpole annual conference, now in its 42nd year, convenes leaders from private and public sectors to advance the field of environmental education. For more information, visit www.naaee.net.*

*UL is a premier global independent safety science company with more than 118 years of history. Employing more than 10,000 professionals with customers in over 100 countries, UL has five distinct business units – Product Safety, Environment, Life & Health, Knowledge Services, and Verification Services – to meet the expanding needs of our customers and to deliver on our public safety mission. For more information on UL's family of companies and network of 95 laboratory, testing, and certification facilities, go to UL.com.*

*NewKnowledge is a non-profit research institute founded to pursue a deep understanding of how people engage with society's grand challenges. The organization works to expand understanding of how knowledge is acquired and acted upon in order to promote a strong democracy that enables all people to live to their greatest potential in harmony with the biosphere.*

## Executive Summary

In 2013, the North American Association for Environmental Education (NAAEE) was awarded a research grant by Underwriters Laboratories (UL) to explore integrating environmental education into STEM (Science, Technology, Engineering, and Math) learning for young people. In conjunction with UL, the California Water Service Company also supported this initiative. As a result of this grant, NAAEE partnered with New Knowledge Organization Ltd. (NewKnowledge), the research partner.

The goals of the research endeavor were to:

1. Identify and assess the most innovative and brightest ideas in E→STEM; and
2. Investigate a suite of activities that inspire young people to learn, experience, explore, and help solve local community challenges.

To accomplish these objectives, NewKnowledge led a multi-faceted suite of qualitative and quantitative research efforts, including a literature review, crowd sourcing, surveys, a workshop, concept mapping activities, and interviews. Hundreds of educators, professionals, and advocates from across the US—joined by a handful of international participants—took part in this major effort.

## Next Generation of E→STEM

As a result of this work, NewKnowledge found that the next generation of E→STEM learning will prioritize four indicators:

*Professional Development*

Professional Development (PD) was the highest priority of E→STEM educators and experts. PD will take the form of strong peer networks of educators from all grade levels, as well as both formal and non-formal backgrounds. Activities will be self-directed and with support from peer mentors across disciplines. And programs will offer long-term, sustained opportunities for collaboration with practicing professionals. Successful PD will incorporate strong communication between educators and administrators wherever possible, as administrative support is critical for K-12 programs to thrive.

*Real Connections*

Programs that make connections to the real environment are still extremely important, no matter how far technology progresses. Spending time outdoors doing hands-on activities is considered a "tried and true" method, with proven results that are widely respected. Outdoor activities remain affordable and offer easy access for most people as well.

*Creativity in Critical Thinking*

Creativity in critical is highly important and innovative in E→STEM programs. A focus on the learning process—whether through student collaborative research, experimental designs, or combining the visual arts with science lessons—show that there is a need for a variety of approaches to E→STEM learning. Diverse learning approaches are naturally appropriate in E→STEM, making it accessible to broader audiences.

*Practical Synthesis*

E→STEM learning will focus on the integration of cross-curricular STEM education, where educators and experts from different disciplines will collaborate in long-term projects. Notable ways to achieve this synthesis are through varied teaching teams, topics such as economics of the environment, and abandoning standardized testing for promoting life-long learning. Cross-curricular collaboration is also a powerful strategy for PD.

The research revealed a set of five supporting attributes for success in E→STEM as well. These were:

- **Technology & Real Problems** – Using of technology to solve real-world issues in the natural environment
- **Media & Community** – Working on real problems with free, technically advanced monitoring systems to support community learning. There is a special emphasis on sharing knowledge with social networks, including those in web-based communities.
- **Community & Cross-Generational Learning** – Educators called for a renewed effort in programs that promote activities for learners of different ages. This is especially promising for building connections within communities.
- **Empowerment** – Urban movements are increasingly utilizing an empowerment, health, and social justice approach to engage youth in E→STEM. This could be an effective strategy for many projects.
- **Digital Tools & Modeling** – using digital tools and mobile technologies to interpret natural environments—with an emphasis on engaging with local settings—which can be paired with outdoor activities.

## Table of Contents

## Project Overview

In 2013, the North American Association for Environmental Education (NAAEE) was awarded a research grant by Underwriters Laboratories (UL) to explore integrating environmental education into STEM (Science, Technology, Engineering, and Math) learning for young people. In conjunction with UL, the California Water Service Company in California also supported this initiative. As a result of this planning grant, NAAEE partnered with New Knowledge Organization Ltd. (NewKnowledge) to research and assess the most innovating and brightest ideas in E→STEM, to investigate a suite of activities that inspire young people to learn, experience, explore, and help solve local community challenges through a combination of environmental education, citizen science activities, and project-based learning.

E→STEM, as defined for this project, refers to learning about the Environment as a pathway to STEM learning. The arrow between E and STEM specifically highlights programs and learning initiatives that engage individuals in the environment as a means to explore concepts in traditional STEM disciplines.

E→STEM aligns with 4 key educational best practices that deeply engage students:

1. **Hands-on**: Project-based environmental learning is hands-on.
2. **Tangible Themes**: The environment is a tangible theme (and "passion area") that incorporates broader learning topics in science, technology, engineering, and mathematics.
3. **Aligns with Interests**: The environment is consistently rated one of children's top interest areas.
4. **Fosters Achievement & Empowerment**: Projects result in a visible impact made by students, which fuels inspiration and a sense of achievement.

### *Long-Term Goals*

The project sought to increase the quantity and quality of tomorrow's STEM workers. This partnership aimed to foster a passion for STEM topics in today's youth, enrich their interest in STEM educational topics, and nurture a passion for STEM-related career opportunities. Through quantitative and qualitative research, NewKnowledge explored how environmental education is an ideal entry point for STEM learning. This report describes the research process and outcomes.

## THE CRITICAL NEED FOR STEM EDUCATION

At the outset of the project, the team recognized that the planet is facing unprecedented environmental, social, and economic issues. This situation is exacerbated by a set of challenges facing the next generation of adults entering the workforce:

- In 2010, the World Economic Forum **ranked the US 48$^{th}$** in the quality of math and science instruction.
- Large companies, like Microsoft, share concern over the **growing deficit** of qualified workers to fill vacant STEM positions nationwide (numbering in the millions).
- Current **barriers to STEM** education include: budget cuts, uninspiring coursework, and difficulty with foundational concepts.

Through an initial background study followed by a sequential set of surveys and interviews (1) identified Bright Spots of Creativity and Programming Gaps in current E→STEM programs in middle and high schools and communities across the US; (2) overlaid Cultural Context to these insights through feedback from educators; and (3) identified potential Partnership & Collaboration Opportunities for UL to develop a high-impact E→STEM program.

To pursue this project, NAAEE sought out the counsel of a small advisory board throughout the research phase including:

- Academic experts in innovation related to education theory and environmental learning from Stanford University, Ohio State University, and the University of Connecticut
- Experts from government and NGO organizations including the Council of Chief State School Officers, WestEd K-12 Alliance, and National Environmental Education Advisory Council – US EPA
- Leaders from the corporate world, including Disney and Microsoft

In addition to the strategic advice on the research process, the project also supported through broadcast of surveys and commentary on the project at various research efforts, including:
Aerospace Industry Assoc., American Society for Engineering Education, Association for Zoos & Aquariums, Edutopia, National Academy of Sciences, National Environmental Education Foundation, National Park Foundation, National Science Teachers Association, US Department of Education, Women in STEM, Washington D.C. Leadership Network, Teachers Recess, National

Math and Science Initiative, National Geographic Society, United Nations, Environmental Funders Network, NASA, National Oceanic & Atmospheric Administration, and California Water Service.

## 2. Background Study

*Where are the bright spots of creativity?*

*What are the most effective programs?*

Overview

To assess the current status of E→STEM, we conducted an internet search of current and innovative programs matching our definition of E→STEM. Search words and phrases employed for the background research included:

- Innovative
- Environmental STEM
- E-STEM
- STEM And Nature
- Environment Science Technology Engineering Mathematics
- Similar variations of the above

Further searches explored current STEM programs, determining which programs used environment or had aspects of their programs that focused on the use of the natural environment.

To expand our understanding of innovative programs, NewKnowledge researchers also compiled a list of new and innovative STEM programs. Although these programs did not directly engage with the environment, they offered insight into innovative methods being used in STEM learning scenarios.

Altogether, a total of 91 E→STEM and "traditional" STEM programs (i.e. those programs that focused on traditional STEM disciplines, without an emphasis on the environment) were found. The majority of were located in a report by the Bayer Corporation that outlined a compendium of best practices for K-12 STEM programs (2010).

Some of the programs found during this background research phase were:

- National Commission on Teaching and America's Future (NCTAF) Learning Studios
- Project Lead the Way (PLTW)
- DREAMS of Wilmington and Fort Fischer Aquarium
- Education through Exploration by the JASON Project
- Model My Watershed by Stroud Center for Water Research

A complete list of nominated programs can be found in Appendix A.

**Methodology**

Using language from each program's website, we compiled a database of program descriptions. Using a qualitative analytical tool called Leximancer, we analyzed word and/or phrase frequency and connections between constructs to locate emergent concepts and general themes from the data corpus.

Leximancer extracts thesaurus-based concepts and creates a concept map in order to analyze the relational aspects of different concepts found in a body of text (for a review of Leximancer see Smith & Humphreys 2006). The program provides a visual tool as seen in Figure 1.1. Here, the tool shows how different concepts—or recurring and similar words (represented by gray dots)—form larger themes (represented by colored circles) and the ways in which they were connected to one another (represented by proximity and overlap). Colors of the themes signify importance and relevance, where red, orange, and yellow are "hot" topics and green, blue, and purple are themes of less importance.

Leximancer can also adjust the visualization of these themes according to a set percent of visibility, with 0% grouping all concepts into one theme and 100% revealing all possible concepts into separate themes. Leximancer uses a default percent visibility of 33%, however this percent can be adjusted depending on individual analysis. The research team used 40% visibility level so as to group the concepts into a meaningful number of themes.

According to Smith and Humphreys (2006), Leximancer offered the flexibility to tailor analysis depending upon the specific research questions, as long as they were part of the analysis strategy. For example, the total number of automatically selected concepts was increased to extract more specific concepts from the low ranked words. Words that occurred frequently and co-occurred with others without contributing to semantic value were removed from analysis. Concepts could also be defined manually based on criteria theoretically relevant to the research question. This strategy enabled an evaluation of the validity of our strategy and ensured it was grounded in evidence gathered through an accepted methodological framework rather than anecdotal reporting that may introduce researcher bias.

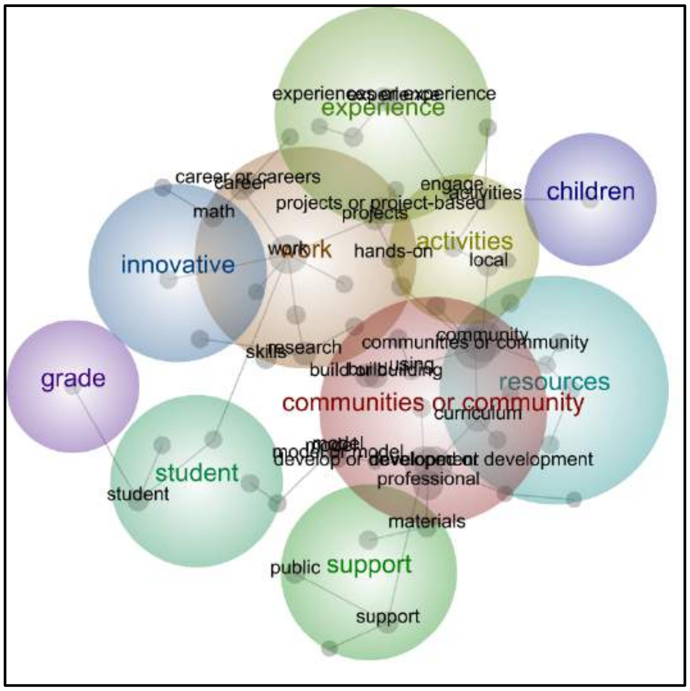


Figure 1.1 Output of themes and concepts from Leximancer

This process resulted in a list of key themes that was emerging in the current field of E→STEM and STEM programs. Specifically, with a 40% concept visibility, 10 themes are depicted in Figure 1.1. These themes contributed in the development of subsequent research efforts. Listed in order of the number of connections to other themes, these themes are:

- communities/community
- work
- activities
- experience
- support
- student
- resources
- innovative
- children
- grade

Thematic analysis of the Background Study was conducted at the same time as the Crowd Sourcing Survey in order to compare descriptions of innovation in E→STEM. Detailed description of these analyses are described in the following section on the Crowd Sourcing effort.

# 3. Crowd Sourcing Survey

*Where are the bright spots of creativity?*

*What are the most effective programs?*

### Overview

The Crowd Sourcing effort was developed as an online survey to crowd source data from members of NAAEE, American Evaluation Association, and National Science Teachers Association, among others. The survey consisted of a nomination process whereby participants were asked describe attributes of the programs that they believed were the most creative, and effective programs in E→STEM.

Over 200 participants completed the survey / nomination process. The results included 179 programs or projects from throughout the world. The majority were based in the US.

Although E→STEM programs necessarily entailed some degree of engagement with the environment, the nominated programs ranged widely in their emphasis on the environment. The results included programs that focused on minority populations to the use of digital media to placing an emphasis on community and civic engagement. Some programs appeared to center around environmental learning, while others used the environment as one of several program components.

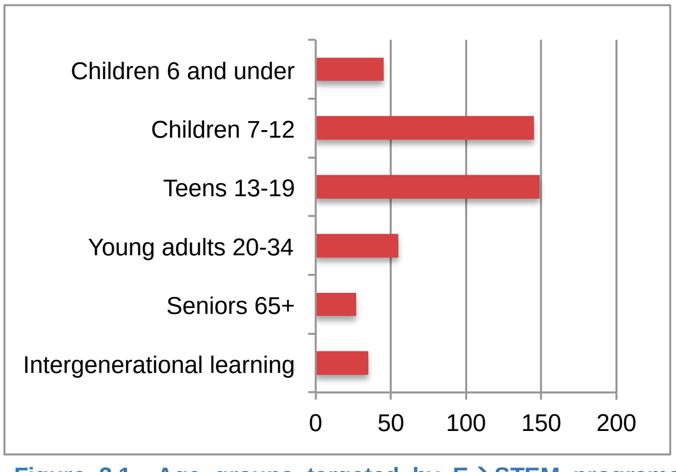


**Figure 3.1 Age groups targeted by E→STEM programs throughout the US and the world. Values represent the number of distinct programs.**

### Nominated Projects

The vast majority of projects nominated were from the United States (96%). The average program catered to between 500-999 participants. Almost all the nominated programs (95%) were described as promoting "science literacy" and incorporating "hands-on learning". Almost as many projects incorporate "experiential learning" (91%) and many claim to "support educators" (85%). Many programs targeted more than one age group. The dominant audience for these projects were youth between 7 to 12 year-olds (*n*= 145, 73%) and 13 and 19 (*n*= 149, 75%).

### International Programs Nominated

Project partners at UL worked to promote participation by an international cohort of educators, rebroadcasting the survey to recruit participants at the request of their German partners. Despite expressed interest from these European partners, only eight projects from outside the United States were received: Australia (*n*=1), Canada (*n*= 3), Guatemala (*n*=1), Kenya (*n*=1), the Philippines (*n*=1), and Venezuela (*n*=1).

These eight programs tended to focus on "experiential" and "hands-on learning" with strong ties to local communities. This small sample of international programs also tended to involve all age groups, but three of the eight programs served adults only.

## E→STEM ANALYSIS: INNOVATION

The information gathered from the Background Study (see previous section) and the responses form the Crowd Sourcing survey were used to describe current innovation in E→STEM. Both sets of data were analyzed as narrative descriptions of innovation in E→STEM. NewKnowledge researchers used Leximancer to conduct a thematic analysis and create a visualization of: 1) an overview of global E→STEM programs, using both automated and user-defined settings (i.e. the Background Study) and 2) the responses to the call for nominations for innovative programs in E→STEM (i.e. the Crowd Sourcing Survey). See the first section, Background Study, for more details about Leximancer.

For this study, the concepts were generated automatically by Leximancer without explicitly including the those that had low initial ranks. Concepts identified by the automatic process were utilized for final analysis and interpretation of the combined datasets. An open-coding process was considered most appropriate for this phase, acknowledging the focus on describing the broadest range of attributes for innovation to be presented for community concept mapping, rather than condensed by the researchers. Since the research questions for this portion of the study had received limited previous attention, the research team chose to allow the software to surface the themes depicted in the data and use these categories for open organization to compress the concepts into discrete semantic coded sets.

Multiple iterations of the data analysis were conducted to understand the themes that described innovative programs in E→STEM. To start this process, all the responses were reviewed by NewKnowledge researchers and then by the Leximancer program. This was followed by using the automated settings to uncover concepts that were deemed relevant by the software. Following this, the researchers adapted the setting to conceal specific references to environment (E), STEM and science, technology, engineering and math but using them as semantic evidence to organize the remaining natural language data.

### Emergent Themes from the Background Study and Crowd Sourcing Survey

Two separate analyses of the emergent themes and concepts extracted from the Leximancer software were compared and proved to have similar results. These “concepts” were rewritten to represent dominant or distinct attributes representing both the Background Study and the Crowd Sourcing Survey. This process produced a total of 97 statements, from which 10 thematic categories were utlimately developed.

## THEMES FROM THE BACKGROUND STUDY

First, NewKnowledge researchers analyzed the results of the Background Study. To create statements that typfiy each theme that emerged in the data, the research team used exemplar statements of themes, extracted from the text by Leximancer, which identified these themes based on the most commonly occurring concept within that theme. Examples of these statements were:

- Working with community partners
- Design and physically build experiments
- Demonstrate how ecological systems work
- Develop digital media lessons
- Use inquiry-based methods to solve real world STEM-related problems

These statements were then compiled and grouped together into similar categories to account for redundancies.

### Themes from the Crowd Sourcing Survey

The researchers then used the data from the Crowd Sourcing Survey to produce theme statements and imagery, again with Leximancer. The theme statements were perhaps the clearest and most useful output for the research team. Here are several examples:

> *Through five face-to-face and two online courses, teachers are acquiring the experiences and / resources necessary to integrate energy concepts into their STEM curriculums.*

> *Local environmental issues [motivate] students to understand STEM topics while solving real problems*

> *This program takes project based learning to the next level and inspires students to create connections to their education, their environment and what experts in the field are doing about the same issues and challenges they are faced with.*

In comparison, Figure 3.2 (left) shows the Leximancer output with the concepts highlighted and is less legible than the statements above.

Lastly, the Leximancer output in Figure 3.3 offers more clarity but less detail.

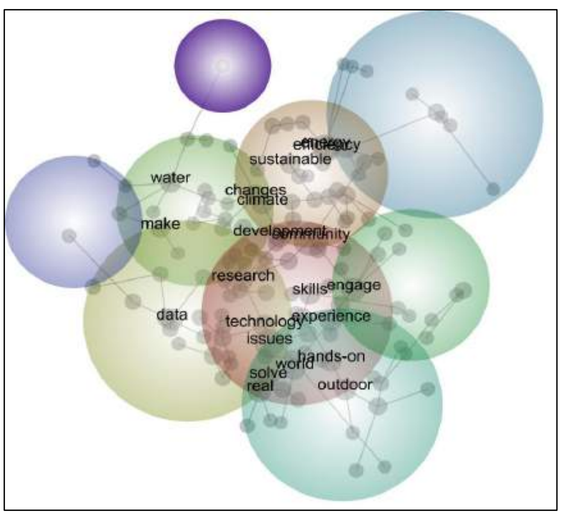


**Figure 3.2 Leximancer output with concepts visible**

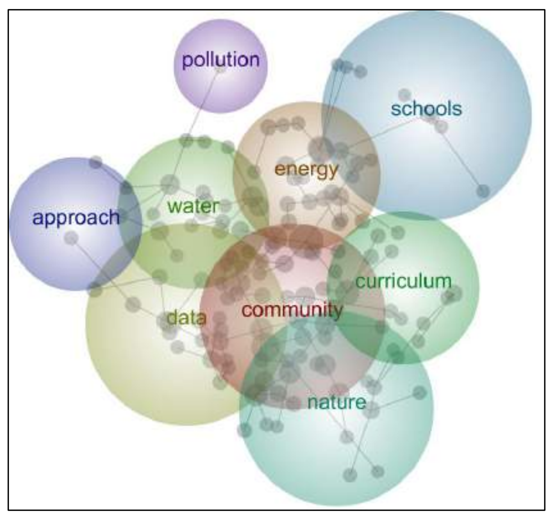


**Figure 3.3 Leximancer outputs with themes visible.**

**Synthesizing Themes**

From the 97 statements produced as a result of the Background Study and the Crowd Sourcing Survey, 10 thematic categories were compiled. Ranked in descending order of the most commonly occuring in the programs that the research team studied, the themes were:

1. Community focus
2. Environmental issues and problems
3. Web-based and digital technologies
4. Hands-on, outdoor programming
5. Youth in at-risk communities
6. Special needs populations
7. Youth development (leadership skills, debating, collaboration)
8. Partnerships between professional practitioners and teachers
9. Partnerships between professional practitioners and students
10. Self-directed learning

This process of compiling 10 overarching themes provided a reliability test to ensure that data from both research efforts were in alignment. These themes were also measured against results of subsequent research efforts, such as the Blue Ribbon Panel (see Section 5).

### E→STEM PROGRAMS: GAPS & CHALLENGES

While the above attributes explain the emergent themes from the data corpus, there were notable components that were not mentioned, or not mentioned nearly enough for Leximancer to identify them as significant. Researchers closely reviewed the data and determined themes that were potential gaps and challenges for E→STEM. Such breaches in innovative and important E→STEM programming included involving family in education and multi-generational learning.

### ESTABLISHING PRIORITIES: THE BLUE RIBBON PANEL

A total of 64 statements representing the 10 key attributes (listed above) and a set of gaps in innovation in E→STEM were developed to have the most innovative attributes of E→STEM for the subsequent panel of experts in the field, the Blue Ribbon Panel. Redundant statements were consolidated into new single statements and other statements were adapted by NewKnowledge researchers to best fit the descriptions of the ten categories mentioned above. Additional statements based on gaps that NewKnowledge investigators saw were developed to follow similar construction as the adapted statements (see Appendix B). The fabricated statements were primarily in regard to different target populations (Appendix B, asterisked items). These were added to test if these missing components may be innovative and worthwhile in expanding E→STEM programming. For a full description of the Blue Ribbon Panel effort, see Section 5.

## 4. National Science Teachers Association Workshop

*What are the best opportunities for professional development, given the need to enhance educators' skills regarding E-STEM, environmental education, and project-based learning?*

*What incentives are needed to engage administrators and educators to improve practice?*

*What support is needed for an E-STEM program to be successful?*

*How would we measure impact?*

*What are the programming gaps that exist in E-STEM? Is there a unique niche that UL can fill?*

*Who are potential partners that UL and NAAEE might work with in the future to enhance E-STEM? – List to be determined in paratnership with UL.*

### Overview

NewKnowledge, UL and NAAEE conducted a workshop at the National Science Teachers Association (NSTA) annual conference in San Antonio, Texas on April 13, 2013. The workshop was a carefully planned event, with the goal of engaging science educators from across North America in discussions about their experience with and hopes for working with E→STEM programs.

### Methodology

The research team recruited 37 educators attending the NSTA conference to participate in the half-day E→STEM workshop. To kick off the session, Christiane Maertens (NAAEE) welcomed the teachers and Ginger Sommer (UL) offered remarks about UL's history and interest in E→STEM. John Fraser (NewKnowledge) then introduced the concept of E→STEM that was used throughout the project and started the first discussion.

In three separate rotations, teachers were organized into discussion groups to focus on one of six sets of questions. To encourage dynamic conversations, participants formed groups with different sets of people each time they rotated. If another group had already worked on a question, the new group was responsible for assessing the previous response(s) and adapting its own response as a new statement. Groups worked out their ideas, thought processes, and conclusions on large presentation-style poster paper. At the end of the workshop, teachers completed individual booklets that allowed them to independently reflect on the workshop's discussions and how they resonated with their own experiences.

NewKnowledge gathered the poster paper and the individual booklets for qualitative analysis. Recordings were not made, due to the multiple conversations taking place at the same time.

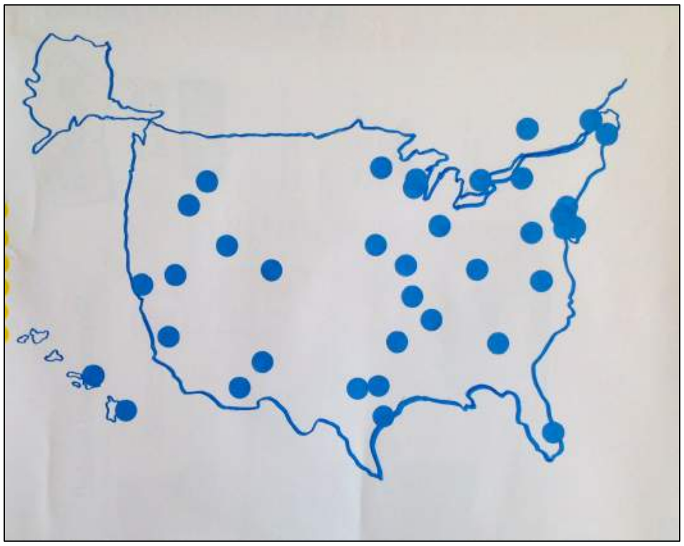

**Figure 4.1 Stickers placed on a hand-drawn map to identify participants hometowns. Attendees represented all regions of the US, and one participant came from Canada.**

### Participants

The majority of participants were K-12 teachers and one principal attended the session as well. Most participants identified as general science teachers, though about 15 said they were cross-disciplinary or had a narrower subject focus, such as environmental education, technology, or engineering. In general, the group evenly represented rural, suburban, and urban school settings, from each region of the United States. One participant was from Canada.

## RESULTS & DISCUSSION

Workshop participants responded to the following research questions in groups, as well as independently. In general, the tone of the workshop was highly positive. Participants acknowledged current challenges of the field, but their attitude was focused on problem-solving and solutions.


**Figure 4.2 The workshop was a lively gathering, where participants worked on problems as groups.**

## E→STEM Programs: Gaps & Challenges

Even though workshop participants were enthusiastic about the potential of E→STEM programs, they acknowledged that there remain a number of challenges and "gaps" related to E→STEM programs at the time of the workshop.

***Alignment with Testing Requirements.*** It was difficult for teachers to align E→STEM programs with state-mandated testing requirements. This presented barriers when it came time to obtain approval from district administrators.

***Time Constraints.*** When E→STEM programs were perceived as outside of curriculum requirements, teachers had trouble arranging for enough time to prepare for and incorporate E→STEM programs into lesson plans.

***Isolated Disciplines.*** Teachers perceived that educators in STEM disciplines (Science, Technology, Engineering, and Math) were separate and did not collaborate with each other in E→STEM programs. They felt that the Next Generation Science Standards released coincident with the meeting contained a number of structures that would enhance student experience with collaboration, something they prioritized as a criterion for success in E→STEM programming.

***Lack of Confidence with Some Subjects.*** Teachers did not feel adequately trained in all STEM subject areas, particularly when it came to engineering.

***Clear Connections to the Environment.*** Opportunities to link the environment to traditional STEM topics were not always clear to teachers. This was most evident for more abstract subjects (such as physics) and "applied" sciences (such as engineering).

### Administrative Support for E→STEM Programs

Educators believed that close communication with school administrators was essential to E→STEM programs' success in the K-12 school system. However, they acknowledged that support for new E→STEM programs was a challenge in many cases. Workshop participants identified the following issues and ideas.

***Teacher Enthusiasm.*** Participants believed that administrative support was more likely when more teachers—including those outside of the STEM subjects—are involved in and excited about introducing a new program.

***Administrator Involvement in Process & Training.*** Educators said that administrators should be invited to participate in all stages of the planning process for new E→STEM programs. Equally important, administrators should join teacher training sessions to increase their knowledge of the program, as well as challenges for teachers.

***Aligning with Testing Requirements.*** Educators acknowledged that administrators were particularly unlikely to support a program if it did not align with mandated testing requirements. Participants suggested programs with proven outcomes would be easier to gain support for, but would still be a challenge in a testing-focused culture.

### Linking the Formal & Non-Formal

Participants believed that programs involving formal and non-formal organizations would be very successful learning opportunities for young people and would also benefit the community. In this case, formal was viewed as K-12 or university settings, whereas non-formal represented broader settings where learning may occur, such as museums, nature centers, or theme parks. Workshop attendees discussed a number of considerations and solutions to the challenges involved in programs that join formal and non-formal partners.

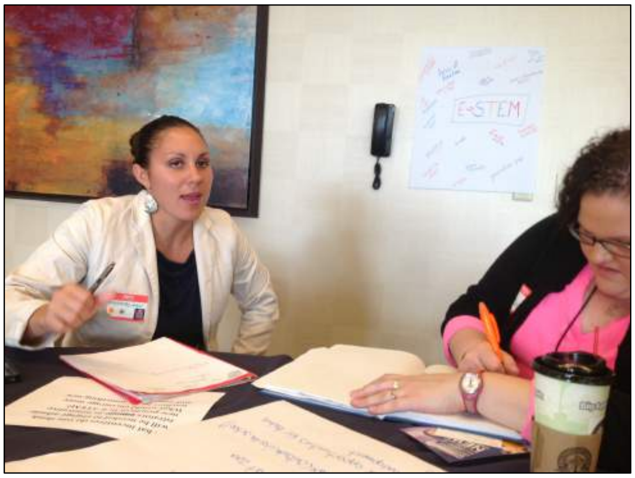


**Figure 4.3 Workshop participants in a group discussion.**

***Good Communicators.*** Participants described a need for personnel with excellent communication skills to serve as liaisons between formal and non-formal partners, particularly to define terms and clarify vocabulary associated with each partner. This alluded to a need for understanding between two settings that may operate with different structures and objectives.

***Local Issues Are Opportunities.*** Local or regional E→STEM issues were said to be ideal for collaboration among formal and non-formal partners. The educators believed that people working in non-formal settings had special knowledge of, contact with, and expertise related to topics that were relevant to communities and therefore of interest to young people.

***Educator Exchange Sessions.*** Participants were interested in training sessions that would allow educators to train with experts in non-formal entities during time away from school.

***Capacity-Building for Youth & Educators.*** Collaboration between formal schools and non-formal partners was described as an opportunity to build young people's interest in and awareness of real and accessible careers. Participants also thought that this type of collaboration had the ability to increase confidence for educators and experts with both formal and non-formal backgrounds.

### Assessing Impact

Workshop participants said it was essential to measure impacts of new E→STEM programs, particularly if they would be introduced into K-12 settings. This alluded to the challenges they saw in obtaining administrative support, in that it was difficult to introduce new E→STEM programs in schools unless they had proven outcomes and alignment with curriculum standards.

Attendees also advocated for evaluation strategies that align with how children learn. Social platforms, interactive notebooking, and concept mapping were noted as tools that may resonate with how youth learn in formal settings.

### Indicators of Success for E→STEM

Participants believed that E→STEM offered diverse positive impacts, which were distinct from impacts they associated with conventional approaches to STEM learning. The following were indicators that workshop leaders described.

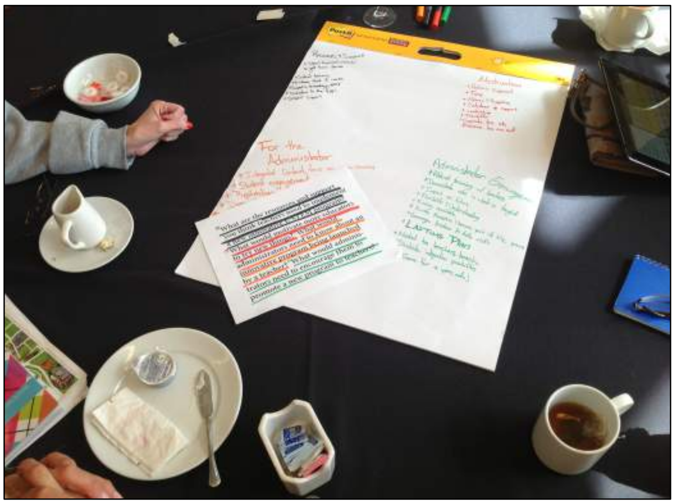

Figure 4.4 Groups created posters to describe their solutions for the research questions.

***Deeper Interest in Many Subjects.*** The "E" in E→STEM was seen as the connector between STEM and other areas of learning, such as geography, the visual and performing arts, politics, and economics. In this way, educators could use E→STEM as a pathway to deeper engagement and exposure to a broad range of subjects.

***Integrated Disciplines.*** Participants said that successful E→STEM programs would integrate and harmonize the traditional STEM disciplines. Elsewhere, they noted that STEM educators were often isolated and in need of better collaboration.

***Youth Advocacy & Citizenship.*** E→STEM programs were described as tools to increase young people's concern for and interest in their surroundings, through a sense of empowerment and ability to effect positive change in environmental and sustainability issues. Attendees also thought that involvement in E→STEM programs would make young people more active and productive citizens.

***Sustained Collaboration.*** Educators believed that E→STEM success would include long-term collaborative relationships between with community partners, such as non-formal learning organizations and corporate entities.

### Professional Development

Professional development (PD) was a high-priority topic among workshop attendees. They were hopeful that PD opportunities would contribute to the success of E→STEM and its increasing prevalence in both informal and formal education. Generally, participants advocated for stronger peer networks, with an ongoing emphasis on PD within these networks. The following tactics were described during the workshop.

***Involve All Grade Levels & Disciplines.*** Participants believed that PD should include vertical integration—that is, equal representation of teachers from different grade levels in PD activities. Cross-disciplinary PD was also seen as valuable, particularly for high school educators, who tend to work in silos once they become comfortable with a subject. Including non-STEM educators was seen as important to building buy-in and support for new E→STEM programs.

***Peer Mentoring.*** Pairing teachers for coaching and feedback was seen as an effective method of PD. Participants thought that this would be especially effective for new teachers, but all teachers could potentially benefit. Sharing "what works" for each grade level were perceived as valuable. Techniques could include videotaping and observing lessons, in addition to systems for consistent feedback loops.

***Training with Practitioners & Experts.*** Participants wanted more contact with E→STEM professionals working outside of education. This would be particularly useful for the subjects with which teachers have lower confidence.

***Involve Students.*** Students' presence and feedback during PD activities were seen as beneficial. Students could present their understanding of E→STEM in order to identify strengths and challenges in the curriculum or associated with teachers.

***Incorporate Time into Planning.*** When working with a new program, educators needed adequate time to successfully incorporate it into an established curriculum. This time would enable educators to plan, implement, and assess the program, then revise and re-implement the program as needed. Participants believed this ability to "fail" and adapt are essential components to building new, innovative, and effective programs.

***Trust.*** The issue of trust emerged in many discussions during the workshop. Attendees repeatedly advocated for increased trust from administrators, parents, and members of the community. This was associated with the theme of respect for educators—for the learning professionals that they are—which would further empower them to pursue PD opportunities.

Opportunities in E→STEM for UL

Participants also had the opportunity to share their ideas about what UL can contribute to E→STEM. The majority said that UL has the potential benefit the field in large-scale ways. UL could:

- Broaden definition of environmental science, particularly in drawing connections between safety and the stewardship of environmentalism;
- Lend E→STEM projects the legitimacy and professionalism that school administrators need to fully commit their time and funding; and
- Provide the topic expertise and knowledge of specific tools to promote a healthier environment.

Participants also said that UL would positively impact E→STEM on smaller scales. UL could:

- Provide monetary incentives for both educators and young people; and
- Partner with school districts and informal learning organizations.

## 5. Blue Ribbon Panel

*What are the most important, innovative and proven strategies for developing E→STEM?*

### Overview

An expert panel of 100 leaders from across the STEM learning field was invited to sort and rank attributes of innovation in E→STEM programs as identified from the Background Study and the Crowd Sourcing Survey. The Blue Ribbon Panelists sorted and rated 64 statements which provided a more detailed picture that helped the research team build upon the findings from previous efforts.

### Instrument Development

The research team developed 64 statements to represent 10 recurring themes that were distilled from the analyses of the Background Study and Crowd Sourcing Survey. (For the list of 10 themes, see Section 3).

In order to create a selection of 64 statements for the Blue Ribbon Panel to judge its innovation and importance in relation to E→STEM, NewKnowledge researchers used statements compiled from the Background Study and Crowd Sourcing Survey that reflected aspects of the themes and modified them to make new statement descriptions of attributes to represent the range within that category that might be considered new and innovative in E→STEM.

As described above, additional statements based on gaps in E→STEM program descriptions were developed by NewKnowledge staff to test if these missing components may be innovative and worthwhile in expanding E→STEM programming. For a full list of these additional statements, see Appendix B.

After identifying important attributes of innovative E→STEM programs from the Background Study and the Crowd Sourcing survey, 64 statements were incorporated into Concept Systems©. Concept Systems Global MAX© is an online survey tool that enables participants to sort statements into categories and then rate them according to a researcher's protocol.

### Participants

A letter was sent to leaders of the partner organizations, who then sent invitations to knowledgeable members within their organizations. Of the 100 invited Blue Ribbon Panelists, 66 began the Concepts Systems survey, but 10 people did not finish. Of the 56 completed surveys, two of them were not counted because the sorting was improperly completed and the results could not be analyzed with the rest of the data. Therefore, 54 responses were used in the analysis.

### Process

Blue Ribbon Panel participants were directed to the Concept Systems® website to complete the sorting and rating exercises. They encountered a disclaimer page, a preamble page, and then a page with questions concerning the organization(s) they represent. Following these pages there were a series of pop-up windows that explained in detail how to sort the given statements into categories.

Participants sorted the 64 statements into 3 to 22 unranked, thematic categories. After participants sorted the statements into these groups, they were asked to look at each statement individually and rate them on a Likert scale from 1 to 7, based on the following three directives:

- *Looking at the following statements please rate them from least innovative, 1 to most innovative, 7.*
- *Now we would like you to rate these statements again, this time focusing on their degree of IMPORTANCE for the next steps in E--> STEM innovation with least important, rated as 1, to most important, rated as 7.*
- *Finally we would like you to rate the same statements one more time, this time focusing on NOVELTY statements, please rate them from tried and true, 7, to experimental, 1.*

## RESULTS

The average participant sorted the 64 statements into 8.11 categories (*SD*= 3.92). NewKnowledge researchers reviewed seven different ways to group the categories in order to test cohesion of disctinct categories. A nine-cluster sort was the most meaningful and therefore the final tool that NewKnowledge used to understand the ratings of the different attributes of E→STEM. The nine categories of statements that were extracted from the data from Concept Systems© were then given description names by NewKnowledge researchers based on the statements grouped in those categories (Appendix B). They are listed here:

- Professional development and collaboration
- Socio-cultural economic perspectives on STEM
- Scientific methods and process to foster critical thinking
- Use of technology to solve real problems
- Connections with the real environment
- Use of media to engage a community of learners
- Community and cross-generational involvement
- Empowerment and social justice
- Digital tools and modeling

The rankings of all statements within each category were then averaged to create a mean ranking for category in Innovation, Importance and Proven Stategies.

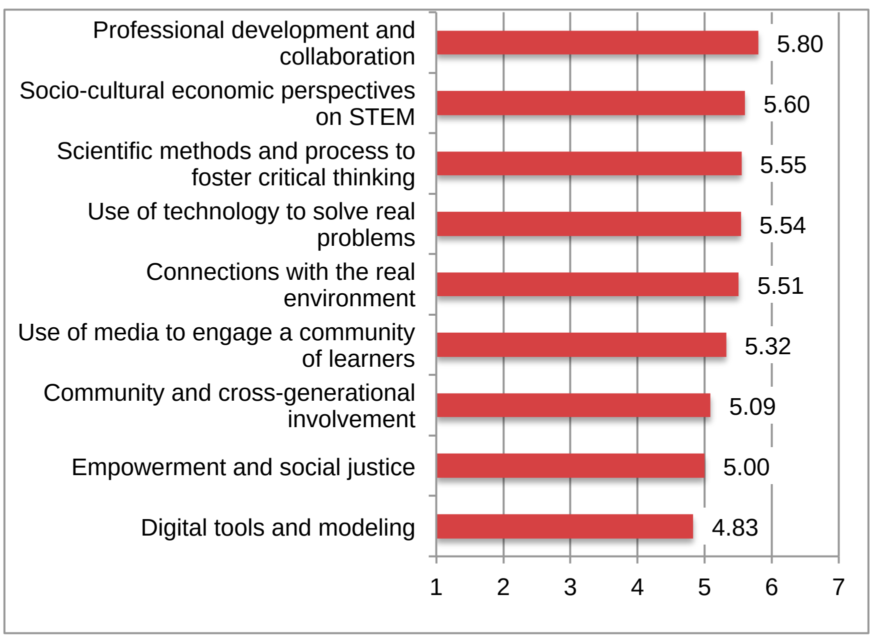


**Figure 5.1 Innovation rankings of categories based on a 7-point Likert scale, with 1 being least innovative and 7 being most innovative.**

### Innovation

Statements grouped in *Professional development and collaboration* (*M*= 5.80) as well as *Socio-cultural economic perspectives* on E→STEM (*M*= 5.60) ranked highest on a scale from one to seven where one was least innovative and seven was most innovative.  Overall, all nine categories were above the rating mean of four.

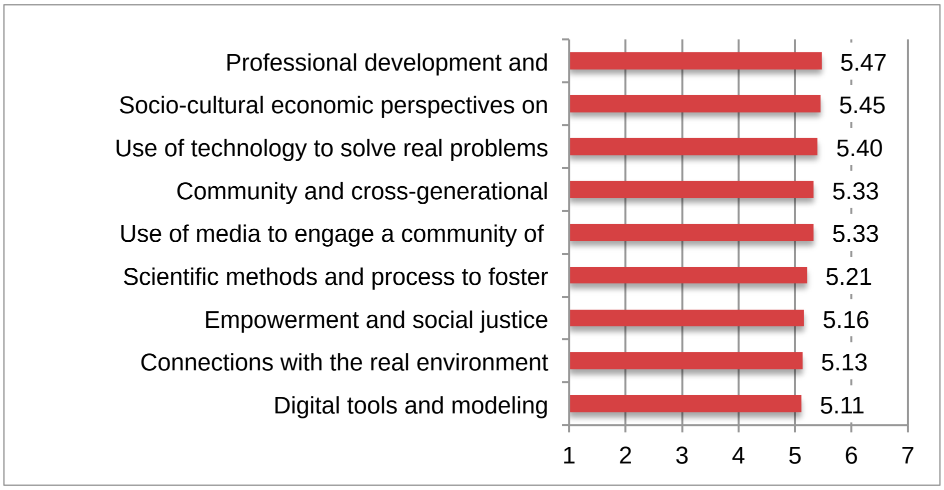


**Figure 5.2 Importance rankings of categories based on a 7-point Likert scale, with 1 being least important and 7 being most important.**

**Importance**

Overall, the Blue Ribbon Panelists rated statements as highly important with the minimum average category ranking at 5.11. The difference between the lowest ranking and highest ranking categories was a difference of 0.36, where *professional development and collaboration* had a mean rating of 5.47 on a scale form one to seven, where one was least important and seven was most important.

**Proven Strategies**

There was a disparity in ratings for *statements* representing experimental and tried and true (proven) strategies in E→STEM education. These items were on average marked in the middle of a scale rated from experimental (1) and tried and true (7), indicating a lack of clarity and understanding by the Blue Ribbon Panel about what really works in E→STEM and what has rarely been tried. This also suggests that the themes identified by other components of this research were less

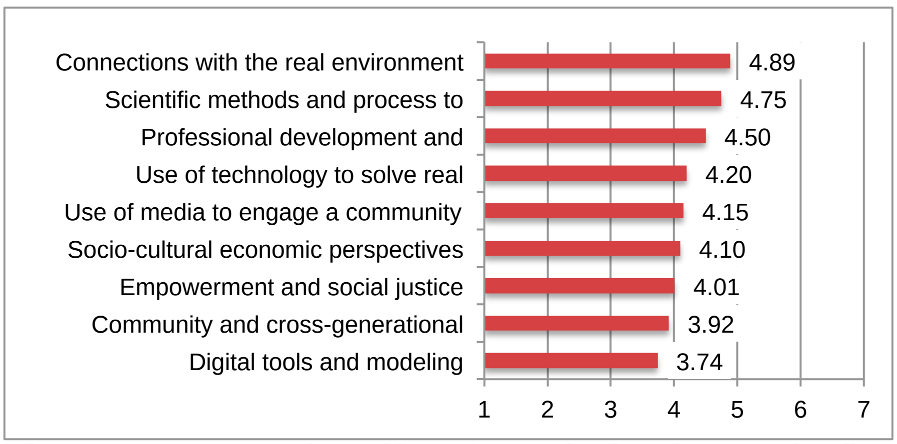


**Figure 5.3 Proven Strategies rankings of categories, based on a 7-point Likert scale, with 1 being experimental and 7 being tried and true.**

applicable in defining what was experimental and was a proven strategy.

**DISCUSSION**

Although the Blue Ribbon Panel results show that *Professional development and collaboration* is highly innovative and very important, it is unclear how novel *professional development and collaboration* is, as there was a range of ratings for components of this category on the experimental/tried and true scale. Specifically *optimizing deep, engaged formal/informal educators* rated as a more proven strategy (*M*= 5.24), while in contrast *allowing teachers to pursue their own life-long development strategy* was ranked as a more experimental approach to E→STEM learning (*M*= 3.76).

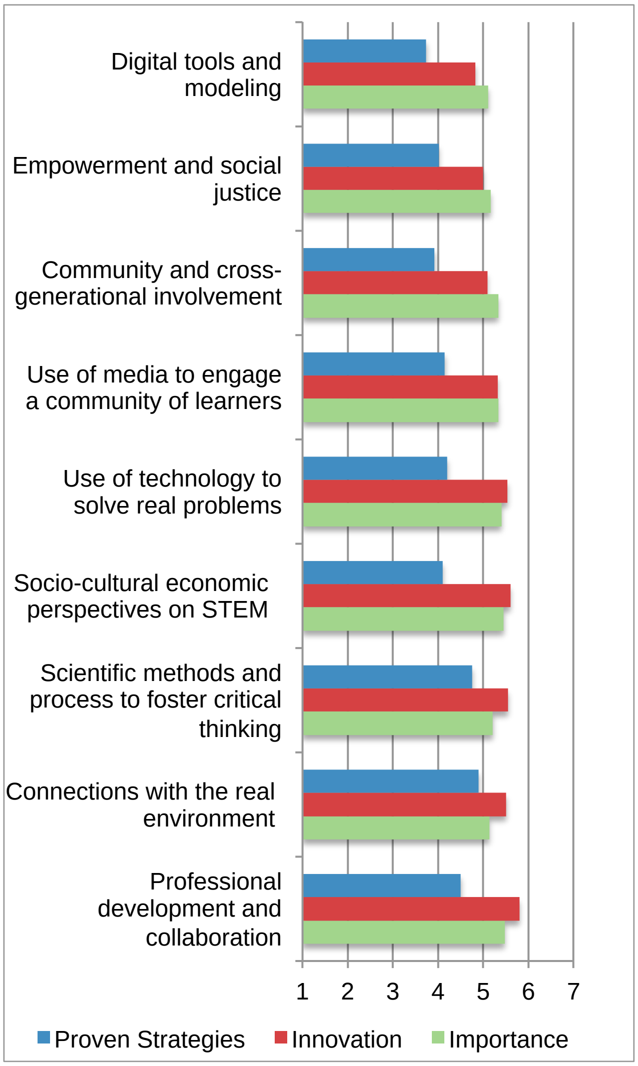


**Figure 5.4 Rankings of categories, based on Innovation, Importance, and Proven Strategies scales. Rankings of all statements on the three scales are given in Appendix XX. For Likert-scale values, see Figures 5.1, 5.2, 5.3.**

The statement ranked as the most experimental method for E→STEM learning was *abandoning standardized testing in favor of life-long learning track for students* (*M*= 2.63), a statement lumped with the *socio-cultural economic perspectives on STEM*. The most proven strategy on the other hand was *hands-on real learning opportunities* (*M*= 5.80). The categories *Connections with the real environment* and *Scientific methods and processes to foster critical thinking skills* were ranked next highest (Figure 5.4).

Examining the interaction of statements among the three different rating scales allowed NewKnowledge researchers to take the study a step further to test validity of the results seen in the Blue Ribbon and create a Blue Print for E→STEM to rate programs with. This additional level of analysis also helped the research team to re-name the categories to represent the statements that most strongly defined the categories (see section X).

## 6. Partner Member Survey

*What are the programming gaps that exist in E→STEM?*

*What are the best opportunities for professional development, given the need to enhance educators' skills regarding E→STEM, environmental education, and project-based learning? What incentives are needed to engage administrators and educators to improve practice?*

*Are there smaller initiatives that could be scaled up? What would that look like? How could a program reach the most students and teachers and achieve the greatest impact, focusing on both quality and quantity?*

### Overview

Like other research efforts, the Partner Member Survey built the previous efforts and asked previously identified questions of educators and administrators. Results of the Blue Ribbon Panel and the NSTA Workshop indicated that programs focusing on professional development, connecting with nature and critical thinking skills are among the most innovative, important, and proven strategies in E→STEM.

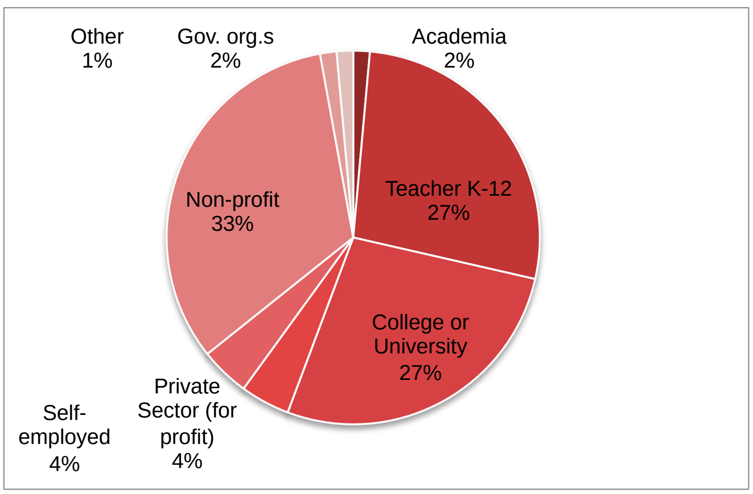


**Figure 6.1 Positions of employment of participants in the Partner Member Suvey.**

This survey effort served as a strategy to evaluate the validity of NewKnowledge methods and ensure they were grounded in evidence gathered through an accepted methodological framework rather than anecdotal reporting that introduced researcher bias.

This survey invited a panel of 80+ individuals from across the STEM learning field to participate. Each person was a member of an organization that partnered with the research team for this project. See Section 1 for a complete list of partner organizations.

### Participants

Participants were recruited via an open invitation broadcast through project partners membership and affinity group newsletters. Respondents came from a range of professional backgrounds and sectors, with a third working in non-profits and almost as many listing academic affiliations in college or k-12 settings (Figure 6.1.). The majority indicated membership in NAAEE (78%). None of the participants indicated membership in Youth Service America, the United Nations, Underwriters Laboratories, Teachers Recess, or the Captain Planet Foundation.

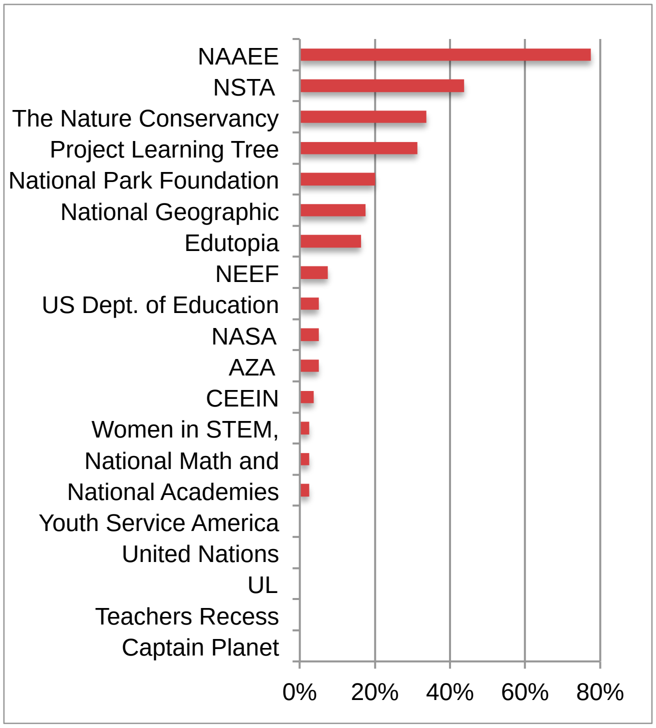


**Figure 6.2 Organizational membership of participants in the Partner Member Survey.**

### Instrument

Members were asked to answer questions about professional development opportunities and educator needs. In addition, participants were prompted to rate different attributes of innovation, importance, and strategies of programs based on their contribution to E→STEM. The 64 statements used in the Blue Ribbon Panel research effort were used to develop this survey. (See Appendix B for the 64 statements).

To assess the needs of E→STEM, this survey explored challenges and gaps of this field and gave participants the option to say that there were no gaps. Additionally a supplementary question with possible areas in which E→STEM experiences and challenges allowed participants to choose elements from a predetermined list as well as list other components that NewKnowledge researchers and NAAEE staff might have overlooked.

Several sets of questions focused on professional development (PD). Logistical questions were also included in this section, particluarly: how much time people *can* spend and how much time people *are willing* to spend, in addition to how far one can travel for professional development opportunities were included.

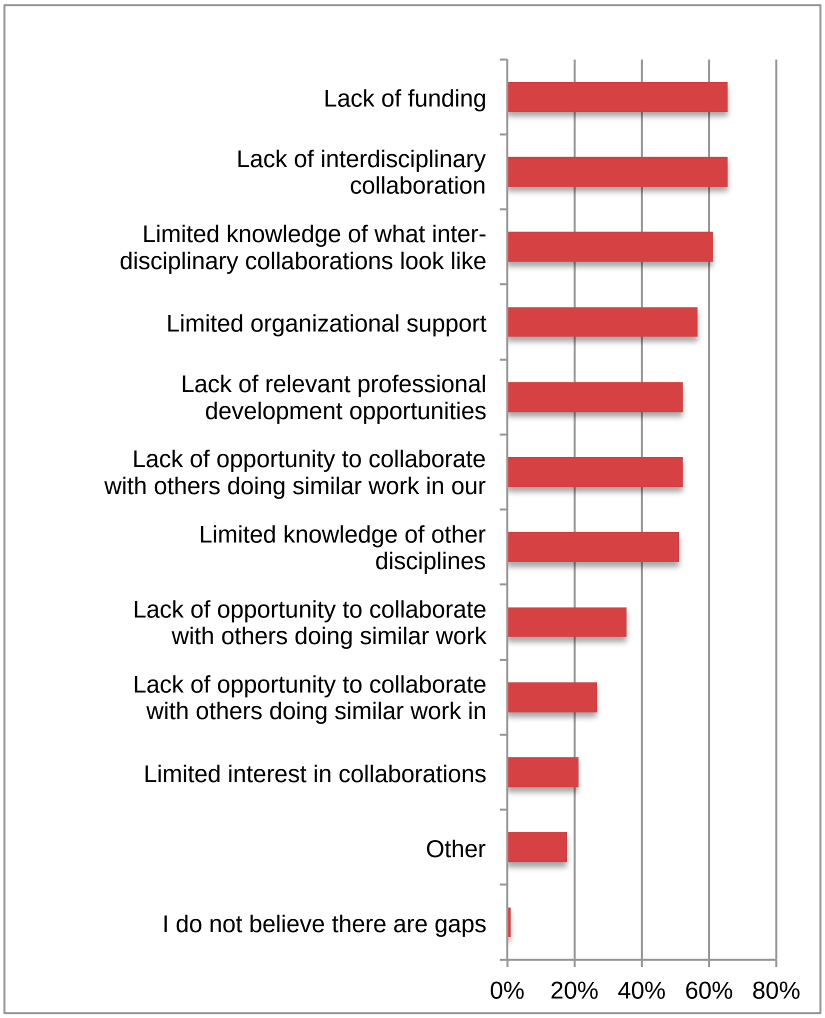


**Figure 6.3 Challenges to the field of E→STEM learning.**

The final sets of questions asked participants to rate the highest ranked elements of innovation, importance and proven strategies from the Blue Ribbon Panel effort to validate the findings from that effort.

## RESULTS

Participants in the Member Survey indicated that there are gaps in the way environment is used as a path for E→STEM (64%). Despite this general agreement, a third of respondents were at first somewhat equivocal about whether there are gaps. The average participant indicated an average of 5.07 items (out of a possible 12) that contribute to the challenges of using the environment as a path to E→STEM (*SD*= 2.70, *N*= 90).

After prompting survey respondents further about the nature of the challenges or gaps in using environment as a path to STEM learning, the majority of respondents indicated that both lack of funding (*n*= 59, 66%) and lack of interdisciplinary collaboration (*n*= 59, 66%) are the greatest challenges with almost all participants indicating that there are indeed some gaps that are worthy of concern (see Figure 6.3).

Following the question about the challenges of E→STEM learning was a question prompting participants to give solutions to those challenges through a topic list for professional development opportunities.

**Table 6.1 Topics in E→STEM Professional Development**

| Topics for PD | *n* |
|---|---|
| Strategies to collaborate with other disciplines | 67 |
| How to employ complementary disciplinary approaches within a single program | 62 |
| Peer networking opportunities to help envision solutions to organizational hurdles | 61 |
| Strategies for pooling funding with other organizations. | 38 |
| Value of interdisciplinary work | 35 |
| Other (please describe) | 16 |

When asked about how far participants could travel for professional development based on funds, the majority responded that they could not afford to go beyond their own region.

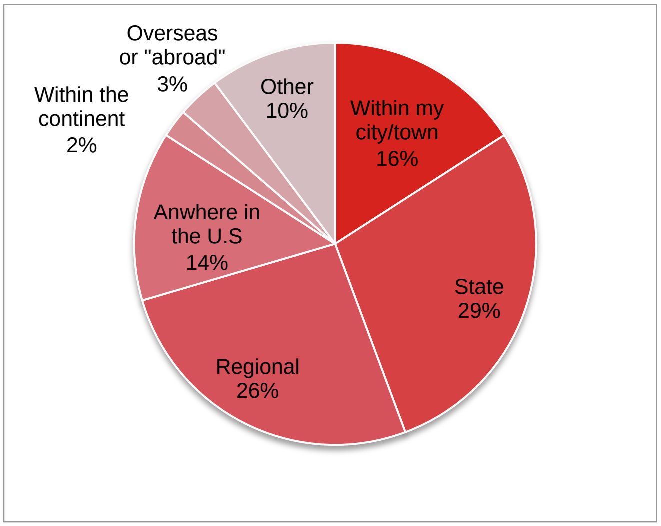


**Figure 6.4 Furthest that educators could travel for professional development.**

About a third of educators were willing to devote a full day each month to professional development and almost three quarters of educators were willing to spend between half a day and a few days each month participating in professional development. However, when asked what the most amount of time per year they could spend in professional development, 73% of respondents believed could not spend more than a week away from their current job, despite the fact that they are willing to do so.

When participants were asked to rate their agreement with a set of four statements about their contribution to innovation in E→STEM, participants felt that *opportunities for professionals to share what works with other peers* was the most innovative (*M*= 4.36, *SD*= .84).

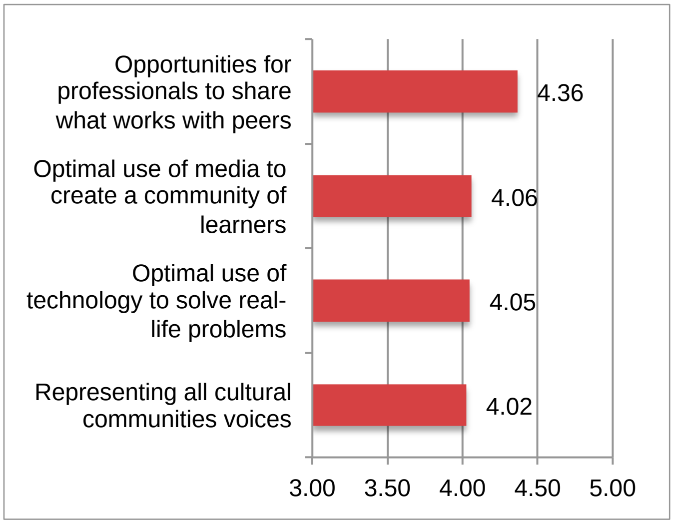


**Figure 6.5 Innovation in E→STEM (1, strongly disagree, to 5, strongly agree).**

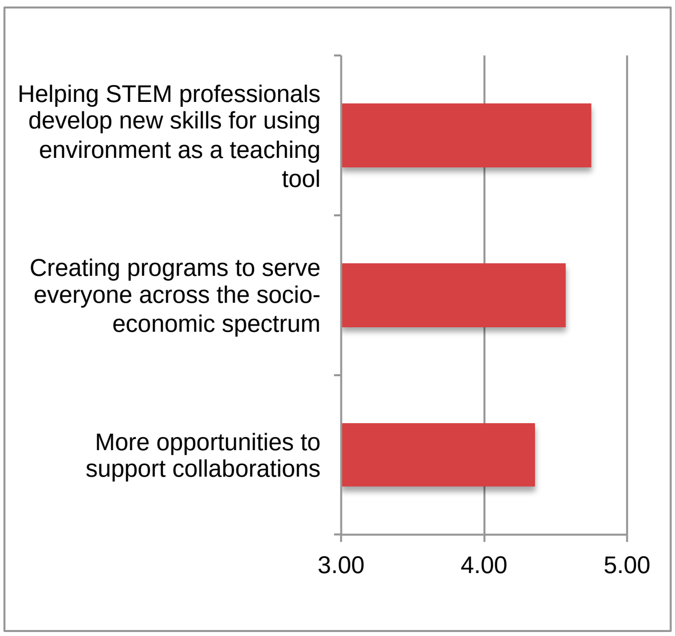


**Figure 6.6 Importance of items to E→STEM (1, strongly disagree, to 5, strongly agree).**

Similarly when asked how much they agreed or disagreed with how important a series of items were for E→STEM, "helping STEM professionals develop new skills for using environment as a teaching tool was most important (*M* = 4.75, *SD* = .59).

When participants were prompted to answer how much they agree with a set of statements about the novelty of their approach to E→STEM, participants felt that cross-generational social learning experiences was the most novel approach (*M* = 4.24, *SD* = .91). Despite, or because of the focus that US culture has on modern technology, modern digital interfaces were not considered as novel as other approaches (Figure 6.7).

Participants were also asked to rate how much they trust different organizational entities for leading innovation in E→STEM. The average most trusted type of organization were academics at universities and colleges (*M* = 5.73, *SD* = 1.03). Although most distrusted organizations were rated on average between *somewhat distrust* and *not sure*, their standard deviations were large, suggesting little consensus about their trust worthiness and the variability that exist within Fortune 500 companies, local school boards and state governments (Figure 6.8).

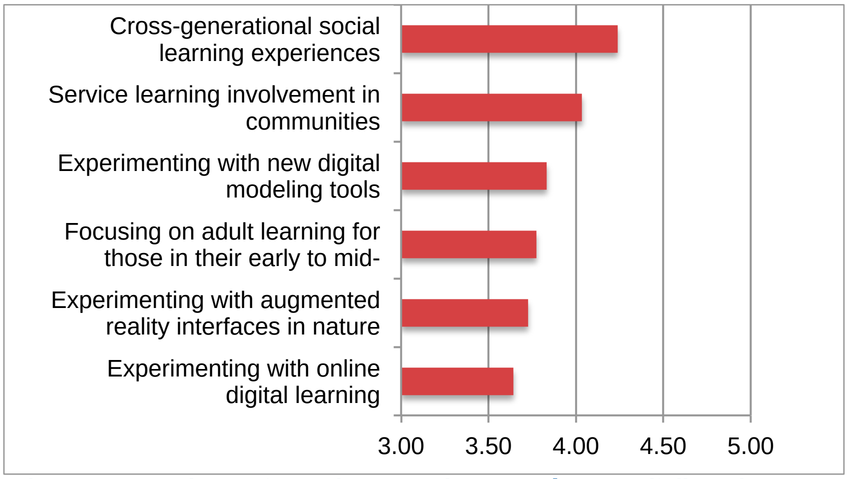


**Figure 6.7 Ratings of novel approaches to E→STEM (full scale was 1, strongly disagree, to 5, strongly agree).**

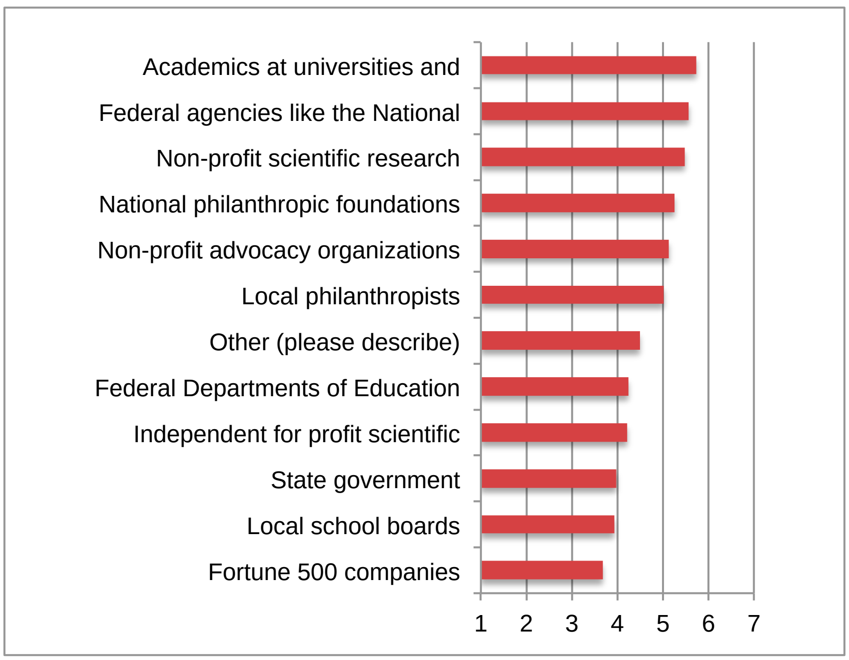


**Figure 6.8 Trust in organizational entities to lead innovation in E→STEM initiatives (1 = completely distrust, 4 = not sure, 7 = completely trust).**

The survey also utilized the responses from the science educators at the NSTA Workshop (see Section 4, above) and the Partner Representative Interviews (see Section 7, below) to frame several statements for validation of previous findings. The majority of participants agreed that the current culture of standardized testing in education in America has failed (*M* = 5.74, *SD* = 1.42). However the greatest consensus surrounded the agreement that forging new alliances between non-profits working in the Environment and STEM field is required before E→STEM will have impact (*M* = 5.58, *SD* = 1.14).

## RECOMMENDATIONS

While the results of this survey suggest agreement with the findings from the previous efforts, the focus on the components of innovation, importance and novelty in E→STEM initiatives possibly could have skewed the results by excluding other components. It is recommended that this survey should be re-launched with greater effort to reach a broader base of participants.

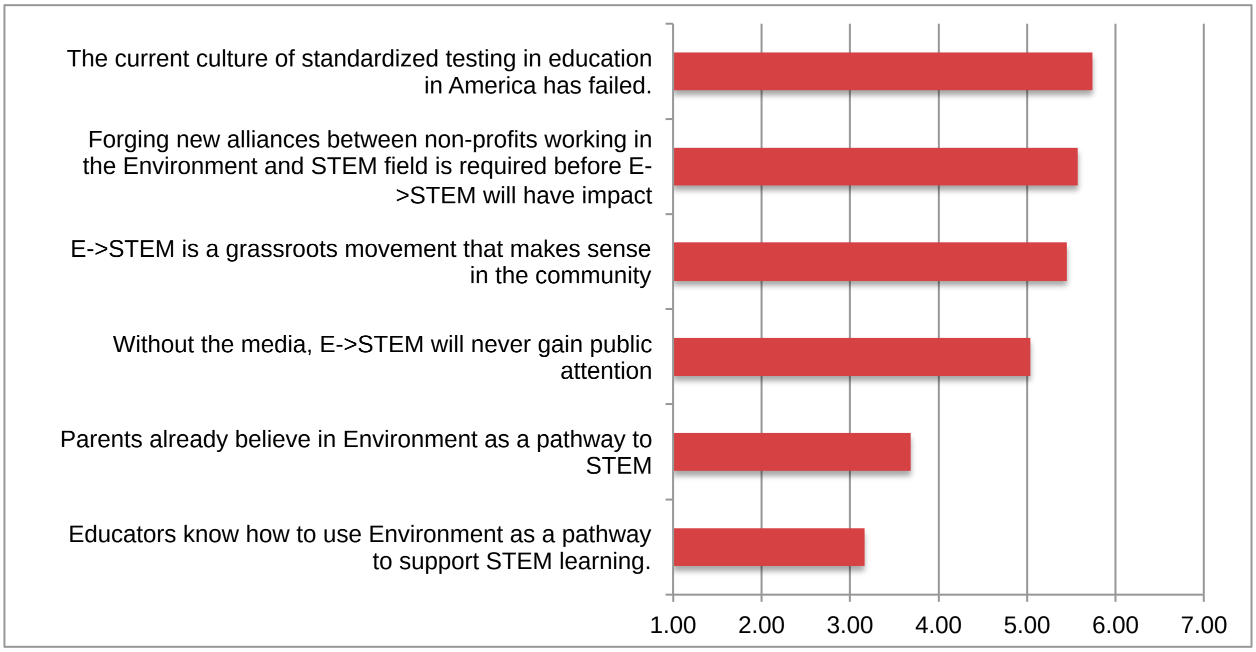


**Figure 6.9 Agreement with claims that have been made about STEM education (1 = strongly disagree, 4 = not sure, 7 = strongly agree).**

## 7. Partner Representative Interviews

*What are partners' and stakeholders' perceptions of UL as an organization?*

*What are potential partnerships and collaborators UL would benefit from working with to further E→STEM?*

*What are the barriers educators see has hindering their ability to create effective E→STEM programs and the solutions to overcoming them?*

### Overview

To futher explore opportunities for innovation in E→STEM, the research team undertook a set of three confidential qualitative discussions with five representatives from project partner organzations. These interviews were used to gather honest independent perceptions of UL, these experts awareness of potential partners for collaboration with UL on an E→STEM initative, solutions to barriers educators perceive as stopping them incorporating effective E→STEM programing, while continuing to gather information of programs or initiatives, which exemplify E→STEM. Results of these interview are summarized in this section.

### Partner Representative Survey Instrument

Nine open ended qualitative questions were asked of each stakeholder.

- What are your thoughts about Underwriters Laboratories (UL) as a company that's interested in making global impact in E→STEM?
- Who do you believe are the strongest potential partners that could collaborate with UL and NAAEE to really make an impact E E→STEM?
- We've heard that teachers are really getting fed up with being talked at by experts. It seems most teachers just want to use the skills they developed in school to implement E→STEM innovations.
- Who might UL and NAAEE partner with to help remove what teachers see as political barriers to them being effective and using E→STEM in their classrooms.

- Can you think about what type of incentives are needed to engage administrators and educators to improve practice?
- We're talking to a number of experts like you and we know you have your ears to the ground on some cutting edge ideas we haven't heard about yet. Can you tell us if there are any smaller initiatives that should be scaled up?
- How could a program reach the most students and teachers and achieve the greatest impact, focusing on both quality and quantity?
- Where do you think we could look at exemplary programs that link formal and non-formal partners?
- Can you think of lessons we should draw from international programs that break the paradigms that are inhibiting success here in American?

**Partner Representative Survey Results**

The interviews were synthesized and results for each question are delineated below. All statements were compiled by a NewKnowledge researcher and reflect the views expressed by at least one participant.

**What are your thoughts about Underwriters Laboratories (UL) as a company that's interested in making global impact in E-STEM?**

- The definition of E→STEM developed for the NAAEE UL study resonated well with advisors.
- Only two participants were familiar with the UL name at first, but all participants recalled the logo when it was described as two letters in a circle that you might have seen on a consumer product label. Following that simple prompt, all participants felt that UL stands for safety assurance, agreeing that UL's attention to E→STEM would create positive interest among teachers because of the legitimacy and track record of the brand.
- For those advocating for curriculum reform, UL was perceived as a valuable strategic "out front" effort with teachers, and parents.
- The focus on supporting teachers through comprehensive mentoring and reform was considered consistent with UL's position to reform if they can show partnership authority and credibility.

- It was acknowledged that budgets are constrained across the country, and large corporate investment will be dissipated if it focuses solely at the program level. Instead, it was recommended that efforts focus on scaffolding systems and consumer behavior as a social citizenship.

**Who do you believe are the strongest potential partners that could collaborate with UL and NAAEE to really make an impact E-STEM?**

- US Green Building Council (USGBC) was identified as a key partner for environment because they focus both on the built world and environmental sustainability.
- Stakeholders suggest that there is an inordinate focus on the “extremely high achievers” rather than the undistinguished and noted that Vocational and Technical Community Colleges seldom are perceived as leaders in this space, yet this area tends to be more important to the professional pipeline.
- Instead of looking at the gold standard, partners working to raise all boats may offer higher impact. There is an American Association of Community Colleges (AACC), which may be a good place to begin laying down the groundwork for partnerships and a more ubiquitous presence.
- Another stream focused on after-school providers, because they are a link between community and formal education, noting the benefit in focusing on local and cultural relevance to the surrounding environments.

**We've heard that teachers are really getting fed up with being talked at by experts. It seems most teachers just want to use the skills they developed in school to implement E-STEM innovations.**

- Most felt that a focus on helping teachers address the common core standards, and career readiness as identified by National Education Association was possible through E→STEM. One participant highlighted the 18 attributes that the NEA prioritized as the 4 c’s of learning (critical thinking and problem solving, creativity and innovation, communication, and collaboration).
- Teacher-to-teacher communications and mentoring were seen as valuable, highlighting the potential benefit in teachers working together toward a culminating project.

**Who might UL and NAAEE partner with to help remove what teachers see as political barriers to them being effective and using E-STEM in their classrooms.**

- Partnerships in the private sector were mentioned as potential solutions to some of the barriers educators encountered because the private sector is one of the biggest contributors to state capital.
- Fortune 100 companies were noted as a potential pool within the private sector to find lasting and effective partnerships, as they have considerable influence in state regulation due to their clout.
- Mustering effort around Common Core initiatives was perceived as something that would be supported by the private sector as they value and need employees with vocational skill sets.
- Stakeholders noted that teachers are very vocal about disliking how assessments are handled, however if the evaluation is something that can be delivered in an experiential E-STEM way, then one will have more alignment with teachers teaching in this manner.
- It is important to think at the state as they ultimately decide their assessments due to their independence from the federal regulations.

**Can you think about what type of incentives are needed to engage administrators and educators to improve practice?**

- There was a sense among these participants that the E→STEM field contains an inherent challenge that does not map against the career aspirations for youth nor is it applicable to business metaphors. Athletics were considered a more valuable metaphor because that language invokes a competitive frame that is local and perceived as more practical or universal and less associated with higher income communities.
- Opportunities may be limited if you don’t embrace change as an emotional campaign.
- The ‘how’ and the ‘craft’ of teaching needs an advocate. When there are innovative ways to look at the demands of a school day, year, and a child’s whole k-12 career, it has the potential to reinvigorate the craft of teaching.

- Models themselves can act as incentives. E→STEM and project based learning illustrates this through the motivation and inspiration they foster within students by engaging them on a physical and hand-on level.

**We're talking to a number of experts like you and we know you have your ears to the ground on some cutting edge ideas we haven't heard about yet. Can you tell us if there are any smaller initiatives that should be scaled up?**

- Although there is a lot of money focused on ad campaigns and Common Core initiatives, the wrong people are trying to solve the problem. We need a powerful marketing campaign to muster support and engage people emotionally.
- Going for Green-STEM is all about the sales pitch, appealing to the interest. It would be good to look at the lexicon of this generation to understand what is effective and inspiring. For example, the National Engineering foundation has recently radically changed the how they frame of engineering as a profession in order to attract women.
- How we talk about these issues affects the way we perceive them and the thoughts we associate with them. These notions need to be imbedded in a culturally significant and relevant narrative in order to engage the relevant generations.

**How could a program reach the most students and teachers and achieve the greatest impact, focusing on both quality and quantity?**

- It’s important to get quality dealt with first. Only until the quality of a program and education is achieved can one can look at replicability (quantity).
- Giving teachers a larger forum so they can establish quality and best practice standards whilst being given opportunities to present at conferences around the country will help toward this aim.
- Efforts to motivate teachers and inspire them to engage more with the material they are teaching will bolster their sense of self as related to their occupation.

**Where do you think we could look at exemplary programs that link formal and non-formal partners?**

- Due to time constraints during the interviews, there were few opportunities to discuss possible collaborations outside of those already established by the partners. The examples given highlighted the value of repeated contact between schools and informal science learning institutions that have recognized missions related to youth education, such as zoos or museums and nature centers. There was a suggestion that long term value was created in a community when staff develop personal relationships that last over many years.

**Can you think of lessons we should draw from international programs that break the paradigms that are inhibiting success here in American?**

- Finland (done) and Brazil (emerging) are examples given as valuable international programs. They looked at performance internationally, but realized they couldn't compete within the EU and subsequently placed a great amount of effort into their education system. They invested in teachers and only acknowledged the top 10% as eligible to be teachers. They paid them well and worked to professionalize the industry. T
- Investment into teachers is a way to raise the standard for the whole country..
- A youth-to-youth campaign may also offer some real value.

# 8. A Blue Print for E→STEM

*How can programs be assessed according to these attributes in order to identify key effective and innovative E→STEM initiatives?*

The Rubric of Innovation in E→STEM, created from the results of the Blue Ribbon Panel identifies the most important, innovative, and effective attributes of E→STEM programs today. Ranking these categories hierarchically the Rubric for Innovation can be used to assess current programs and initiatives for their potential to facilitate STEM learning, foster a passion for STEM topics in today's youth and nurture a passion for STEM-related career opportunities.

**Rubric Design**

The Rubric for Innovation was created from feedback from the Blue Ribbon Panel. Its design and structure was informed by six core objectives. To:

- Establish Core Literacies (priority setting)
- Fit Literacies to the Target Audiences
- Highlight Key Vectors (ie, teachers, partners, media, etc.)
- Inform a Diffusion Plan
- Reveal Key Indicators
- Advise a Timeline

Based on feedback from the Blue Ribbon Panel nine categories were created using Concept Systems Global MAX©. Each category was then given three ratings, one for each of the three 7-point Likert scale ratings that each item within the categories were rated on. These three ratings were equally weighted and averaged, resulting in a single rating score for each category. These rankings were then used to sort the nine categories into hierarchical order in order to create a rubric from which to assess E→STEM programs. Eleven programs were selected from those nominated programs to represent a range of focus from small to large programs, from local to large. These programs were used assess the validity of the rubric in practice. The final results revealed that the rubric was consistent and that across the 11 programs, all criteria were represented in at least one program.

### Rubric Instrument

Based on the Blue Ribbon Panels ratings of Importance, Innovation and Novelty, NewKnowledge proposes this rubric as a barometer to assess the quality and value of E→STEM programs. When using this rubric, we propose that in order for a program to be considered amongst the leaders in E→STEM, the top three categories (A-C) must be fulfilled, with the fulfillment of each subsequent category further bolstering the efficacy and value of that program. Each category with the Rubric of Innovation is comprised of a number of attributes. The more attributes a program embodies the greater the innovation and strength of that program to align with E→STEM.

The descriptions for each category of the Rubric are listed below. These are followed by the Rubric on the following page.

### A. Professional Development

This category represents the most important components of innovation in E→STEM: professional development and the need for collaboration between informal and formal educators. It also includes the need for collaboration between formal educators and practicing professionals. This category consistently emerged across all of the research efforts.

### B. Real Connections

*Making connections to the real environment* was a prevalent theme, indicating that physically spending time in the natural environment was extremely important and a tried and true method of engaging youth in E→STEM. Participants in all of the research efforts called attention to this category.

### C. Creativity in Critical Thinking

Participants indicated that critical thinking and creativity in E→STEM programs are highly important and innovative. A focus on the learning process—whether through student collaborative research, experimental designs, or combining the visual arts with science lessons—showed that there is a need for a variety of approaches to E→STEM learning.

In the Blue Ribbon Panel, 11 statements originally fit into the *Focusing on scientific methods and process to foster critical thinking* category, but the analysis showed that participants identified about half of the statements as most innovative and most important – among those, creative approaches were prioritized. This new conglomerate focuses on the importance of creativity in critical thinking for E→STEM programs.

### D. Practical Synthesis

A variety of attributes combined to form the Practical Synthesis category, suggesting that E→STEM learning will focus on the integration of cross-curricular STEM education. Notable ways to achieve this synthesis are through teamwork, economics of the environment, and abandoning standardized testing.

### E. Technology and Real Problems

Participants in several research efforts prioritized technology in several ways, with an emphasis on using it purposively to increase connections with the natural environment.

### F. Media and Community

There was an interest in solving real-life problems using free, technically advanced monitoring systems to support community learning. This category places special emphasis on sharing knowledge with social networks, including those in web-based communities.

### G. Community and Cross-Generational Learning

Community and cross-generational learning was lacking from the Crowd Sourcing and Literature Review results. However, after adding them in as part of the gap analysis, half of these methods ranked in the experimental area of E→STEM strategies, suggesting the need for research to provide proof of their efficacy.

### H. Empowerment

Empowerment of individuals and communities was important for participants in the Blue Ribbon Panel, but was ranked relatively low compared to the other E→STEM components. However one of the statements in the original category ranked very high in comparison with other statements: urban movements are increasingly utilizing the empowerment, health, and social justice approach to engage youth in E→STEM. Blue Ribbon Panel participants closely related the attribute of empowerment with other categories, suggesting that it could be an effective approach for many E→STEM strategies.

### I. Digital Tools and Modeling

This category focuses on using digital tools and mobile technologies to interpret natural environments, with an emphasis on engaging with local settings.

## RUBRIC

### *A. Professional Development*

- Integration of mentors into project development
- Engages formal and informal educators
- Promotes collaboration between practicing professionals and experienced educators
- Provides mentoring for teachers to help them strategize about using the local environment
- Provides professional development experimentation for teachers
- Encourages teachers to pursue their own life-long development strategy

### *B. Real Connections*

- Encourages spending time in *local* outdoor environments
- Utilizes national, state, or private parks as outdoor classrooms
- Maximizes time spent outdoors in local environments
- Incorporates physical demonstrations of how biodiversity affects local ecological systems
- Promotes time in nature, away from computers
- Introduces nature to pre-school learners

### *C. Creativity in Critical Thinking*

- Combines performing / visual arts with science lessons
- Optimizes individual creativity in experimental design
- Emphasizes critical thinking skills
- Provides hands-on real learning opportunities
- Provides opportunities for student collaborative research
- Emphasizes experiential learning to foster passion and motivation

### *D. Practical Synthesis*

- Integrates cross-curricular STEM education
- Incorporates the economics of the environment for practical applications of STEM literacy
- Abandons standardized testing in favor of life-long learning track for students
- Optimizes teamwork to increase debate skills using scientific concepts

*E. Technology and real problems*

- Uses technology to address local relevant real-life problems
- Optimizes the use of modeling tools for local solutions such as alternative energy

*F. Media and Community*

- Provides free technically advanced monitoring systems to real life situations to support community learning
- Promotes cross disciplinary collaborative teaching

*G. Community and Cross-Generational Learning*

- Focuses on opportunities to help seniors and young learners work together
- Provides practical internship experience with professionals in the field
- Focuses on senior citizens' interest in their environmental legacy
- Refocuses service learning towards entire families
- Promotes synergistic community partnerships
- Directs resources to support youth in at-risk communities
- Promotes civic group collaborations with learners

*H. Empowerment*

- Focuses on environmental health / justice to empower individuals to engage community issues

*I. Digital Tools and Modeling*

- Utilizes geospatial technologies (i.e. ARC GIS, or Google earth)
- Utilizes mobile technologies for interpreting natural environments on site

# Appendix A: Programs Analyzed For Background Study and Crowd Sourcing Efforts

Notes. Background Study (B) and Crowd Sourcing (C)

| | |
|---|---|
| 10,000 Environmental Studies Program | C |
| 10,000 Islands Dolphin Project's "Environmental Studies Program" | C |
| Acting Wild Zoo Theatre Class | C |
| Adopt a Trout | C |
| Agency: An Alternate Reality Game for Middle School Environmental Education | C |
| All annual science fairs leading up to the International Science & Engineering Fair. | C |
| All the Rivers Run Level II | C |
| Allegheny Women's Biotech Workforce Collaborative | B |
| Alliance to save Energy's PowerSave Campus Program | C |
| American Chemical Society's Project SEED | B |
| American Forest Foundation - Project Learning Tree | C |
| American Tall Ship Institute (ATSI) Educational Adventures | C |
| Anchorage STrEaM Academy | C |
| Aquatic WILD: K-12 Curriculum & Activity Guide. (The recently expanded Project WILD Aquatic curriculum). | C |
| ARTS+ACTION Cafeteria Waste Reduction (A+A CWR) - NYC School Program and Multi-media Toolkit | C |
| ASSET Inc | B |
| Babcock Ranch Community STEM/EEC (E squared C) Sci.-Tech.-Eng.-Math /Envir.-Econ.-Culture & SW FL STEM TEAM | C |
| Bayfield High School Alternative Education Program | C |
| Bayfront Alternative Education Program-US | B |

| | |
|---|---|
| Beaver Ponds Environmental Education Center | C |
| Biology Levers Out of Mathematics (BLOOM)- US | B |
| Biomimicry Education: A sy-STEM-atic approach- US | B |
| Biomimicry Youth Challenge | C |
| Bioscience Explorations | B |
| Biotech Partners | B |
| Breakthrough Collaborative | B |
| Broadening Advanced Technological Education Connections (BATEC)- US | B |
| Building Math | B |
| Camp in a Can | C |
| Camp Oty'Okwa Science Station | C |
| CAPSULE: CAPStone Unique Learning Experience- US | B |
| Career and Technical Academy Innovations in Teaching and LearningThe Southwest Career and Technical Academy (CTA)- US | B |
| CHANCE (Connecting Human And Nature Through Conservation Experiences | C |
| Character education through Observation, Reflection,Ecological restoration and Scientific literacy[CORES] | C |
| Chemical Circus! Increasing the STEM Pipeline through Service Learning- US | B |
| Chemistry Facets: Formative Assessment to Improve Student Understanding in Chemistry- US | B |
| Cherry Street Elementary's School Garden | C |
| Chippewa Middle School Rain Garden STEAM Laboratory | C |
| CimateAudit.org | C |

| | |
|---|---|
| Climate Science Investigation: South Florida (CSI: SFI) – Online Program | C |
| Coastal Roots | C |
| Communities of Learning for Urban Environments and Science (CLUES) | C |
| Community Bottle Block | C |
| Community Garden | C |
| Community Resources for Science | B |
| Cook County Citizen Scientists | C |
| Copper River Stewardship Program | C |
| Creating a High Performing STEM School Culture, DSST's (Denver School for Science and Technology)- US | B |
| Critical Zone Observatory (GEO/EAR/CZO)- US | B |
| Cultivating Mathematical Habits of Mind in All Students- US | B |
| Decision Making Curricula for the Great Lakes | C |
| Deeply Digital Student Engagement and STEM Learning- US | B |
| Demonstrate to Innovate | C |
| Desert Diversity Environmental Education Program, Saguaro National Park | C |
| Design Squad: Inspiring a New Generation of Engineers- US | B |
| Detroit-Area Pre-College Engineering Program | B |
| Developmental Approaches in Science, Health and Technology (DASH) | B |
| Disneynature Educational programs | C |
| EarthWorks STEM | C |
| East Africa Biodiversity Food And Education Security Based Conservation Project (BIOSEC) | C |
| EAST Students Use Technology to Address Local Challenges- US | B |
| EbD-TEEMS | C |
| Ecology Explorers, part of the Central Arizona-Phoenix Long-Term Ecological | C |

| | |
|---|---|
| Research project at Arizona State University, sponsored by NSF | |
| Ecology Project International (EPI) | C |
| EcoMOBILE- US | B |
| EcoMUVE Engages Students in Real-World Science through Virtual Ecosystems- US | B |
| Education Through Exploration: Using STEM to solve environmental problems.- US | B |
| EE STEAM | C |
| Energy for ME | C |
| Engaging Youth Through Engineering (EYE)- US | B |
| Engineering is Elementary | B |
| ENTRYPOINT! Internship Program for Students with Disabilities | B |
| Environment as a Context for Opportunities in Schools (ECOS) | B |
| Environmental & Sustainability Enhanced Lessons | C |
| Environmental education in Australian schools | C |
| Environmental Learning for Kids "Denver Youth Naturally" | C |
| Environmental Literacy and Inquiry (ELI). http://www.ei.lehigh.edu/eli/ | C |
| EQUALS | B |
| ESF SCIENCE (Summer Camps Investigating Ecology in Neighborhood and City Environments) | C |
| eSTEM Academy- US | B, C |
| Expedition: Yellowstone! | C |
| Expeditionary Learning - EL schools works with whole schools to redesign curriculum and instruction. | C |
| Exploring Creative Expression Through Music and Audio Technology- US | B |
| Extended Day Vegetable Container Garden Project | C |

| | |
|---|---|
| ExxonMobil Bernard Harris Summer Science Camp (EMBHSSC) Project | C |
| Family Math/Matematica para la Familia | B |
| Fayette Academy Bat STEM Project | C |
| Floating Wetlands | C |
| Forest Watch at the University of New Hampshire | C |
| Foundational Approaches in Science Teaching (FAST) | B |
| From Local to Extreme Environments (FLEXE)- US | B |
| Full Option Science System (FOSS) | B |
| Future Scientists: Sowing the Seeds for Success | B |
| Gateway Institute for Pre-College Education | B |
| Girl Game Company | B |
| Glaciers and Climate Change | C |
| GLOBE | C |
| Going Green in Brownfields: A New Diet for Mushrooms | C |
| Goo to gardens | C |
| Great Explorations in Math and Science (GEMS) | B |
| Green Leadership Academy for Diverse Ecosystems (GLADE) | C |
| Green Schools National Network - Green Schools National Conference | C |
| Green Schools STEMbassador Program | C |
| Greenhouse project | C |
| Growing Green Leaders at Irvine Nature Center | C |
| Hands on the Land (HOL) | C |
| Healthy Habitats | C |
| High Desert Leapin' Lizards, Inc- US | B |
| I Love A Clean San Diego Watershed Education Program | C |
| IcEarth | C |

| | |
|---|---|
| Illinois Math and Science Academy Excellence 2000+ (IMSA E2K+) | B |
| Inquiry Adventures | C |
| Institute for Earth Observations | C |
| Integrating Engineering & Literacy- US | B |
| iPhone App for School Data Collection and Critical Thinking About Ecology and Biodiversity- International | B |
| Issues-based Literacy | C |
| Junior Engineering Technical Society (JETS) | B |
| Keep America Beautiful's Recycle-Bowl Program | C |
| Keep It Clean - Neighborhood Environmental Trios (KIC-NET) | C |
| Kentucky Green and Healthy Schools | C |
| Kestrel Educational Adventures Place Based Ecology Programs for Schools | C |
| KIDS for the BAY/Watershed Action Program | C |
| Kinetic City | B |
| Kohl's Wild Theater | C |
| Kū 'Āina Pā: Standing Firmly in Knowledge Upon the Land, teacher training program for school learning gardens. | C |
| LIFE - Learning in Florida's Environment | C |
| LiMPETS (Long-term Monitoring Program and Experiential Training for Students) | C |
| Linking Food to the Environment - making choices and changes in the way we eat (LIFE) | C |
| Living in Relations- US | B |
| Logan Rogersville High School Field Research Rogersville, MO | C |
| Luck School Harvest Garden | C |
| Macoun Marsh Biodiversity Project | C |
| Marine Activities, Resources and Education (MARE) | B |
| Massachusetts Audubon Society Drumlins Farm | C |

| | |
|---|---|
| Math and Science Program for English Language Learners (MSPELL) | B |
| Math Out of the Box® | B |
| Mathematics, Engineering, Science Achievement (MESA) | B |
| McDowell Environmental Center | C |
| Merck Institute for Science Education | B |
| MIND Research Institute | B |
| Mississippi State Univeristy's Entomology and Plant Camp | C |
| Model My Watershed: Developing a Cyberlearning Application and Curricula to Enhance Interest in STEM Careers- US | B |
| Modeling Engineered Levers for the 21st Century Teaching of STEM- US | B |
| Montana Girls STEM Collaborative | C |
| Montana Outdoor Science School (MOSS) | C |
| National Engineers Week Future City Competition | C |
| National Environmental Education Week | C |
| Nature in the Classroom – Out-in-School Partnerships | C |
| Navarre Beach Marine Science Station – a student created, student driven program which focuses on ocean conservation | C |
| NCTAF STEM Learning Studios- US | B |
| NEXT.cc Offers Students and Teachers an Interdisciplinary Approach to Environmental Design- international. | B |
| NH Education and Environment Team: Building Vertical Science Literacy through K-8 Teacher Professional Development | C |
| NOVA Labs: Energy | C |
| NREL EDUCATION CENTER | C |
| NWF's Green STEM Initiative | C |
| Oak reforestation project in Union City, CA | C |
| Oglebay Institute's REACH Program | C |
| Omaha Public Schools/Banneker 2000 | B |
| Orange County Ocean Restoration Project | C |

| | |
|---|---|
| Oregon Natural Resources Education Program: Stewardship Schools | C |
| Oregon Small Woodlands Owners Association | C |
| Out in School: Modeling Inquiry in Schoolyards | C |
| Pacific Education Institute http://eeweek.org/webinars/pei_webinar | C |
| Parks As Classrooms: Cape Cod National Seashore | C |
| PBIS- Project Based Inquiry Science | C |
| PEAK Student Energy Actions | C |
| PENCIL Partnership Program: Private Sector/Public School Partnerships to Improve Student Achievement in STEM-US | B |
| Plots to Plates Organic Gardens | C |
| PLT GreenSchools! | C |
| Portland Metro STEM Partnership | C |
| PowerSave Schools | C |
| Preston Middle School STEM- US | B |
| Project Lead The Way . | B |
| Project Learning Tree's five GreenSchools! Investigations on Energy, Environmental Quality, School Site, Water, and Waste & Recycling | C |
| Providence After School Alliance (PASA)-US | B |
| Reading A River's Vital Signs: Using Remotely Sensed Environmental Data in Classrooms; Hudson River Estuary Program | C |
| Reforest The Tropics Environmental Education Program | C |
| Ridgeland High School Aquaponics Project | C |
| River to the Sea | C |
| Robert Frost Sustainable Community Support Initiative | C |
| Round Valley Watershed Education and Training Project | C |

| | |
|---|---|
| Saving the Planet One Vegatable and Fish at a Time | C |
| School Garden Project's STEM in the Garden Program | C |
| Science & Spanish Club Network | C |
| Science Career Continuum (SCC) | C |
| Science Education for Public Understanding (SEPUP) | B |
| Science First in Lake County (SFLC) | C |
| Science Foundation Arizona "STEM" Initiative Wins National Science Foundation Grant to Expand Rural Engineering Education Program- US | B |
| Science in Motion | B |
| Seattle Aquarium / Citizen Science High School Nearshore Monitoring Program | C |
| Seeds of Science/Roots of Reading™ | B |
| SENSE IT Connects Students to STEM in the Real World- US | B |
| SERC Media Design Workshop- US | B |
| Shep Run Cross Section Project | C |
| Smithsonian Quests- Digital Badging Program | C |
| Society's Grand Challenges in Engineering as a Context for Middle School Instruction in STEM- US | B |
| Solar Roller Project | C |
| St. Louis Regional Engineering Academy | B |
| Stanford Medical Science Youth Program | B |
| STEM - Connecting us to Ocean Life- International | B |
| STEM Plus Workshop - Learning to be an Innovator - Level 1 | C |
| STEM to Stern at the Maritime Explorium | C |
| Stewardship Schools Program: | C |
| STOMP - Student Teacher Outreach Mentorship Program- US | B |
| StreamWebs Student Stewardship Network | C |

| | |
|---|---|
| Studio STEM | C |
| Studying Topography, Orographic Rainfall, and Ecosystems (STORE) | C |
| Summer Science Academy | B |
| Take Action: Support Bird Biodiversity | C |
| taylor science center lobby | C |
| TCATS - Tuolumne, Calaveras, & Amador Teach Science! | C |
| TeachUNICEF | C |
| Techbridge | B |
| TED-Ed | C |
| Texas Bioscience Institute | B |
| Texas Tech University Outdoor School | C |
| TexPREP | B |
| The Biodiversity Quest- US | B |
| The Botanical Research Institute of Texas - BRIT | C |
| The CLEO Project on Climate | C |
| The Corps for Education Outside | C |
| The Earth We Share (TEWS) | B |
| The EAST Initiative | C |
| The Greenhouse Project NYC Bringing Sustainability/STEM education to Life through Urban Agriculture- US | B |
| The HERP Project (Herpetology Education in Rural Places & Spaces) | C |
| The Louisiana Universities Marine Consortiumâ€™s Bayouside Classroom Program | C |
| The Nature Research Center Connects Students and Teachers to Real Scientists in the Field- US | B |
| The NEA Foundation and the AT&T Foundation- US | B |
| The OpenLab Network – US | B |
| The Pacific Education Institute's Puget Sound K-12 FieldSTEM Program | C |
| The Pine Bush Project | C |

| | |
|---|---|
| The Service-Learning Waste Reduction Project | C |
| The Story of Soil | C |
| The UTeachEngineering Project at The University of Texas- US | B |
| The Virtual Scientist Guest Lecture Series: Bridging the gap between the lab and classroom.- US | B |
| The Water Investigation's Program | C |
| Thunder Bay River Watershed Project | C |
| Tiger Woods Learning Centers | C |
| TransOptions Junior Solar Sprints | C |
| Twin State Mercury Project | C |
| U.S. Fish and Wildlife Service Schoolyard Habitat Program | C |
| UC Davis Youth Science Institute | C |
| UCSC OpenLab - Project: Blue Trail: Imagination + Innovation for Ocean Sustainability- US | B |
| University of Michigan School of Natural Resources and Environment (SNRE) Master's Projects | C |
| Urban Advantage: Formal-Informal Collaborations to Improve Science Learning and Teaching- US | B |
| VBAP (Volunteer Biological Assessment Program) | C |
| Visualrealization.com | B |
| Walnut Creek Wetland Center Design Challenge | C |

| | |
|---|---|
| Water Discovery Days at BLM Campbell Creek Science Center | C |
| Water Quality Monitoring and Education of Allen's Creek - Tampa Bay | C |
| West Meadow Garden on the Campus of Dr An Wang Middle School, Lowell, MA | C |
| Where is Waldo? 6th graders Track Eastern Box Turtles at the Lake Raleigh Area, NC | C |
| Wiki Watershed (Model My Watershed) http://wikiwatershed.org/model.html | C |
| Wild Discoveries: Wacky New Animals | C |
| Wild Science Academy at the Phoenix Zoo | C |
| Wildlands Restoration Volunteers - Youth & Inclusiveness Program | C |
| Will Steger Foundation's Minnesota's Changing Climate Project | C |
| Wisconsin K-12 Energy Education Program (KEEP) | C |
| Woodland Park Zoo's Ready, Set, Discover | C |
| Woodland Park Zoo's Wild Wise: Coexisting with Carnivores | C |
| www.builDDDers.com 3d printing for kids. | C |
| YES-Net | C |
| You Are About To Enter The Dead Zone! | C |
| Youth Energy Summit (YES!) | C |
| Youth Leaders for the Pachamama | C |
| Zoo Crew Explorers | C |

## Appendix B. Statements Used in Blue Ribbon Panel

1. Integrated cross-curriculum STEM education
2. Integrating mentors into project development
3. Optimizing online resources to keep students connected to their learning groups
4. Focused time spent in local outdoor environments
5. Expanded efforts to integrate service learning with government conservation priorities
6. Focus on competitions to support reasoning about science solutions to environmental problems through essays
7. Optimize geospatial technologies such as ARC GIS and Google earth
8. Focusing on opportunities to help seniors and young learners work together
9. Using digital models to replicate complex real-world phenomena
10. Linking physical fitness with nature learning
11. Prioritize student-driven research/ self-directed learning plans
12. Optimize shareware to promote continuous improvement in the learning experience
13. Blending digital game based learning with tradition EE strategies
14. Optimizing links between food and the environment
15. Using global environment data sets like photos to focus on big issues
16. Optimizing online resources to keep students connected to their projects
17. Focused connections between scientific methods as a tool to analyze environmental health that impacts learners
18. Focusing on spiritual connections to nature to support moral decision making in science
19. Applying free technically advanced monitoring systems to real life situations to support community learning
20. Optimizing deep, engaged formal/informal educators
21. Combining performing/ visual arts with science lessons
22. Optimize individual creativity in experimental design
23. Using technology to address local relevant real-life problems
24. Optimize use of online media to share lessons with others across the globe
25. Practical internship experience with professionals in the field
26. Optimizing use of national/ state/ private parks as outdoor classrooms
27. Collaborative between practicing professionals and experienced educators
28. Place more emphasis on critical thinking skills
29. Maximizing time spent outdoors in local environments

30. Focus on environmental health/ justice to empower individuals to engage community issues
31. Optimizing the use of modeling tools for local solutions such as alternative energy
32. Creating imaginary scenarios to solve real-world problems
33. Investing in afterschool programs to deepen engagement
34. Optimize mobile technologies for interpreting natural environments on site
35. Optimize state of the art technology in the classroom
36. Mentoring teachers to help them strategize about using the local environment
37. Focus on competitions to make real world solutions, like Solar Decathalon
38. Cross disciplinary collaborative teaching
39. Focus on senior citizens' interest in their environmental legacy
40. Focus on hands-on real learning opportunities

41. Frequent in person meetings with professional practitioners
42. Focusing on next generation decision-makers (21-35)
43. Focusing on the economics of the environment for practical applications of STEM literacy
44. Optimize student collaborative research
45. Teaching sensitivity to cross cultural differences
46. Combining latest technology with art exploration about the environment
47. Using environment to teach moral values
48. Physical demonstrations of how biodiversity affects local ecological systems
49. Focusing on the life cycles of flora and fauna to investigate the environment
50. Reshaping professional development experimentation for teachers
51. Focusing on real nature experience away from computers
52. Refocusing service towards entire families in programs
53. Optimize use of new virtual technologies
54. Deeply engaging synergistic community partnerships
55. Abandoning standardize testing in favor of life-long learning track for students
56. Placing emphasis on community infrastructure
57. Introducing nature to pre-school learners
58. Emphasize experiential learning to foster passion and motivation
59. Optimizing teamwork to increase debate skill using scientific concepts
60. Directing resources to support youth in at risk communities
61. Allowing teachers to pursue their own life-long development strategy
62. Optimizing civic group collaborations with learners
63. Optimize virtual visits by STEM professionals to the classroom
64. Focus on adult learning (age 35-55) to create role models