ENGINEERING FOR MIDDLE SCHOOL RURAL LEARNERS –

LEARNING THEN EARNING DIGITAL BADGES

Attributes of a Global Engineer (AGE), Middle School Initiative

Dr. Barbara Peterson, Tiffany Coulson
NLA Group ⬩ Wapato,Washington

This white paper describes a ten school district collaboration with the NLA Group, Central Washington University and others to build a middle school pipeline to recruit rural central Washington students, including many Hispanic and Spanish speaking studenst, to engineering and STEM fields. Washington State is home to Boeing and other global firms who engage an international workforce to complete major project, necessitating a new kind of engineer – one that is globally aware, speaks languages in addition to English, can work collegially across space and time zones, can problem solve and collaborate with fellow engineers around the world. The field of engineering is diversifying, bringing more persons of color and greater gender balance to its workforce. The time to recruit future engineers is middle school; if students aren't on track for rigorous math and science as they <u>enter</u> high school, they likely will not pursue an engineering college major nor imagine it as a career. Students in rural central Washington include many who are culturally diverse (Hispanic, Native American), may speak another world language (Spanish), and who are exposed to engineering concepts (wind towers, dams and water reclamation, technologically sophisticated agricultural machinery, etc.) but are not attuned to careers in these fields. Many rural middle school students retain curiosity and an innate engineering aptitude. This initiative uses a nationally recognized engineering design curriculum coupled with digital badges that give students recognition and durable evidence of their work in rigorous engineering projects that recruit students to engineering.

I. Background

In 2003, Boeing began development of the 787 Dreamliner. Departing from their traditional manufacturing process, Boeing engaged global subcontractors in India, Italy, Japan, South Korea, Sweden and other US firms outside the Pacific Northwest to complete sub-assemblies that were shipped to the Boeing Everett plant where the parts were assembled. This global collaboration with internationally sourced and developed components was intended to engage the very best minds, to build a lean and nimble new manufacturing process, and to reduce costs. But it ran into several snags that resulted in delays in 2007 and 2008, when component parts did not mesh as designed.[17]

For global firms like Boeing, the challenge of facilitating complex projects from sites around the world has spurred the need for a new kind of engineering professional. Not only must early career professionals display knowledge and competence in science, technology and engineering, they must also possess 21st century skills such as cultural competence, collaboration, digital literacy, communication through various media, and proficiency in more than one language.[4] As these global companies started to develop a list of these competencies, they directed their human resources departments to search out appropriate candidates. In turn, these HR departments began collaborating with universities, encouraging them to augment their engineering programs to turn out globally-competent engineering graduates. From here the pipeline extended down to the high schools, as universities broadened the scope of what they were seeking as they admitted new freshmen. (L. Brown, personal communication, June 2013.)

In response to this need to refine the profile of engineering professionals who will be ready to work across global borders, The American Society of Engineering Educators (ASEE) embarked on a seven year effort to identify the core strengths required by those organizations hiring engineers throughout the world.[4] The resulting report, *Attributes of a Global Engineer*, produced 20 of the most important attributes engineers will need as they begin working in an increasingly global setting (see Appendix A).

The final report on Attributes of a Global Engineer was delivered at the ASEE Annual Meeting in Seattle Washington in the summer of 2015. Less than two years earlier, Washington State had launched its own initiative to educate a more global workforce. In a state where up to 40% of jobs have international connections, area leaders identified a gap between industry needs and academic focus. "Select students are engaged globally, but the majority is not exposed to the international perspectives they need to live peacefully and productively in our globally diverse and interdependent society."[14]

Refining the skills of globally competent engineers complicates an already challenging recruitment picture. The proportion of new engineering degrees awarded is increasing outside the United States but declining here.[6] A seminal paper released in 2005 from the National Academy of Sciences and National Academy of Engineering, *Rising Above the Gathering Storm,* suggested that the ability of the United States in the 21st century to recruit and educate world-class scientists, mathematicians, engineers and technologists was critical to sustaining the health and vitality of the United States.[21] The committee writing the report recommended "placing a higher priority on improving the undergraduate and graduate talent pool for science and engineering by improving pre-college science and mathematics education."[22] This is a challenging requirement because of a lack of a specific engineering curriculum in the pre-college environment of U.S. high schools and middle schools. With no curriculum and minimal if any exposure to what engineering is and what engineers do, the pathway to recruiting students is difficult to locate, much less navigate.[5]

As Boeing's Dreamliner manufacturing experience suggests, finding engineers with 21st Century skills is critical to the global supply chain. Furthermore, as noted by the National Academy of Science, National Academy of Engineering and Institute of Medicine of the National Academies, 2007, diversity will drive innovation. Engineering has been dominated by white males, but today there are fewer of them coming into the professions, just as a significant number of white males is preparing to retire from the field.[6] This trend strongly suggests the need to recruit outside this demographic if we hope to replenish the supply of engineers.

II. Middle School: Pivotal timing for developing engineering skills.

Schools all over America are filled with students who have immigrant backgrounds from many nations and most of these students speak a second language in addition to English. "The U.S. student body is diverse and includes increasing numbers of low-income, minority, and immigrant students. Racial, ethnic, gender, and social-class differences in interest and preparation appear as early as elementary and middle school and early disadvantages produce persistent educational and labor force disparities that limit the diversity of students entering STEM fields." As these differences in engagement prevent middle school students from aligning their educational plans and career goals, they will produce long-term deficits, particularly in STEM fields.

As students enter middle school, there is often a reduction in school attachment in general, and a decline in their engagement with math and science. Given that the vast majority of U.S. middle and high school, especially those schools serving underrepresented students, offer no curriculum and often no mention of engineering, these students don't aspire to be engineers. Such students might be drawn to the positive contributions engineers make and the problem-solving engineers do, but the paucity of information available to them nearly ensures that unless specific outreach is provided they will not pursue engineering fields. "Engineering interventions and outreach need to help students develop realistic strategies to bridge their interests with the opportunities available to them during the complex transitional years of middle and high school."[5]

To make it possible to bring these diverse students along the pre-college pipeline ready to enroll in university engineering programs, recruitment must start in the middle school. The most decisive moment in a student's readiness for an engineering career is the year in which he or she first takes algebra. Students who complete algebra in 7th or 8th grades are in step to complete the additional science and math high school coursework that prepare them for collegiate programs and possible engineering careers.[26] If their parents are highly educated, the likelihood that students will take rigorous courses of math and science that will prepare them for a potential engineering career is higher whether or not they have a stated desire to pursue engineering. For underserved students, this critical decision point is missed. Without parental or counselor support, these student populations have little or no incentive to take the requisite science and engineering courses. With little or no exposure to engineering activities, and minimal support for academic preparation, there is little likelihood that these students will aspire to an engineering field.[26]

III. Rural Students: Local context for engineering education

For rural students, challenges in school staffing, community expectations, teacher training and academic resources limit their exposure to quality STEM curriculum in school.[27] In order to meet these challenges, it is necessary to take a harder look at what goes on in a geographically isolated environment. Students in rural areas often have first-hand exposure to engineering outside the classroom thanks to their familiarity with sophisticated agricultural field machinery or highly mechanized fruit packing facilities and their proximity to dams and water irrigation programs, myriad newly installed wind towers, etc. But they are not often made aware of the fact that these activities represent careers they might be uniquely qualified to pursue.[2] "Whether on the farm, working with the hydraulic system of a tractor, or in the backyard tinkering with old car parts, children in rural settings acquire science and engineering skills and knowledge in the context of their daily lives."[3]

Using local "funds of knowledge" to fuel interest in engineering is a key component of a curriculum that would reach both rural and Hispanic students at an early age. Making engineering relevant to students highlights their natural affinity for creative thinking, problem solving and collaboration. Dr. Christine Cunningham, Vice President of Research at the Boston Museum of Science, and consultant at the Center for Engineering Educational Outreach at Tufts University, has observed: "Children are born engineers – they naturally want to solve problems and we tend to educate it out of them."[3]

Perhaps the most promising advantage of presenting engineering as a career to marginalized populations during middle school is the integration into the curriculum of skills that are required to work successfully on engineering projects. "In contrast to traditional mathematics and science courses, where students are typically encouraged to independently identify a single correct solution to problems, an engineering approach requires logical and divergent thinking, problem solving, communication of ideas, and teamwork."[5] Even students who struggle with academic content may find success taking part in engineering processes, and this success has the power to drive more interest in engineering among students of all backgrounds prior to high school.

As the base of students who are exposed to engineering grows, it is important to consider the needs of a widely diverse population that will be drawn to the profession. "The state of Washington, for example, is one of the most diverse in the country, ranking 10th in the U.S. Seattle Public Schools enroll students from more than 98 countries, and teachers support students and families speaking more than 208 languages."[14]

Washington State's rural populations are unique in the U.S. Washington stands behind only Alaska and New Mexico in the number of rural areas with the largest percent of English language learners, indicating thousands of students who speak another world language (primarily Spanish) in addition to English.[19] These bi-lingual students are associated with either agricultural or other rural environments and are therefore exposed, but not attuned to engineering fields.

IV. Hispanic Students: Recruitment of a more diverse population in engineering

If they are recruited and nurtured, Hispanic populations offer great potential as a source for providing diversity to the engineering corps. They are the fastest growing racial group and, as a group, they are younger than whites and all racial minorities.[29] While not many Latinos and Latinas apply to engineering majors, those that do tend to persist. As noted, the field of engineering remains significantly white and male. However researchers note, "…the problem in engineering for Latinos and Latinas is primarily one of recruitment not retention." Further, "engineering is not a "weed-out" major; a landmark study showed that engineering matriculants persist more than any other major."[6]

Hispanic culture gives an elevated status to engineers, conveying respect for the profession similar to a medical doctor.[6] Encouraged by this cultural regard, Spanish speaking students may find their way to engineering as a career if supported early in their education. Recommended ways for engaging Latinos in engineering include making engineering meaningful for students by changing the pedagogy to enable students to envision themselves engaged in real work problems, emphasize the value of working in teams, and demonstrate how the contributions of engineers improve society and communities.[6] Especially for rural Hispanic students who may experience geographic and cultural isolation, the presence of social networks, mentors and role models is essential if we want to help them engage with the engineering community and build a network that will support them into post-secondary engineering study.

V. Second Language Advantages

One of the most important reasons for cultivating engineering skills in rural, Hispanic students is their knowledge of a second language and the contribution they could make toward achieving a bilingual engineering community. Fluency in a second language not only contributes to employability in the global workplace, it can enhance self-image, cultural awareness, and the ability to learn and think creatively, all of which are skills valued in the engineering profession.[4]

Out of the 20 Attributes of a Global Engineer, mastery of foreign languages is considered an essential communication skill by corporations around the world; yet it is virtually the only attribute that is not endorsed in any academic or professional set of standards. According to its definition, a global engineer should be "Technically fluent in at least two languages, acknowledging English is considered a key global language."[4]

The Global Washington initiative also recognizes the importance of foreign languages from preschool through post-secondary education. The initiative advocates for all students to learn a second language, and recognizes that highlighting fluency in additional languages can provide benefits to those children who are part of the 1 in 6 families in Washington State that speak a second language at home. "For students who are second language learners, it is also important that their languages and cultures be seen as valued in their school environments. Enhanced self-image and the security of acceptance, result from foreign language learning that capitalizes on the cultural diversity of the classroom and community."[14] Engendering a global perspective within local contexts may be an important part of including more diverse populations in the engineering community through foreign language learning.

While second language use may certainly be considered a valued skill, it is also a catalyst for learning and processing information. "Marcelo M. Suárez-Orozco, the Ross University professor of Globalization and Education at New York University, explains that 'neuroscience is beginning to show that the brains of bilinguals may have advantages in what will matter most in the global era: managing complexity, rational planning and meta-cognition.'"[14] Fluency in more than one language developed in early childhood has also been shown to give bilingual children a cognitive advantage over monolingual children. As they increase their skill in switching across lexical systems, this skill is transferred to other tasks.[9,11] Enhanced "cognitive flexibility" in bilingual children may actually prepare them early in life to think like engineers.

VI. Project Intent

Engineering has the potential to highlight the strengths of some marginalized students in STEM subjects. Curiosity, creativity, the ability to think about community, to work in teams, and the ability to communicate to a variety of audiences in more than one language can make up for other academic and resource deficits these students might encounter. "Producing a larger and more diverse next generation of engineers requires that we improve underserved students' interest in, knowledge about, and ability to track toward careers in engineering at this critical time in their educational experiences."[5]

This project seeks to do just that – to provide exposure to engineering concepts, activities and projects to populations of underserved middle school students – rural, Hispanic, low income, both male and female, in rural Central Washington only a few hours from the home of Boeing corporation and its world-renowned engineers.

The project, Attributes of a Global Engineer (AGE), Middle School Initiative, was presented last September to a group of educators and engineers who affiliate with the SOAR[3] GEAR UP Program with Central Washington University. The purpose of the project is to build the middle school portion of the AGE pipeline that currently connects the industry to universities and select high schools. Recognizing that middle school years represent the critical point where students must engage with rigorous math and science in order to be ready for collegiate programs when they graduate high school, this was deemed the critical time and place to expose students to rigorous but engaging engineering tasks that would tap into their innate interest in and aptitude for engineering.

The September meeting set in place several initiatives: 1. Identify a nationally or internationally recognized curriculum that could be the underpinning of the content of these rigorous activities; such curriculum needs to be at least aligned with Common Core State Standards and Next Generation Science Standards; 2. Pursue the idea that students could earn some nationally-recognized credential chronicling their completion of these tasks; digital badges were identified as the best solution; 3. Augment this curriculum with tasks that reflect the additional challenge of building the 'global' skills that are needed to communicate with people of other cultures and different languages, and to be sensitive to needs of populations beyond American borders; 4. Find a way to measure the impact of these efforts. Assessment efforts should focus on changes in: a. student attitudes toward engineering or STEM fields; b. the curricular rigor of STEM offerings, specifically engineering, at the middle school level; c. teacher attitudes toward underrepresented students' ability to 'do' engineering and d. willingness of universities to recognize digital badges as evidence of the likelihood that these students will succeed in academic programs.

VII. Indicators of Progress

Before the launch of the project, both participating project students and students not targeting but still within the school district were given *the Middle/High School Attitudes toward STEM Survey*, produced by the Friday Institute for Educational Innovation.[12] The survey was cross-referenced against the Attributes of a Global Engineer for similar content. Attributes not addressed by the survey were supplemented with 12 pilot questions for evaluation in the initial assessment. The survey will be given again, after year one of the project.

VIII. Curriculum and Learning Tools

Our unique population of students presents a particular set of challenges in adopting a design for engineering education that will fit their needs. The particular needs of the students, their parents, and community and educators in both in and out of school contexts were all carefully considered in the design of this project. The three pieces of the engineering education initiative that was designed for rural, middle school students eventually included the curriculum, an abbreviated system of digital badges, and a progressive social media platform.

Because engineering in small, rural schools tends to be taught either as a supplement to science classes, or as a stand-alone program outside of school, it was important to find curriculum that would support educators, inform parents and connect with community as well as introduce sound engineering principles to students. The validation of educational materials for engineering takes place through alignment to accepted standards such as Common Core Anchor Standards, Next Generation Science Standards, ITEEA Technology Standards, and Career and Technical Education Standards. The use of project-based learning in which students work from a guiding question, use the engineering design process, learn from analyzing failure, reflect on their work and communicate their work to others are all essential parts of effective engineering curriculum. In addition, curriculum should be piloted in a variety of educational environments, and evaluated or vetted by professional engineering educators. Several sites on-line offer excellent resources for teaching engineering that meet these criteria: *TeachEngineering.org, TryEngineering.org, and EIE.org.*

Digital badges are virtual artifacts of learning that not only display achievement, but also hold information about content such as alignment with standards. Since engineering curriculum is not commonly standardized or understood, the transparency offered by digital badges helps validate the experience of the person who has earned the badge.[15,16]

The choice to work in the beginning exclusively with the Engineering is Elementary curriculum, produced by the Museum of Science in Boston, was made because of their emphasis on "maximally inclusive" design principles.[7,8] Engineering is Elementary, and the companion middle school units entitled "Engineering Everywhere" are well-researched and piloted curriculum modules that are built on inclusive design principles. The project-based learning modules are carefully constructed so that all students are able to participate and enjoy success while learning the principles of engineering. The elements of an equitable and inclusive engineering curriculum are real-world context, authentic engineering practices, scaffolding of student work, and fostering a collaborative, student-led learning environment.[8] (see Appendix B)

Among the ten districts participating in the AGE Middle School initiative, there are five pilot middle schools (Chief Joseph Middle School, Richland School District; Orchard Middle School, Wenatchee School District, Tonasket Middle School, Omak Middle School, and Highland Middle School) who will test the premise and preview and experiment with the curriculum, and help with the design of associated digital badges. A science teacher at Tonasket Middle School will preview components in a full-semester implementation beginning in March 2016, using the following five units from Engineering Everywhere: Bioplastics, Vertical Farms, Prosthetic Tails, Pandemic Reponse and Insulated Homes.

Real World Context

Making curriculum relevant to students helps them see how engineering can be used in a way they can understand. "The study of real world contexts such as the local environment or global contexts has been found to increase students' engagement, enthusiasm, and achievement."[8] Especially for marginalized populations, this kind of interest is essential to changing student attitudes toward engineering.

While the curriculum supports real-world context, digital badges can amplify this aspect of inclusive engineering curriculum by validating the content to people outside a student's local context. Validation of their effort by people in the engineering field, and by other engineering educators and students makes real world application of concepts even more "real" to them.

Authentic Engineering Design Practices

Inclusive curriculum design includes open-ended questions such as one finds in project-based learning, values failure as a means of learning, and supports use of both qualitative and quantitative indicators of achievement. "It must engage students in active participation in the practices of engineering as they work toward developmentally appropriate design challenges…"[8]

Digital badges augment opportunities for recognition outside of conventional assessment methods.[15] They may represent recognition of participation, developmentally appropriate levels mastery, or measures of learning non-academic skills such as collaboration, leadership, communication and creativity. As students recognize their achievements in non-academic aspects of engineering, they may adjust their view of the challenges that they expect to face in succeeding in STEM subjects.

Scaffolding Student Work

Assessment of content knowledge in quality engineering curriculum should remain rigorous and be aligned to accepted standards so that all students have the opportunity to engage in engineering activities at a high level. The EIE curriculum adds inclusive design to rigorous content that scaffolds student learning through modeling, multiple modes of learning, and by assuming no prior experience with concepts or terms. "…scaffolding and guidance support students as they learn key concepts and practices and become fluent with the cultural norms of engineering."[8]

Demonstrate that "Everyone Engineers" and Everyone CAN Engineer

Inclusive curriculum design "…must engender learning environments where students can contribute, collaborate, and develop their own sense of agency, expertise, and ownership."[8] As students become engaged with engineering projects in a way that highlights contribution rather than competition, they are able to see success and identify themselves as part of an "engineering" community. Students who are given the opportunity to make choices about their learning and the responsibility to carry through with all aspects of a project are more confident in themselves and more interested in the subject. "Whether they are knowledgeable or struggling, students are more likely to adopt a science (or engineering) identity if they have the opportunity to be active and collaborative producers of knowledge for the classroom community."[8]

As students are able to choose various pathways within the curriculum, digital badges enhance self-regulated learning by allowing them to collect and display their chosen achievements.[15,16] Badges will be offered not only for content knowledge or completion of curriculum, but students will also be able to pursue mastery of communication, mentoring, leadership or teamwork badges that will emphasize their strengths in the 21st-century skills that are valued in the engineering profession. Digital badges do more than represent achievement; they act as a visual identity of affiliation with the engineering community.[25]

Digital badges augment inclusive design principles by recognizing learning across contexts, by assessing students using alternative methods and by providing transparency outside the learning ecosystem that can validate learning and add value to engineering experiences for the student.[1]

In order to share their achievements and broadcast their identity as engineering participants, students will become part of a virtual educational platform called ObaWorld, where they will be able to display e-portfolios, discuss their projects with others and display their badges. Maintained by the University of Oregon Department of Education, ObaWorld was developed by international author, speaker and educational reformer Yong Zhao. In his 2012 article, "World Class Learners," he asserts, "Excellence in education should … be measured by its effectiveness in providing personalized education that promotes diversity and creativity, on a globalized campus that engages children in global interactions, through product-oriented learning that inspires entrepreneurship and innovation."[31] ObaWorld will be an essential tool for allowing rural students to reach beyond their communities to communicate with other student engineers. The platform will give Hispanic students a way to mentor each other and to be mentored by other Spanish-speaking students and educators within the ObaWorld community. And the virtual environment will introduce students to a means of practicing engineering skills outside the context of the classroom by making distance collaboration a reality for them. The extension of the 21st-century skills acquired through project-based engineering curriculum will be applied in the ObaWorld virtual environment.[30]

Experts in the field of digital badging have identified 40 design principles important for successful badging projects.[15,16] However, the context of each badging project determines the relative importance of those design principles. For Hispanic, middle-school students in rural areas, the purpose of digital badges is to motivate young learners by successfully engaging with STEM subjects, and to help them to identify themselves as potential engineers.[15]

Attributes of a Global Engineer

Adopting the "Engineering Everywhere" curriculum from the Museum of Science in Boston will ensure the project has an inclusive framework that can be used highlight Attributes of a Global Engineer. While the built-in assessments are designed around curriculum content, digital badges may be earned based on alternative standards of measuring student learning outcomes. Students will be able to show understanding of important engineering attributes by participation, by demonstrating the ability to work in teams, to communicate using technology, and to potentially align their work with students outside of the U.S. by communicating in a second language and identifying areas in the world where the artifacts of their curricular unit might find real-world applications. One example would be to use the lesson learned in the curricular unit on vertical farms to see if such a concept might help displaced rural refugees from agricultural regions in Mali in sub-Saharan Africa. People in this region of the world, because of political instability, have been relocated to urban settings in the main city of Bamako. Could concepts of vertical farming allow these displaced persons to engage small-scale farming techniques in a much denser environment, allowing these agricultural families to reduce their own food scarcity and provide a small income? Students could test these applications against design constraints imposed by this real-world application, and then look for ways to solicit feedback from NGOs located in Mali to test their learning.

In these ways, we are hoping to engage and prepare rural, underrepresented students to become engaged in engineering, in order to motivate and encourage them to pursue college majors and careers in engineering.

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Appendix A

20 Attributes of a Global Engineer

	High School	College	Professional	*The following are Attributes of a Global Engineer from the international study conducted by the American Society for Engineering Education's Corporate Member Council.* *As communicated by global research participants, the top eight attributes according to importance and need for proficiency are highlighted. Variations that outline the top two desired attributes at each stage of an engineer's development are indicated as well.*
1.	X	X		Demonstrates an understanding of engineering, science, and mathematics fundamentals
2.				Demonstrates an understanding of political, social, and economic perspectives
3.		X		Demonstrates an understanding of information technology, digital competency, and information literacy
4.				Demonstrates an understanding of stages/phases of product lifecycle (design, prototyping, testing, production, distribution channels, supplier management, etc.)
5.				Demonstrates an understanding of project planning, management, and the impacts of projects on various stakeholder groups (project team members, project sponsor, project client, end-users, etc.)
6.				Demonstrates an understanding of the ethical and business norms and applies norms effectively in a given context (organization, industry, country, etc.)
7.				Communicates effectively in a variety of different ways, methods, and media (written, verbal/oral, graphic, listening, electronically, etc.)
8.				Communicates effectively to both technical and non-technical audiences
9.				Possesses an international/global perspective
10.				Possesses fluency in at least two languages
11.				Possesses the ability to think both critically and creatively
12.			X	Possesses the ability to think both individually and cooperatively
13.			X	Functions effectively on a team (understands team goals, contributes effectively to team work, supports team decisions, respects team members, etc.)
14.	X			Maintains a positive self-image and possesses positive self-confidence
15.				Maintains a high-level of professional competence
16.				Embraces a commitment to quality principles/standards and continuous improvement
17.				Embraces an interdisciplinary/multidisciplinary perspective
18.				Applies personal and professional judgment in effectively making decisions and managing risks
19.				Mentors or helps others accomplish goals/tasks
20.				Shows initiative and demonstrates a willingness to learn

The Attributes of a Global Engineer Project | Global Engineering Dean's Council. (2015, June 1). Retrieved September 1, 2015, from https://www.gedcouncil.org/publications/attributes-global-engineer-project

Appendix B

ENGINEERING IS ELEMENTARY: RECOMMENDATIONS

The Engineering is Elementary project is firmly committed to creating curricular materials that invite all children to engage in problem-solving, inquiry, and innovation. Drawing from related research and our experiences, we articulated design principles and applied these principles to the guide the development of 20 elementary curriculum units. These units have been tested and used in classrooms across the country; to date we estimate that approximately 2,700,000 children and 32,700 teachers have used EiE. Research and evaluation data suggest that the EiE materials have engaged girls, children of color, children from low socioeconomic groups, and children with disabilities and have resulted in learning gains related to both engineering and science (Lachapelle, Cunningham, Jocz, Kay, Lee-St. John, et al., 2011; Lachapelle, Cunningham, Jocz, Kay, Phadnis, et al., 2011).

We purport that attention to including underserved and underperforming groups must be central to the design of materials from their inception. Well-designed materials are critical for attracting, engaging, and retaining students' interest and confidence in engineering. Thus, we set forth our inclusive principles as a starting point for a conversation about resource design.

Set Learning in a Real-World Context:
– Use narratives to develop and motivate students' understanding of the place of engineering in the world.
– Demonstrate how engineers help people, animals, or society.
– Provide role models with a range of demographic characteristics.

Present Design Challenges that are Authentic to Engineering Practice:
– Ensure that design challenges are truly open-ended with more than one correct answer.
– Value failure for what it teaches.
– Produce design challenges that can be evaluated with both qualitative and quantitative measures.
– Cultivate collaboration and teamwork.
– Engage students in active, hands-on, inquiry-based engineering.

Scaffold Student Work:
– Model and make explicit the practices of engineering.
– Assume no previous familiarity with materials, tasks, or terminology.
– Produce materials that are flexible to the needs and abilities of different kinds of learners.

Demonstrate that "Everyone Engineers" and Everyone CAN Engineer:
– Cultivate learning environments in which all students' ideas and contributions have value.
– Foster children's agency as engineers.
– Develop challenges that require low-cost, readily available materials.

Cunningham, C. M., & Lachapelle, C. P. (2014). Designing engineering experiences to engage all students. *Engineering in pre-college settings: Synthesizing research, policy, and practices*, 117-142. Retrieved from http://www.eie.org/sites/default/files/2012ip-Cunningham_Lachapelle_Eng4All.pdf