AC 2012-3712: K-12 ENGINEERING EDUCATION: PRIORITIES, RESEARCH THEMES, AND CHALLENGES

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Elizabeth Parry is an engineer and consultant in K-12 STEM (science, technology, engineering, and mathematics) Curriculum and Professional Development and the Coordinator of K-20 STEM Partnership Development at the College of Engineering at North Carolina State University. For the past 15 years, she has worked extensively with students from kindergarten to graduate school, parents, and pre-service and in-service teachers to both educate and excite them about engineering. As the Co-PI and Project Director of a National Science Foundation GK-12 grant, Parry developed a highly effective tiered mentoring model for graduate and undergraduate engineering and education teams, as well as a popular Family STEM event offering for both elementary and middle school communities. Current projects include providing comprehensive professional development and program consulting for multiple K-8 STEM using engineering schools, serving as a regional partner for the Museum of Science, Boston's Engineering is Elementary curriculum program, and participating in the Family Engineering project. She currently serves as the Chair of the American Society for Engineering Education K-12 and Pre-college Division. Other professional affiliations include the International Technology Education Association, the National Council of Teachers of Mathematics and the National Science Teachers Association and serving on the Board of Directors for the Triangle Coalition for STEM Education. Prior to joining NCSU, Parry worked in engineering and management positions at IBM Corporation for ten years and co-owned an informal science education business.

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Malinda Zarske is a is a former high school and middle school science and math teacher with advanced degrees in teaching secondary science from the Johns Hopkins University and in civil engineering from the University of Colorado, Boulder. She is a First-year Projects Instructor at CU, Boulder, on the development team as well as a content editor for the TeachEngineering.org digital library, and the immediate past Chair for ASEE's K-12 and Pre-college Division. Her primary research is on the impacts of project-based service-learning on student identity, recruitment, and retention in K-12 and undergraduate engineering.

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K-12 Engineering Education:
Priorities, Research Themes, and Challenges

Abstract

The K-12 and Pre-College Division of the American Society of Engineering Education (ASEE) has been working to identify the top programs and issues in K-12 Engineering Education. Among these efforts are annual workshops focused on K-12 teachers, special plenary sessions at the ASEE Conference, best practices panels, regular discussions of the executive committee, and a member survey. The results of these sessions and discussions are useful to a wide audience of people engaged in K-12 Engineering Education, and they have implications for curricular and policy reform, as well as future research opportunities.

Several common themes have surfaced from these initiatives: the need to focus on teacher professional development, the need for a clear definition of engineering for K-12 audiences, the need for strategies for integrating engineering into STEM disciplines, and the need to engage students in engineering design in K 12 education. This paper reviews the results and themes that emerge from recent K-12 Division initiatives: a NCSU invited workshop in Raleigh, a special plenary session geared towards K-12 teachers on programs and issues at ASEE 2010 in Louisville, the 2011 nationwide online Division member survey, and the 2011 special working session geared toward teachers on priorities and challenges in K-12 Engineering Education in Vancouver, BC. Implications for classroom instruction, grant writing, and policy direction will also be discussed.

Introduction

Since the National Academies' *Rising Above the Gathering Storm* [1] publication in 2007, numerous calls to action have appeared that draw attention to the need to improve the performance of US students and to satisfy a growing need for engineers and STEM-literate citizens. There is an emerging consensus [2] that introducing engineering into the K-12 curriculum will illustrate the "real-world" importance of the principles of mathematics and science. This will enhance student interest (and performance) in these topics as well as to spark interest in pursuing STEM careers, even among students who would otherwise not have considered it.

The K-12 and Pre-college Engineering Division of the ASEE has the goal of becoming the primary source for information, curriculum, policy, and expertise in K-12 engineering education. The Division strives to provide a focus for development of innovative K-12 engineering education curricula and delivery approaches and a forum for the presentation and sharing of K-12 engineering educational initiatives and methods. It aims to create a vital community of researchers and practitioners engaged in K-12 engineering initiatives; to encourage the professional development of teachers in K-12 engineering education methodologies; and to increase awareness and participation of university faculty and industrial educators/partners in K-12 engineering initiatives. Lastly, the Division works to promote engineering as the context to integrate science and mathematics with all subjects in the K-12 setting; to encourage the participation of K-12 educators in the creation and delivery of K-12 engineering content; and to synthesize and broadly disseminate lessons learned.

These goals come into focus at ASEE's yearly Annual Conference and Exposition, which is typically attended by more than 3000 engineering educators. For the past eight years, as a part of this conference, the Division has co-hosted a Workshop on K-12 Engineering Education that focuses on implementing engineering in the K-12 classroom. Not only are classroom teachers strongly encouraged to attend the workshop, the division also welcomes administrators, counselors, informal and afterschool educators, and university-level engineering educators and outreach staff. Each year, depending on the location where the meeting is being held, as many as 250 teachers and administrators from the local school districts, the nation, and overseas attend these Workshops.

Over the past two years, a special effort was made to engage the teachers present at these meetings in discussions of best practices in using engineering to enhance the teaching of science and mathematics with the intention of disseminating this information to the engineering and the K-12 communities. This paper describes those activities as well as a recently-completed survey of its membership that will be used to guide the Division's future engineering-related, K-12 activities.

Raleigh Meeting

On May 4th, 2010, the executive board of the ASEE K-12 and Precollege division convened an invited meeting at North Carolina State University in Raleigh, NC of fifty-five researchers and practitioners of K-12 engineering. The "Beginning the Dialogue on K-12 Engineering Education: *Issues and opportunities for moving forward on a national dialogue to realize the advantages of engineering in Elementary School education*" session was intended to be not an isolated event but rather to begin a progressive dialogue with more and more collaboration and involvement from each of the organizations and institutions involved in this issue.

The meeting agenda was determined by participants using the Open Space facilitation method. Participants raised more than 32 major issues related to realizing the advantages of engineering in Elementary School education, and arranged them into a 4-session working agenda. They added a few more and took some away on the second day. In all, they self-managed and documented 27 working conversations. On the second day, each participant was able to view the notes from all the sessions. Each participant then identified for himself or herself the ten most important of these issues.
The prioritized results represent the broadest and clearest multi-constituent statement of what is possible and the foundation of a new era in preparing Elementary School engineering teachers to realize the advantages of engineering in their work. The top five vote getters serve as practical starting points for the large amount of work to be done.

Top-Voted Issues and Recommendations for Next Steps

1. STEM Integration, What do Elementary Kids Need to Know about Engineering and Engineering Standards?
2. Teacher Preparation

3. Too Little Empirical Evidence about effectiveness of projects
4. How do we impact policy in support of STEM?
5. Schools of Engineering Engagement Collaboration with Schools of Education

(Final draft of proceedings available at http://www.engr.ncsu.edu/theengineeringplace/spotlight/may2010mtg.php)

2010 Louisville K-12 Workshop

At the 2010 ASEE Annual Conference & Exposition in Louisville, Kentucky, the K – 12 Workshop featured a special plenary session: ***K-12 Engineering Outreach: Programs and Issues*** organized by the K-12 and Pre-College Engineering Division. For the purposes of the plenary, engineering outreach was defined as

> *"an in-class or after-school project or activity that provides hands-on reinforcement of topics in science and mathematics by illustrating their real-life engineering applications."*

The session began with presentations from a panel of leaders in K12 Engineering Education: Robert George (Woodside Magnet School in Newport News, VA), Bill Rodriguez (University School of Nashville), and Ray Haynes (DaVinci School in Hollyglen, CA) along with University STEM Specialists Gail Hardinge (William and Mary) and Elizabeth Parry (North Carolina State University). The panelists were each given six minutes to stimulate the group discussion by focusing on the common theme of sustainability. The specific topics addressed by the panel were how to avoid teacher burn out, developing affordable projects, getting administrative buy-in, and teacher professional development.

After the panel presentations, the participants (over 200 teachers in the audience of 300 plus) was divided into groups by the tables at which they were seated. They were charged with discussing the development, implementation, and assessment of K12 engineering outreach programs and how to sustain them. Specifically the various tables were asked to discuss one of these issues: (1) establishing, (2) implementing, (3) sustaining, or (4) evaluating K12 engineering outreach programs. The participants were permitted to move around to tables representing the topic that was best suited to their interests. In addition to the topics mentioned above, several tables were designated to discuss "other" topics with the thought that a topic might arise that was not anticipated by the organizers. It was anticipated that the discussions would involve, but not be limited to the following questions:

- What is the proper place for engineering in the K-12 classroom?
- What are the characteristics of, and reasonable goals for, effective K-12 engineering education outreach programs?
- How can mentors (experienced scientists and engineers) be most effectively used in the classroom?
- What are the characteristics of the most effective mentors?
- How do you know that it works? Anecdotal or other evidence of success?
- Characteristics of effective and affordable program assessment?

- What are the advantages with working with local colleges of engineering (and education)?
- What are some examples of effective partnerships?
- Career counselors/parents as gatekeepers. How to reach them?
- Getting entre into the classroom. How practitioners can best work with teachers and the school administration.
- Characteristics of the most effective STEM education professional development programs for teachers?
- There are hundreds of STEM-related curricula and projects out there. Why aren't more of these resources used by teachers in the classroom?

The four topics above were further subdivided as follows and the particpants asked to make sure to include a consideration of at least these areas in their discussions:

1) Establishing
    - Where to find K 12 engineering materials and programs.
    - How to get administrative buy-in.
2) Implementing
    - Engineers as classroom mentors—who needs them and why?
    - Working with local colleges and universities—Merits and method.
3) Sustaining
    - How to avoid teacher burnout.
    - How to keep the programs affordable.
4) Evaluating
    - What are the characteristics of effective programs?
    - How do we know we are having the desired effect?

Each table selected a facilitator and note taker with the idea of reporting out on the table's discussion during the last 30 minutes of the plenary session. Following the meeting, an electronic "forum" was set up and the participants were encouraged to continue the discussion on line and, if appropriate, also reply to the comments that other participants posted.

The following is a topic by topic summary of the discussion as reported out during the meeting and distilled from the table notes and the forum responses.

1) **Establishing:** Successful programs need to come from a school or district initiative (not from an individual teacher), they need to be tied to state standards, aligned with the appropriate grade level, embedded in the curriculum, and assessed in order to show what works. The professional development of teachers is essential, and it must be an on-going process, not a one-day endeavor. Stipends and continuing education credits should be provided, and the sessions should be led by teacher leaders, not high-powered experts. Remember that professional development takes teachers out of the classroom and thus time is limited, and it must be used efficiently. Summer programs should be considered. Content should include integrating engineering into the curriculum, modeling the engineering design

process, focus on not only what to do, but how to do it (pedagogy), and include differentiated instruction directed at different types of learners. Don't forget that problem-based learning requires extra work on the part of the teacher.

2) **Implementing:** These comments repeated the thought that in establishing a program you have to go from the top down. Ideally, you need to start at the district level. You're not going to be successful if you do this working with individual teachers or even at individual schools. In terms of grade level to assure long-term success, you have to reach students at as young an age as possible. Fourth grade is where students lose interest in math and science. Middle school is where students make choices that can enhance or limit their ability to pursue STEM careers.

   Having engineers in the classroom is important for overcoming misunderstandings about engineering. Many children have not met an engineer and they need to see what the jobs are that engineers do. For best effect student/engineer interaction should be local and face-to-face and involve repeated contacts and long-term projects. However, engineers need to be taught how to talk to kids. A good example of student/engineer interaction is provided by Tau Beta Pi's MindSET K-12 program (http://tbp.org/pages/About/Programs/K12/index.cfm).

3) **Sustaining:** To be sustainable, programs must be affordable and not be dependent on kits of supplies. When the materials run out, the program may die. Cut costs by using recyclable materials and having teachers share materials. Local companies can help with sustainability by providing materials, and help can sometimes come from local engineering and technical education faculty and local universities. Funding can come from corporate sources, national programs (NDEP for schools with a large number of military students), local STEM booster clubs, and even the school board in response to carefully crafted reports of student success. Teaming with the school's engineering and technical education faculty and local universities might be helpful in getting resources needed to operate programs.

   Teacher burn-out is a result of trying to do too much with too little support from the administration and parents. Keep reminding yourself that "it's all about the kids," and collaborate with other teachers. In the long run, the role played by teachers has to be elevated as part of a campaign leading to a change in the national value system (engineering vs. athletics, as an example).

4) **Evaluating:** Knowing whether the program is having the desired effect requires longitudinal data, however, short term effects might be seen in increased number of students participating in more advanced math and science classes and in AP and ACT scores. Teachers can evaluate the effectiveness of their own programs, but it's important for teachers to identify their goals properly. For example, "Are we trying to create engineers or increase general technological

and engineering literacy?" In addition, good outcomes must be defined—college, deferred college, 2-year college, workforce or sometimes, just graduating is a good outcome. Measuring teamwork, problem solving abilities, and an understanding of the design process is the most difficult.

Characteristics of an effective program include use of hands-on activities, significant blocks of time devoted to STEM, ready availability of manipulatives, collaborative, engaging, purposeful student involvement, community engineering/professional organization partners, presence of a K-12 engineering coordinator/STEM coach, a STEM budget, and an established STEM school network.

Comments from the "other" tables included the need to:

- integrate activities across the curriculum to involve reading and social studies for evidence and debate and mastering math skills through story-telling,
- address elementary school teachers' fear of the unknown – for topics they aren't good at or aren't familiar with,
- overcome the high school requirements/college curricular disconnect,
- remedy poor math skills among high school graduates and poor teamwork and problem-solving skills for open-ended problems, and
- develop engineering education standards at K-12 level

2011 K-12 Division Member Survey

In May 2011, the K-12 Division sent a request to its membership to complete a short online survey The goal was to help the Division identify the "top 10 research questions" about K-12 engineering as defined by the practitioners to funding agencies and fellow researchers. Specifically, the Division asked participants to consider the most important current issues in K-12 engineering. The survey contained a mix of 15 multiple choice and open-ended items that queried respondents on their research priorities in engineering education, recommendations for ASEE K-12 Division activities, and respondent demographics. The survey remained active for three weeks, and several email reminders were sent to the membership. This section will discuss the first three survey items, related to research priorities and challenges in K-12 Engineering Education.

Ninety-three individuals responded to the survey, with 9% (n=9) of those individuals self-identifying as affiliates from industry, 24 % (n= 22) as K-12 teachers and administrators, and 67% (n= 62) as University faculty, staff, and students. Many of the respondents work across multiple grade levels, from preschool to high school ages. Many of them (n=44) have worked with K-12 students for over 10 years, and 59 respondents have worked specifically in K-12 engineering for at least 6 years. Over 60% of respondents (n= 65) indicated that they have attended an ASEE Annual Conference, while over 30% (n= 33) have attended an ASEE Annual K-12 Workshop.

The participants' top research priorities were analyzed and presented to the Membership during the 2011 K-12 Workshop in Vancouver, BC, to facilitate discussion of challenges and future research related to K-12 engineering education. The survey items pertaining to priorities were analyzed using a method of quantifying open-ended, textual survey responses; the participants' comments were aggregated by codes developed to create categories.

The first question asked participants, "Please list what you believe to be the top research priorities in K-12 engineering education today." Most member responses fell into a few main categories (See Figure1). The top three research priorities from this cohort of members included assessment of learning and skills (18% of respondents, n=29), integrating engineering into STEM (14% of respondents, n=22), and engaging students (14% of respondents, n=22). Some participants also mentioned defining engineering education, the engineering design process, and curriculum in general, project-based learning, gender, societal issues, resources, and standards.

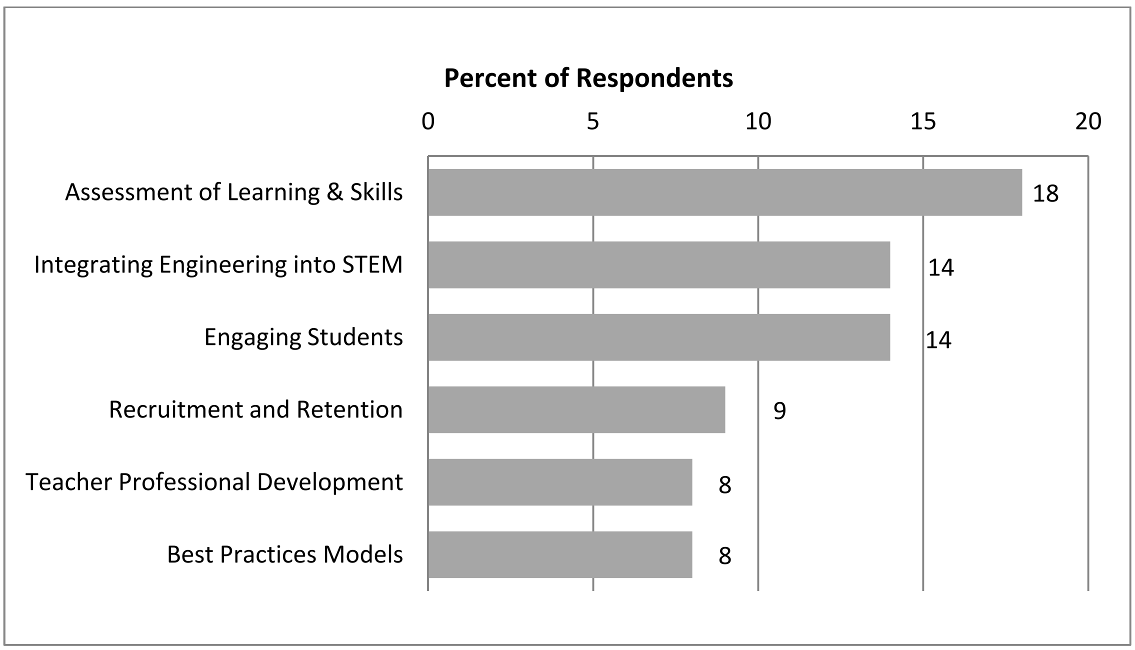

Figure 1: Research Priorities in K-12 Engineering Education

The next question asked participants, "Based on your experience, please list the greatest challenge to K-12 engineering education today." The responses varied greatly and the top nine categories included lack of teacher participation (19% of respondents), defining engineering (11 percent of respondents), and finding space in the curriculum (10% of respondents). Figure 2 shows the most frequent responses. Participants also mentioned high stakes testing, underrepresented students, students' lack of interest in STEM, critical thinking skills, acceptance by universities, lack of engineering standards, lack of engineering hub, and sustainability of programs.

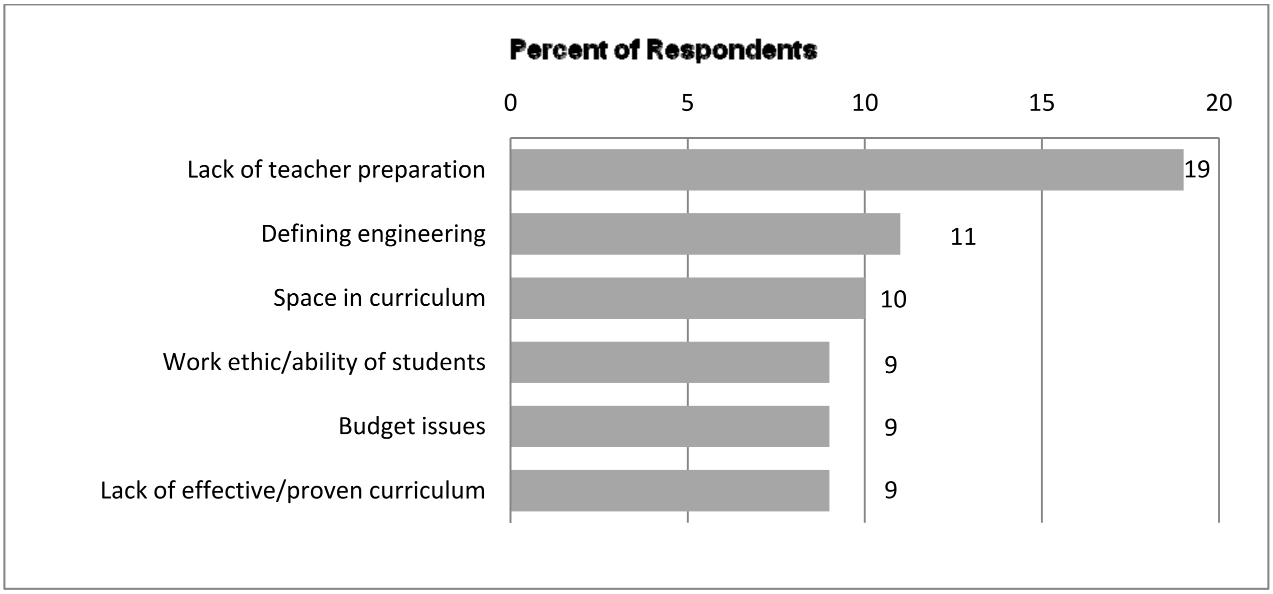

Figure 2: Greatest Challenges to K-12 Engineering Education

The third research question posed to participants asked, "If you could participate in a meeting with STEM educators from various countries, what would you define as the most important topics to discuss?" Figure 3 shows the most frequently mentioned issues. For this question, the top responses included global/international issues (15% of respondents), best practices in engineering education (11% of respondents), and integrating engineering into STEM (8% of respondents). Some members also mentioned active learning, motivating students, collaborations, cultural awareness, societal issues, national standards, overall curriculum, motivating students, communication, lessons learned, math, finding resources, sustainability, design, ethics, and informal learning

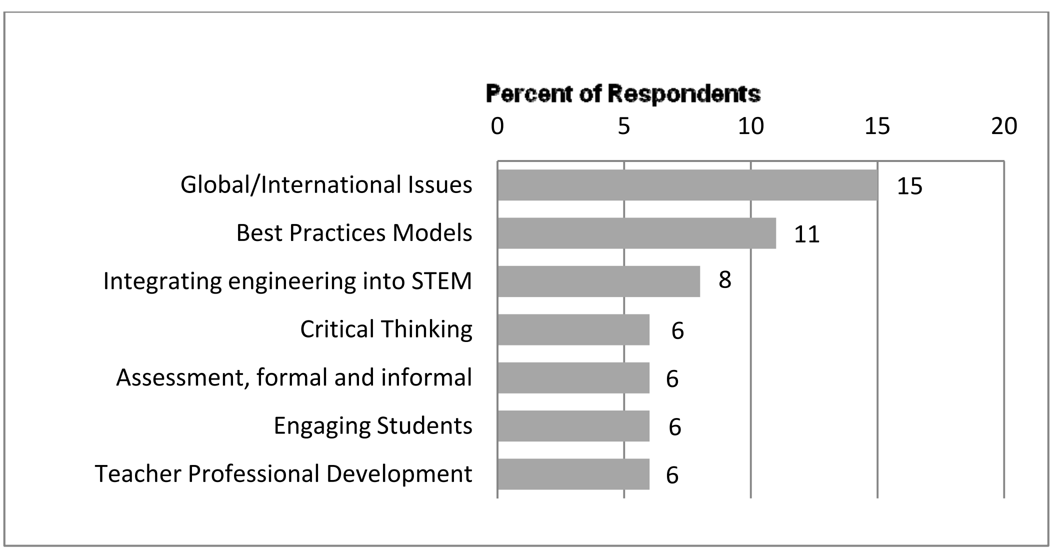

Figure 3: Most Important Discussion Items in International K-12 Engineering Education

Overall, integrating engineering into STEM, best practices models, and engaging students were repeatedly listed as top priorities in research and international discussions. Also, teacher professional development (and lack thereof) was a concern across members for all research and challenges questions.

2011 Vancouver K-12 Workshop

In June, 2011 at the Vancouver K-12 Workshop, the division executive board led a discussion on the results of both the Louisville plenary session and the 2011 member survey over a working lunch Nearly 170 participants were given an overview of the information gathered on K-12 Engineering Outreach at the plenary, and then were shown the results of the member survey identifying the most pressing research questions on K-12 Engineering. The survey identified the top three research priorities as assessment of learning and skills, integrating engineering into STEM, and engaging students. Survey respondents reflected general concern about teacher preparation and in service teacher professional development overall. Participant feedback from all methods to date also identified a need to "define" the engineering skills to be taught in K-12 so the question was posed to the Vancouver group. Using these prioritized results, small groups of mixed participants (i.e. K-12 teachers, university faculty and staff and others from informal science, industry or non-profits) were asked to discuss the following questions, recording both the salient points and strategies to address them:

1. After discussion, reach a group consensus on one specific challenge related to "Lack of teacher preparation." Then, define three actionable strategies to address this challenge.
2. After discussion, reach a group consensus on a specific research question related to one of the following, and then define three actionable strategies to address this research question:
    - Assessment of learning and skills
    - Integrating engineering into STEM
    - Engaging students
3. After discussion, reach a group consensus on a specific definition for one of the following skills and then describe a strategy for teaching that skill in an engineering context:
    - Problem solving
    - Design under constraints
    - Applying the design loop
    - Creativity

Nearly 40% of participants identified themselves as K-12 teachers, 40% university representatives (engineering faculty or staff largely) and the remaining 20% as representing informal science, industry, community or non-profit organizations.

Participant responses to the issues around **teacher preparation** were remarkably similar across the groups and reinforced input from previous efforts. In general, participants agreed current teacher preparation programs needed to be aligned with the integrated nature of STEM, i.e. the science and math professors in colleges of education currently had no real impetus to collaborate with each other or colleagues from other STEM disciplines. Students were rarely exposed to engineering in pre-service contexts, and technology remained a subject largely restricted to instructional tools vs. human made design. From the in-service standpoint, participants point out the current budget issues in K-12, accountability measures that emphasize math and English language arts, the lack of standards for engineering (and again technology being perceived as an instructional tool), and a lack of time in the school day and in professional development schedules (funding again was raised as an issue). Overall, a common and pervasive issue is the general lack of knowledge among pre- and in-service teachers about engineering. Elementary teachers, it was stated, are prepared as generalists and tend to have fears about science that extend and grow when engineering is in the mix. Secondary teachers are taught in separate programs and then operate in those same separate departmental areas in their schools causing, as one group noted, a feeling of "why care?" in these science and math instructors.

Strategies suggested to overcome these significant and longstanding barriers were mostly consistent with previous efforts, i.e. more funding, more time for training, more time for teaching, materials and kits, and effective professional development. Other creative suggestions involved the development of strong and accountable collaborations between Colleges of Engineering and Colleges of Education to both include engineering education expertise in the education classes but also to open engineering classes to non-engineering majors. Industry partnerships were often mentioned both as sources for expertise but also as key factors in "customer driven" changes that need to be made. Summer and out of class experiences for teachers and engineers together to essentially "cross pollinate" skills as well as support the K-20 pipeline of students was also identified as a possible solution strategy. Finally, standards were cited as the key driver to K-12 education and correlation to and support of current and future standards on any subject is essential to changing this preparation paradigm.

Question two dealt with the **top research priorities** identified in the member survey. Groups were to choose one of the three to focus their discussion and strategies on. "Engaging students" was chosen by half of the groups, with "assessment of learning and skills" and "integrating engineering into STEM" each chosen by 25% of the groups. When identifying strategies for engaging students, participants almost universally cited the need for relevant, hands on, integrative and problem based instruction. Several suggested using complex issues as a context for teaching all STEM subjects, seeing this as an opportunity for students to connect the theory based environment of the classroom to the world around them. All indicated a need to identify effective ways to engage more and more diverse students, and then to study these methods to determine long term impact on student achievement and future education and career choices. Comments made by those groups who chose assessment or integration fell along the same lines of identifying and publicizing models and tools that work, conducting meaningful assessment of their efficacy and sharing them widely. The word "meaningful" was often used to describe instructional approaches for engagement, integration and assessment. It is worth noting that nearly all strategies on these research topics describe the very approach to instruction and evaluation that would require teacher training and implementation these same participants identified as lacking in teacher education today.

In question three, again using feedback gathered through previous efforts, we began the process of trying to identify key aspects of **engineering principles needed in K-12** and effective strategies for teaching them. The four topics: problem solving, design under constraints, applying the design loop and creativity, are all essential to the iterative approach employed by engineers in developing solutions to complex problems. Again, groups were allowed to choose one to focus on. Nearly half the groups chose to work on "problem solving", with the remainder spreading equally between the remaining three. Participants pointed out that "problem solving" can have a much broader meaning in the K-12 classroom, but in the end it often ends up referring strictly to mathematics. However, these participants defined problem solving as iterative, based on constraints, having multiple solutions, relevant, complex, and including reworking or improving. This broader definition places problem solving in a similar role as both design under constraints and applying the design loop. Creativity was described as an even more integrative approach involving the arts and other non-STEM subjects. An issue was raised around how to assess these topics, in particular creativity, and this suggests again a return to a general lack of knowledge of what engineering can and does look like in the K-12 classroom.

Through this effort, the ASEE K-12 and Precollege Division has further honed key aspects of engineering in K-12 classrooms.

Instructional and Policy Implications

In looking over the results presented here, there are the recurring themes that have arisen in the Louisville and Vancouver meetings and the member survey that are echoed by the instructional and policy recommendations found in *Engineering in K-12 Education* [2]. These recommendations and their connection with these themes (in parentheses) are:

- Recommendation 1. Foundations and federal agencies should support long-term research to study the impact of engineering education on students' career aspirations and technological literacy. (The need for engaging students through sound curricula and experiences.)
- Recommendation 2. Funding agencies should support rigorous evaluation programs. (The need for quality assessment)
- Recommendation 3. Federal funds should be provided to support research into the use of engineering design as a tool for enhancing math and science education. (Need for engaging students through sound curricula and experiences.)
- Recommendation 4. The American Society of Engineering Education, through its Division of K-12 and Pre-College Education, should begin a national dialogue on preparing K-12 engineering teachers. (This is the purpose of this paper.)
- Recommendation 5. Teacher professional development training should be differentiated by racial, gender, socio-economic group, and location (urban or rural) in order to enhance its effectiveness. (The need for teacher professional development.)
- Recommendation 6. Foundations and federal agencies should fund research that respects the differences in school systems and provides engineering-related educational access to

under-represented groups. (The need for funding to develop and support quality K-12 engineering programs.)

From an instructional viewpoint, changes in both pre-service training and in-service professional development to incorporate engineering and technology principles will be required for paradigm shifts in the K-12 classroom. The results of these efforts help to both define these changes and develop ways to provide a research-based body of knowledge on which to base them. From a policy perspective, the ramifications of the ten year old No Child Left Behind reauthorization of ESEA (Elementary and Secondary Education Act) have led to an environment where standardized testing and the resultant accolades or sanctions that may result drive instructional time in the classroom. The ability, therefore, to add any subjects to the already packed school day is limited. By identifying the important engineering principles to be addressed, we can focus on those key points and seek ways to integrate instruction to provide our students with a more relevant and practical educational experience for their future success. In addition, engineering educators should be a part of new policy initiatives and standards development to assure both inclusion of key skills and integration of subjects for a rigorous and relevant K-12 education, including having a significant and meaningful presence in the development and definition of standards involving engineering, such as the Next Generation Science Standards.

Conclusions

The national conversation about STEM as well as alignment of funding priorities to support it in K-12 schools is providing a uniquely opportune time for engineering educators to participate. Traditionally, STEM has meant either math or science or some combination of those two. The emergence of the importance of technology and engineering to a comprehensive and effective STEM implementation provides those disciplines the opportunity to shape the direction of the movement. Many recent national and international reports and indicators speak to the need to increase the overall engineering and technological literacy of citizens. Clearly, the inclusion of engineering educators is key to any paradigm shift anticipated in K-12 STEM education. By identifying the challenges and opportunities to sustainable and effective STEM programs in the US and globally, the ASEE K-12 and Precollege Division seeks to establish guidelines for a foundation of research based practice which will directly impact student learning and performance.

References

(1) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, National Academies Press, 2007.

(2) *Engineering in K-12 Education*, National Academy of Engineering & National Research Council, National Academies Press, 2009.