ENGINEERING FOR US ALL

Engineering For US ALL (E4USA)

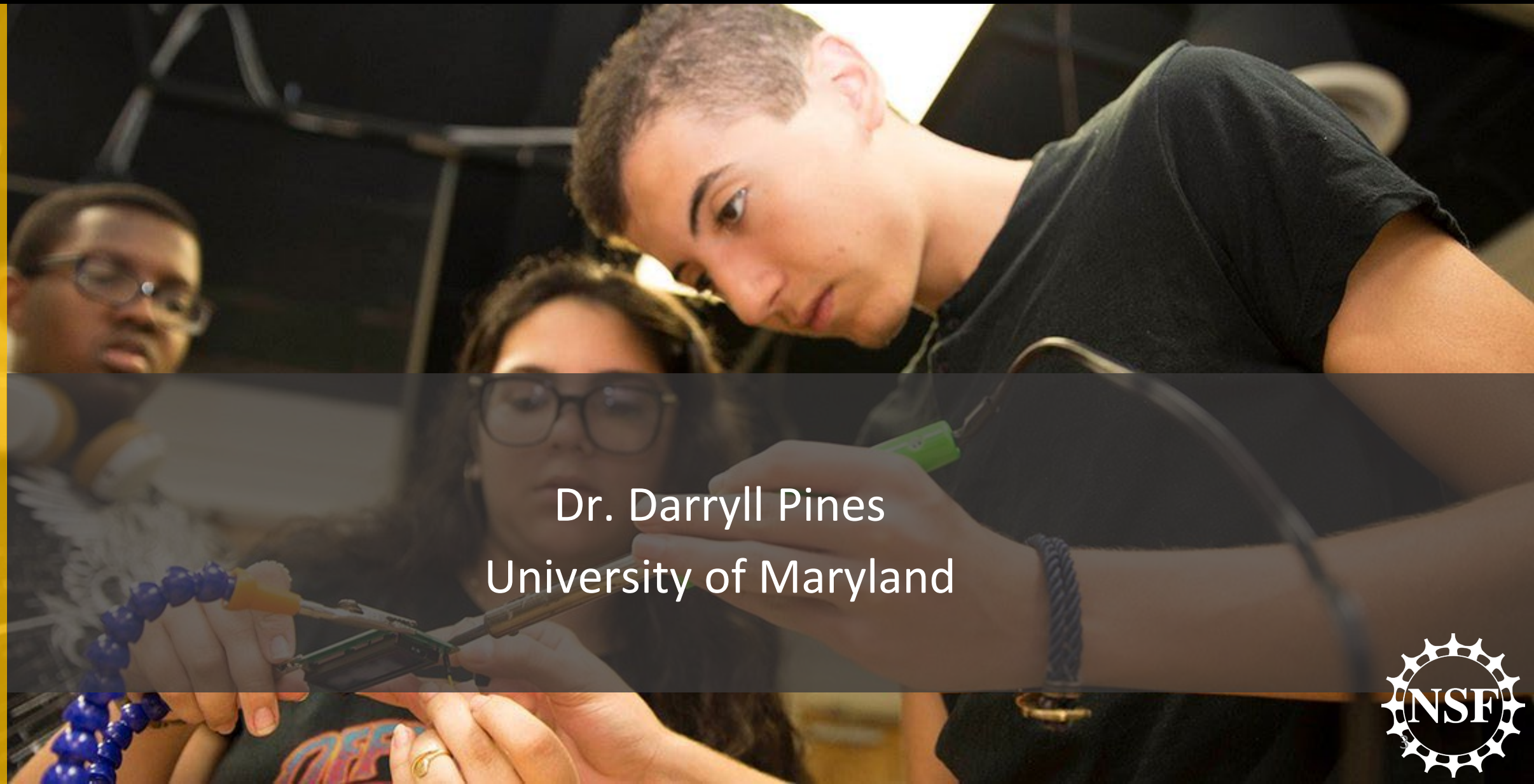
NSF EEC Grantees Conference
October 2019

ENGINEERING FOR US ALL

Overview

- Overview
- Curriculum
- Professional Development
- Partnerships
- Credit and Placement
- Research & Assessment
- Small Group Breakouts
- Final Questions

Introduction



Dr. Darryll Pines
University of Maryland

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The National Problem

In 2007, *a Carnegie Foundation* commission of distinguished researchers and public and private leaders concluded that "the nation's capacity to innovate for economic growth and the ability of American workers to thrive in the modern workforce depend on a broad foundation of math and science learning, as do our hopes for preserving a vibrant democracy and the promise of social mobility that lie at the heart of the American dream"[1]. However, the U.S. system of science and mathematics education is performing far below par and, if left unattended, will leave millions of young Americans unprepared to succeed in a global economy.

- **Reduction of the United States' competitive economic edge**
  - Shrinking share of patents: Foreign competitors filed over half of U.S. technology patent applications in 2010.
  - Diminishing share of high-tech exports:
- **Lagging achievement of U.S. students**
  - The 2012 Program for International Student Assessment (PISA) ranks the United States as 23rd in Science, 30th in Math, and 20th in Reading Literacy out of 65 OECD education systems.
  - In 2012, 54% of high school graduates did not meet the **ACT's college readiness benchmark** levels in math, and 69% of graduates failed to meet the readiness benchmark levels in science.
- **Essential preparation for all careers in the modern workforce**
- **Scientific and technological literacy for an educated society**

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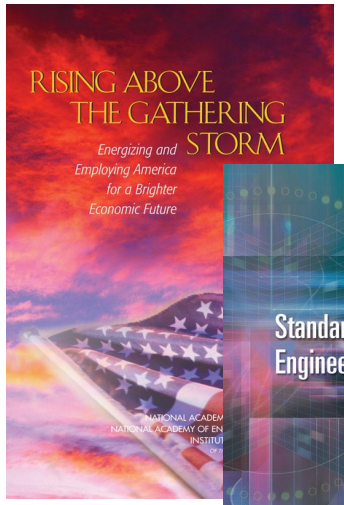
National Academy Studies

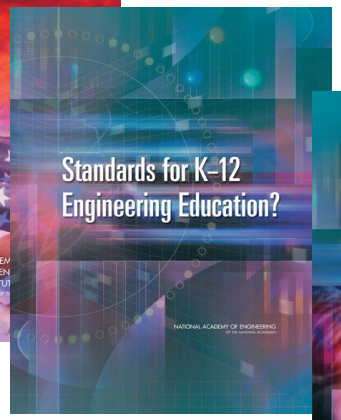
Call to Action

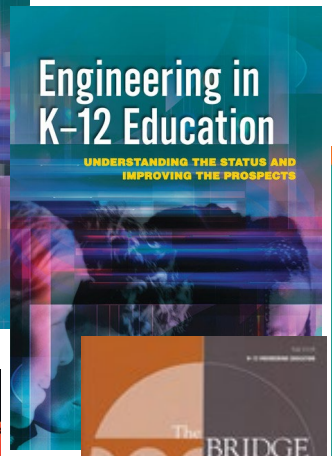
Framework/Standards Development

Curriculum Development

Implementation



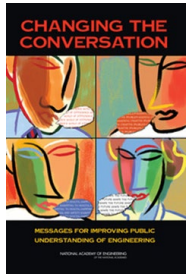


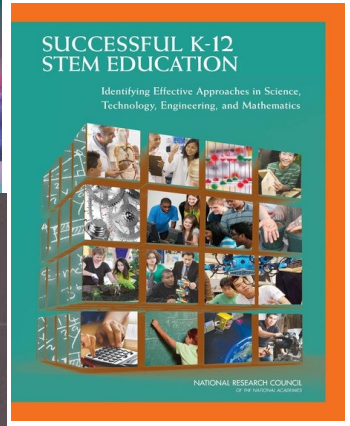


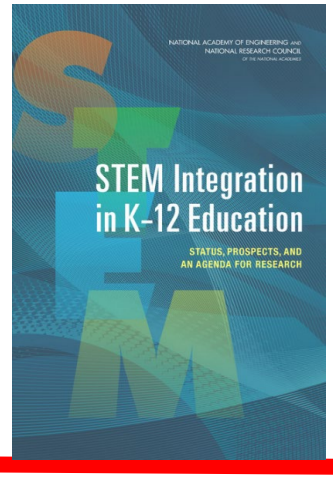
NEXT GENERATION SCIENCE STANDARDS

"Now Includes Engineering"

Norm Augustine
C. Dan Mote
Linda Katehi







K-12 Network:
LingEngineering.org

Curriculum Refinement

Professional Development
Training
NSF REF

Assessments
Evaluation

2006 2008 2010 2012 2014 2016 2018 2020

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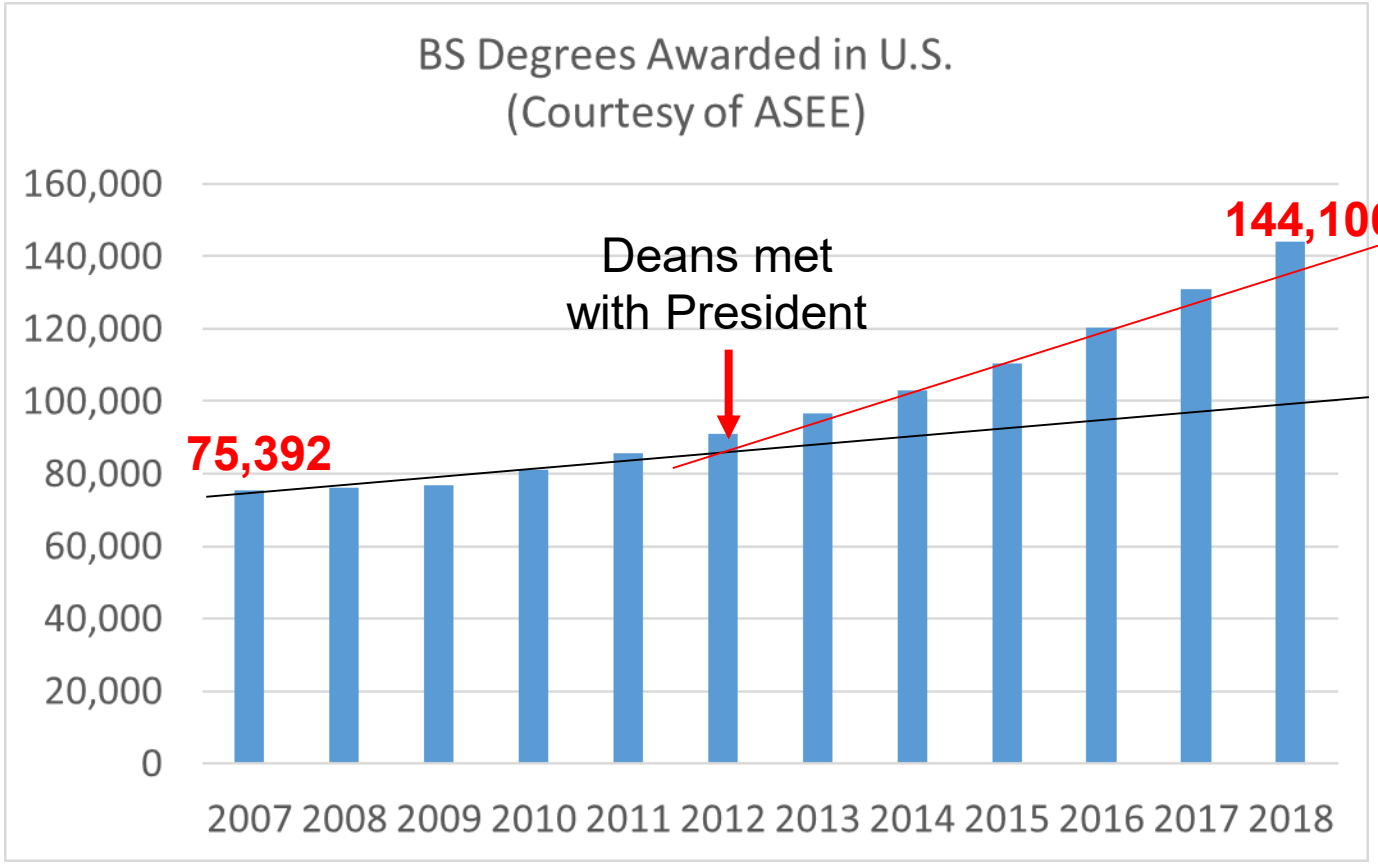
BS Degrees Awarded



In 2018

22.4% to Women
3.53% to African Americans
9.97 to Hispanic Americans
12.5% to Asian Americans

Engineering Retention and graduation rates improved

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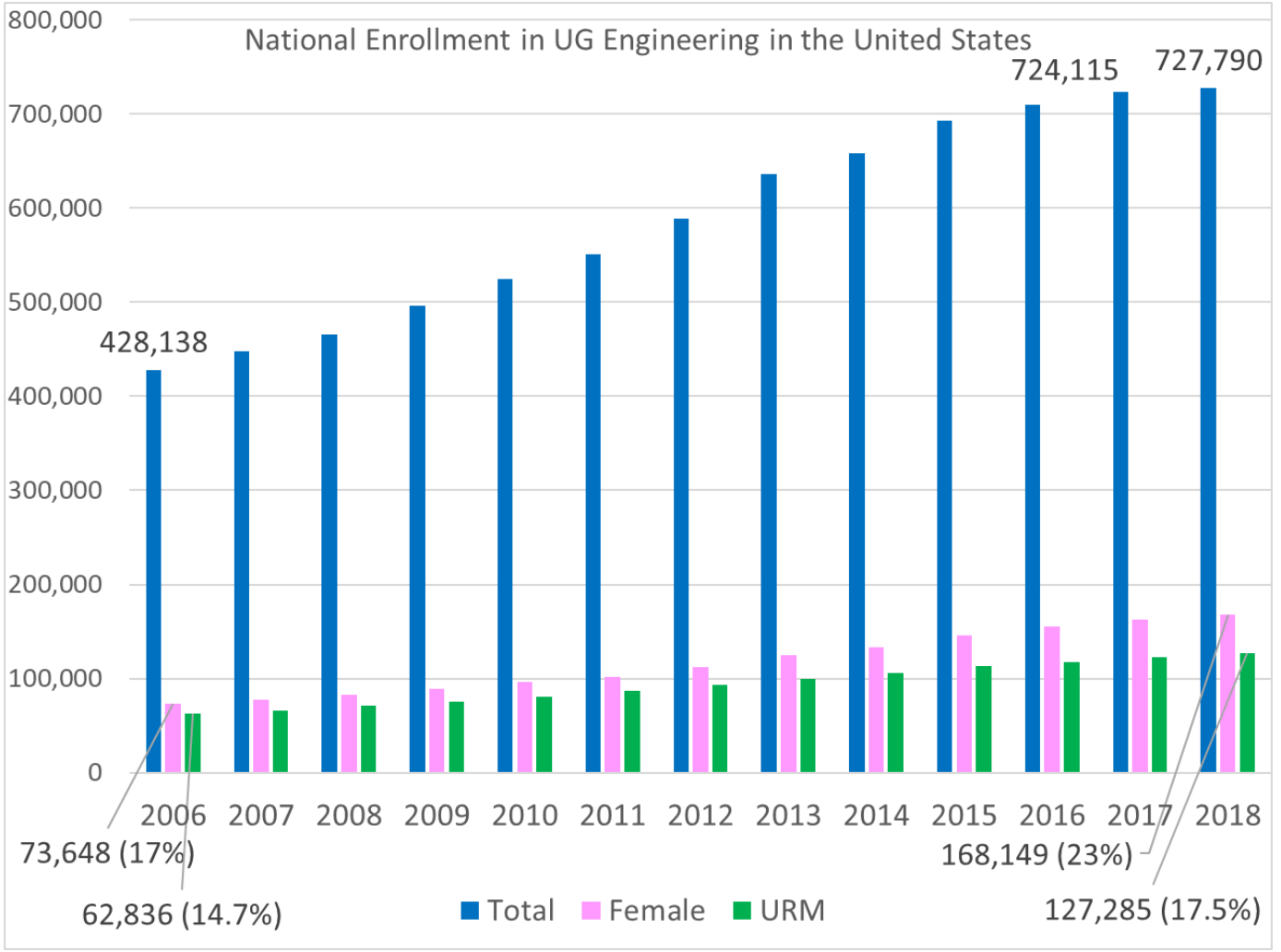
National Enrollment in UG Engineering in the United States



Enrollments started to soar

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Changing the High School Engineering Landscape

Imagine…

- Engineering as a fundamental high school subject for all students
- Bringing high school teachers and the engineering community into ongoing conversation in order to iterate on engineering course curricula
- Clearing a pathway from high school into undergraduate and professional engineering programs
- Ensuring high school students have fundamental engineering problem solving skills, which will help them in future studies, and in life…

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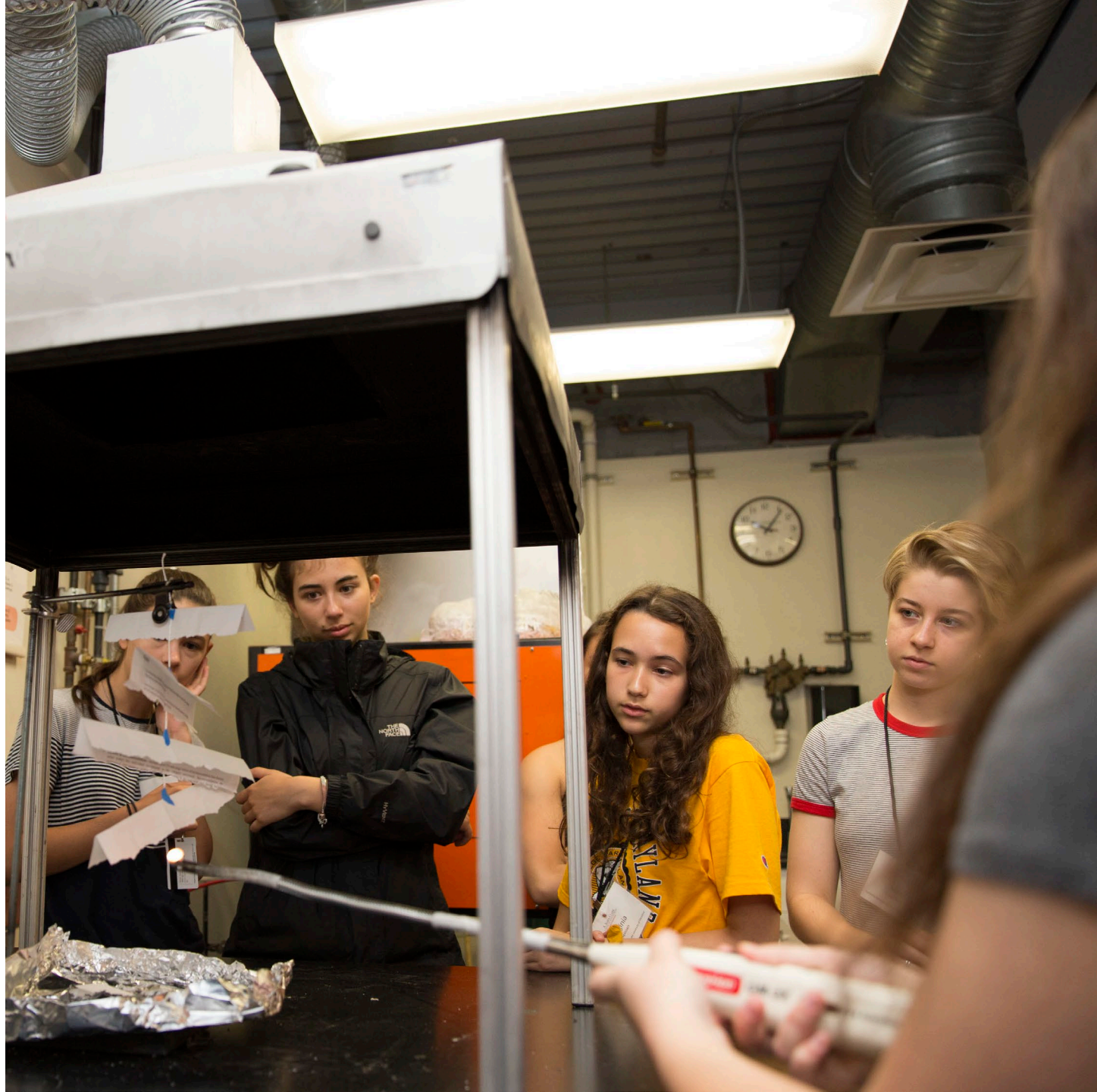
E4USA: What is it?

- A national pilot program for high school engineering course and database
- Provides a standardized educational curriculum for pre-college students to learn and demonstrate engineering principles, skills and practices
- Incorporates a authentic design-based experience
- Has the potential for students to earn universally recognized and transferable engineering course credits at colleges and universities



Step 1

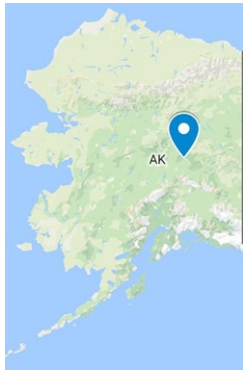
- **Big Idea 1: Engineering and Society**
- **Big Idea 2: Engineering Processes**
- **Big Idea 3: Essential Engineering Content, Skills and Tools**

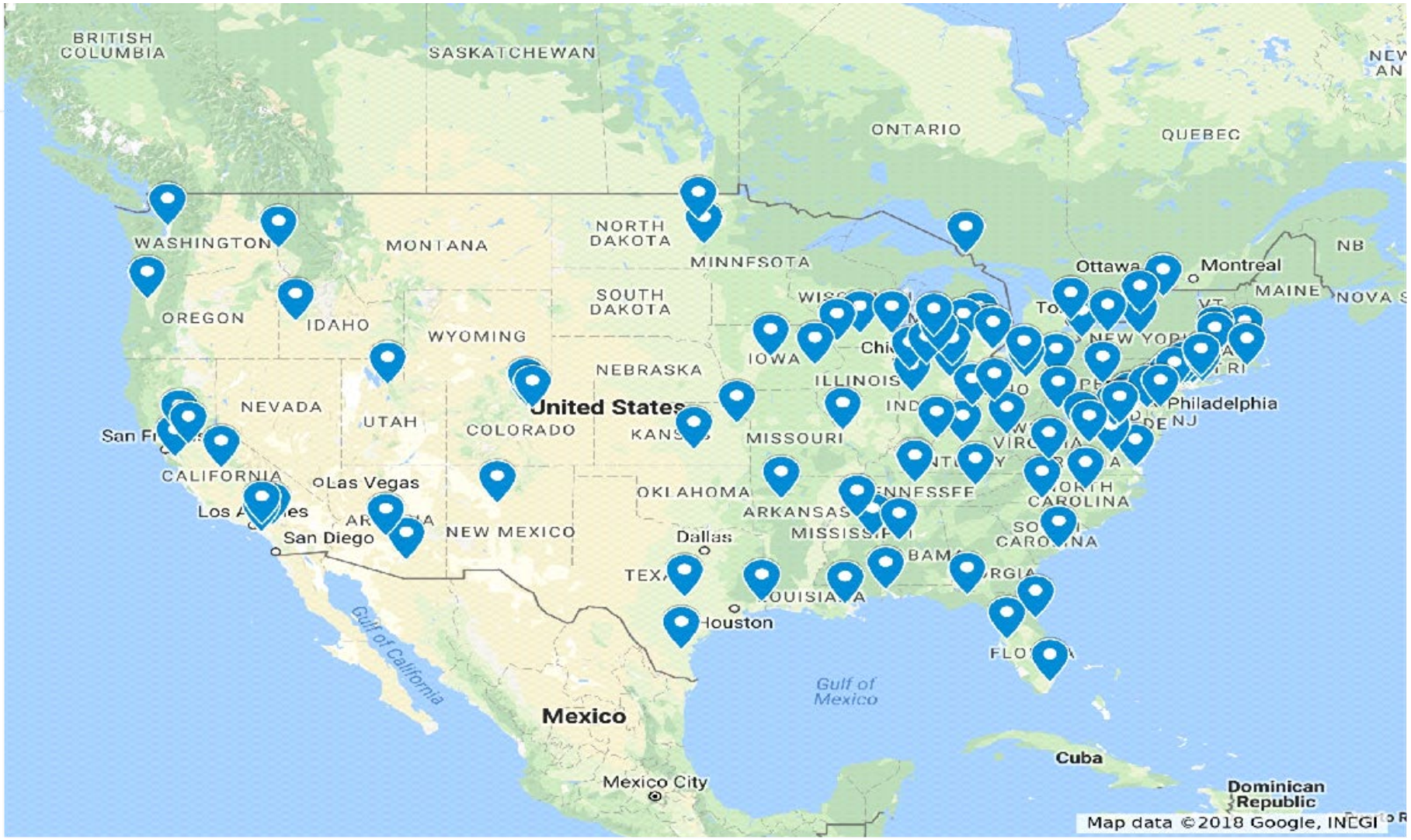
Underpinned by NAE's Grand Challenges

Sustainability
Health
Security
Joy of living

- **Engineering Transfer Goals (Skills and Practices):**
- Students will be able to independently use their learning to ...1. Applying engineering methods to create or design systems, components or processes to provide viable and ethical solutions to complex problems.2. Justify decisions, processes, selections and/or actions.3. Collaborate effectively on a multi-disciplinary team.4. Communicate effectively for a variety of purposes and settings.
- **Assessment:** The assessment will comprise both an end-of-course exam and project-based tasks that students will complete during the term of the course. The end-of-course exam will focus primarily on the Essential Engineering Content, Skills and Tools (Big Idea 3),while the through-course tasks will require students to integrate concepts from all 3 Big Ideas: Engineering and Society, Engineering Processes, and Essential Engineering Content, Skills, and Tools.

Step 2 University Pledges





List of Schools

109 to date out of 366 schools

Old Dominion University
Texas A&M University - Kingsville
University of Toronto
University of Massachusetts - Amherst
New York Institute of Technology
Oregon State University
University of Massachusetts - Dartmouth
George Mason University
City College of New York
University of Virginia
Grove City College
University of South Florida
Wichita State University
Virginia Commonwealth University
University of Washington
University of Kansas
University of Colorado Boulder
University of Utah
University of Mississippi
Western New England University
Purdue University
University of New Mexico

West Virginia University
Syracuse University
University of Tennessee, Knoxville
University of Louisville
The George Washington University
University of North Dakota
Rutgers University
Lake Superior State University
University at Buffalo
Wayne State University
Florida A&M/Florida State University
University of Alaska Fairbanks
Lawrence Technological University
University of Wisconsin-Platteville
Tennessee State University
University of New Haven
The University of Arizona
University of Rochester
Tulane University
Kettering University
University of Kentucky
University of Denver

University of the Pacific
Ohio University
Clarkson University
Valparaiso University
University of North Carolina, Charlotte
University of New Hampshire
University of Portland
University of Connecticut
Mississippi State University
Michigan State University
North Dakota State University
The University of Notre Dame du Lac
Wright State University
James Madison University
Boise State University
Rowan University
Embry-Riddle Aeronautical University, Prescott, AZ
University of Alabama, Huntsville
North Carolina State University
Case Western Reserve University
Embry-Riddle Aeronautical University, Daytona Beach, FL
Colorado School of Mines

Lipscomb University
California State University, Fresno
University of Delaware
Santa Clara University
Lamar University
University of Wisconsin-Milwaukee
University of Maryland
Grand Valley State University
Arkansas Tech University
Tufts University
Hofstra University
Iowa State University
Western Carolina University
California State Polytechnic University, Pomona
University of Wisconsin-Madison
Virginia Tech
St. Louis University
Temple University
Johns Hopkins University
The College of New Jersey
Pennsylvania State University
Morgan State University
State University of New York, ESF
University of Washington
University of Iowa
University of the District of Columbia
University of Bridgeport

Stony Brook University
Arizona State University
University of Idaho
University of South Alabama
West Virginia University Institute of Technology
Western Michigan University
Trine University
The University of Akron
Florida International University
The University of California, Irvine
The Citadel
The University of Texas at Austin
The University of Southern California
Vanderbilt University
Marshall University
Indiana University – Purdue University, Fort Wayne
Stevens Institute of Technology

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DARRYLL PINES

LEIGH ABTS

ETHAN EAGLE

JACKELYN ROSHWALB

KEVIN CALABRO

BRIANA O'NEAL

FIU FLORIDA INTERNATIONAL UNIVERSITY

LOYOLA UNIVERSITY CHICAGO

BRUK BERHANE

MATTHEW MILLER

TOWSON UNIVERSITY

VANDERBILT UNIVERSITY

JENNY KOUO

STACY KLEIN-GARDNER

ASU Arizona State University

ADAM CARBERRY

ANN MCKENNA

JAMES COLLOFELLO

TIRUPALAVANAM GANESH

VIRGINIA TECH

BEV WATFORD

KEN REID

CHERYL BEAUCHAMP

TINA GRIESINGER

MORGAN STATE UNIVERSITY

KEMI LADEJI-OSIAS

STEVE EFE

MARNIE WONG

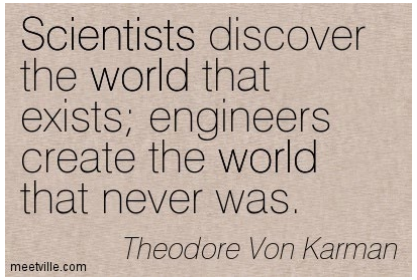
MEDHA DALAL

HOPE PARKER

ENGINEERING FOR US ALL

Summary

- This is a Watershed "**E**ngineering **4 US** All-**E4USA**" moment in time for our discipline and profession.
- This will be disruptive to the historic K-12 education system. It will move engineering into the lexicon and content view of the educational system.
- The time is now for us to act.
- As engineering educators, we must be willing to
  - Collaborative with other K-12 partners (PLTW, CB, and others)
  - Be Global, and out front on engineering education issues
  - define the *Advanced HS Course in Engineering* curriculum framework
  - modify our first-year programs to grant credit and placement/exemption
  - modify our general-education curriculum to grant credit and placement for all
- It is our choice, let's not waste this incredible opportunity.



Curriculum

Dr. Kenneth Reid
Virginia Tech

Current status:

- Engineering For All - first of two courses
- Initial 2019 -20 course development complete: in revision
- Incorporated teacher input during summer PD

Curriculum Development Team	Participants
2-day development (College Park)	~10 (2 teachers)
2-day development (Virginia Tech)	~ 8
2-day virtual meeting/workshop	~ 8
(Constant) working meetings	

E4USA Year-Long Curriculum Overview

The curriculum is to be designed as a thirty week course focused on four “big ideas.” Unlike other Engineering offerings, this course is intended to provide design experiences and connections for students among fields of personal interest, not a technology focus or survey course.

- Discover Engineering
- Engineering in Society
- Engineering Professional Skills
- Engineering Design

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Seven Curriculum Units

Introducing Engineering

Unit 1 - Engineering is Everywhere

Unit 2 - Engineering is Creative

Applying Engineering: Generating a solution to a local problem

Unit 3 - Engineering is Human-Centered

Unit 4 - Engineering is Responsive

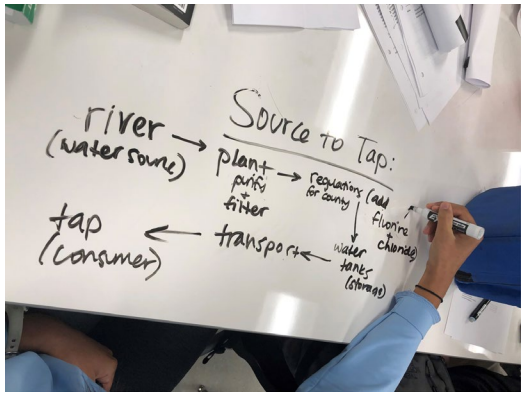
Applying Engineering: Generating a solution to a global issue

Unit 5 - Engineering is Intentional

Unit 6 - Engineering is Iterative

Generating an engineering solution to a problem relevant to you

Unit 7 - Engineering is Personal



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Seven Curriculum Units - Summary

Unit 1 - Engineering is Everywhere
Discovering engineering, engineering identity

Unit 2 - Engineering is Creative
Teaming, Design: constraints, stakeholders...

Unit 3 - Engineering is Human-Centered
Creating and Evaluating Solutions at a local level

Unit 4 - Engineering is Responsive
Iteration, Re-Engineering, and Accommodating Feedback

Unit 5 - Engineering is Intentional
Global Problem Identification

Unit 6 - Engineering is Iterative
Develop & Prototype

Unit 7 - Engineering is Personal
Projects of interest to student(s)

Discover Engineering

Big Question - What is Engineering? Am I an engineer?

- Learning outcomes:

	Discover Engineering
	Iterate and evolve the definition of what it means to engineer and be an engineer.
	Awareness of changing perspectives on one's current identities with respect to engineering through regular reflection.
	Recognize the value of engineering for all regardless of one's potential career.
	Explain and apply ethical considerations when exploring an engineering problem.

- Student Expectations
  - Growth mindset - students who are motivated to act and create change will excel.
  - Engage in critical self-reflection; share what they learn with each other and the community.
- Teacher Expectations
  - Culturally responsive teaching practice - engaging with students where they are, how they want to learn.

Engineering in Society

Big Questions - What problems do engineers solve? How does engineering interact with society?

- Learning outcomes:

	Engineering in Society
	Explore the impacts of past engineering successes and failures on society as a whole.
	Use systems thinking to propose and analyze the relationship between inputs, intention, and impacts of technology in society.
	Recognize and investigate the world's greatest challenges and the role that engineering plays in solving these challenges (e.g., Engineering Grand Challenges, UN sustainability goals, etc.).
	Integrate diverse disciplinary thinking and expertise to inform design solutions that add value to society.
	Identify and analyze issues when bringing a solution to scale.

- Student Expectations
  - Adopt multiple viewpoints - Logic (Math), Reasoning (Science), Identity (History), Communication (Language), and Purpose (Design)
- Teacher Expectations
  - Mentor access and facilitation for students to connect to practicing engineers

Engineering Professional Skills

Big Question - How do I act like an engineer? How do I communicate?

- Learning outcomes:

	Engineering Professional Skills
	Apply strategies to collaborate effectively as a team.
	Use various forms of communication (oral, written, visual).
	Recognize when to use various communication tools based on audience.
	Develop, implement, and adapt a project management plan.
	Contribute individually to overall team efforts.

- Student Expectations
  - Collaborate towards team projects and grow as a teammate
  - Create multi-media content, written (report / poster) and audio/video
- Teacher Expectations
  - Prepare students and hold them to professional standards
  - Provide supports for successful team experiences

Engineering Design

Big Question - What is that designed to do? How can I or we improve it?

- Learning outcomes:

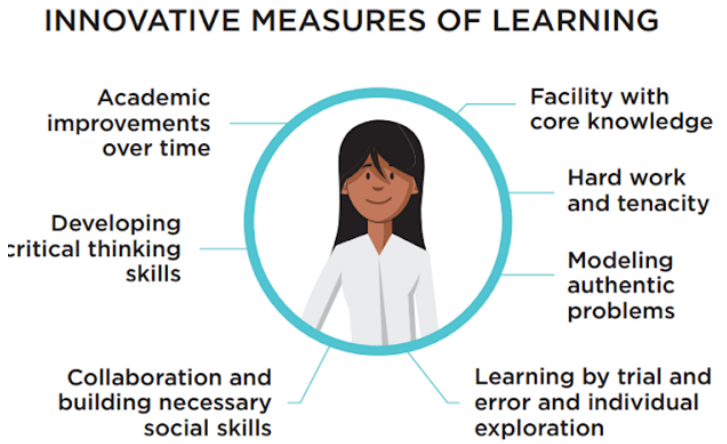
	Engineering Design
	Uncover a problem that can be solved with a potentially new product or process.
	Identify appropriate stakeholders and evaluate stakeholder input.
	Plan and conduct research by gathering relevant and credible data, facts, and information.
	Model physical situations using mathematical equations.
	Evaluate solution alternatives and select a final design by considering assumptions, tradeoffs, criteria, and constraints.
	Use and recognize when to use computational tools.
	Create a prototype.
	Create and implement a testing plan to evaluate the performance of design solutions.
	Apply iteration to improve engineering designs.

- Student Expectations
  - Find problems. Create artifacts and document their design. Present via a digital portfolio.
- Teacher Expectations
  - Access to making equipment / space

Curricular Challenges

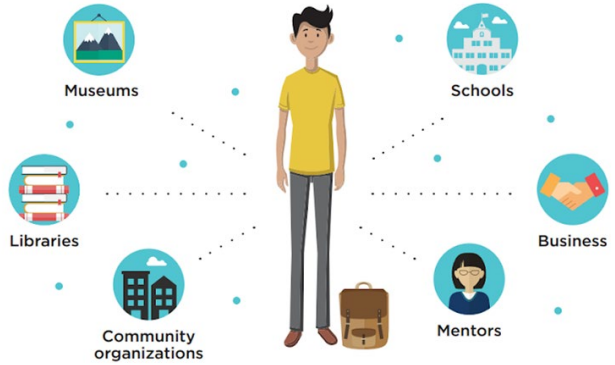
1) Failure and iteration

3) Inclusive classrooms (for all)



2) Assessments

4) Student-driven design project uncertainty



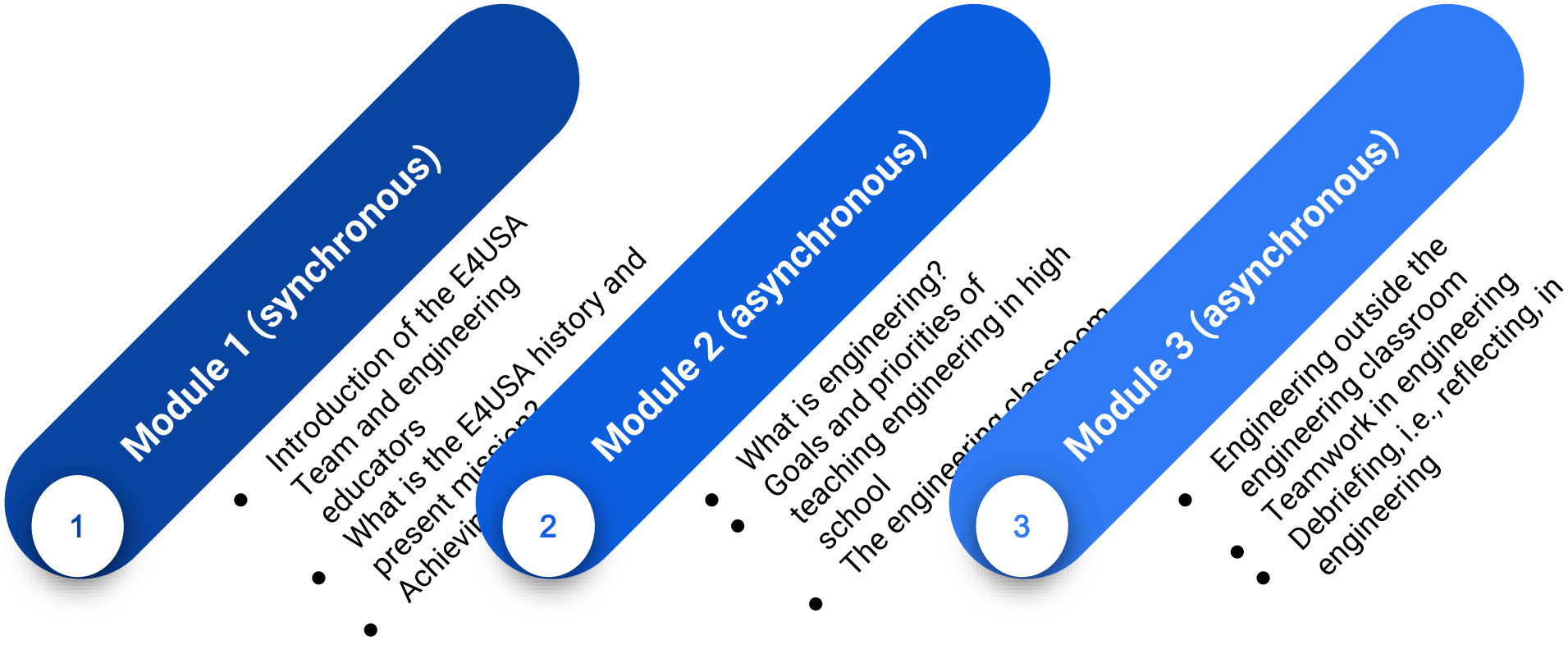
5) Community partnerships

images from https://innovation.ed.gov/files/2016/09/AIR-STEM2026_Report_2016.pdf

Professional Development

Dr. Jennifer Kouo
Towson University
Dr. Adam Carberry
Arizona State University

Spring E4USA Virtual Professional Development



canvas

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In-Person Summer Development Workshop

Workshop I.
June 23-June 28

4 Engineering Educators
Maryland
Tennessee
Arizona

Workshop II.
July 28-August 2

5 Engineering Educators
Maryland
Washington D.C.
Virginia
Pennsylvania

ENGINEERING FOR US ALL

In-Person Summer Development Workshop







E4USA Community of Practice

Weekly Reflections
All Sections
Last post at Sep 12 at 11:03am

Unit 1. Share-Out Lesson Materials & Questions
All Sections
Last post at Sep 10 at 3:46pm

Unit 2. Share-Out Lesson Materials & Questions
All Sections
Last post at Sep 10 at 8:52pm

Unit 3. Share-Out Lesson Materials & Questions
All Sections

Continuing the Community of Practice - Interested in being a Mentor?
https://tinyurl.com/E4USACOP

Partnerships

Dr. Bruk Berhane

Florida International University

Dr. Kemi Ladeji-Osias

Morgan State University

High School Partnership Efforts to Date

Academic Year	**2019-20 (actual)**	**2020-21 (planned)**
High Schools (AZ, MD, and VA)	5	45
High Schools (other regions)	4	30

2020-2021 *E4USA* Participation Timeline

- August 2019 - High School and College/University Applications Released
- **November 15, 2019 - High School and College/University Applications Due**
- December 2019 - High School Sites and College/University Partners Announced
- Spring 2020 - Online Professional Development for Educators
- June/July 2020 - One-Week *E4USA* Professional Development ("Summer Institute") for Teachers
- August/September 2020 - *E4USA* sites launch courses
- Fall 2020 and ongoing - Check in meetings with *E4USA* sites, data collection, and additional online professional development

Site Expectations for High Schools

- The course must be offered as a full-year course.
- The class offering should meet for a minimum of 100 hours prior to the summative course examination scheduled during the second week of May.
- We assume 200 minutes of instructional time per week for a minimum of 30 weeks prior to the mid-May summative examination.
- This course scheduling should permit sufficient time to work on engineering design projects between the start and end of the class meeting times.

Site Expectations for High Schools (cont'd)

- Tools and facilities should be available to ensure students have the opportunity to create prototypes of their designs projects.
- Teachers should be given adequate time during the school day to properly prepare for and generate curricular materials in response to student design project concepts.
- School sites should support each E4USA teacher's attendance at a Summer Institute and participation in virtual or on-site professional development sessions throughout the duration of the school year.

Site Expectations for Colleges and Universities

- Consider accepting this course for college credit on their campus.
- Offer their campus as a site for professional development (*note: this does not obligate a college/university to actually facilitate the professional development, but only to offer it as a host site*).
- Be a member of the Community of Practice.
- Offer $5,000 for a teacher stipend, and up to $2,500 for materials and supplies.
- Serve as a resource to provide technical, logistical and other curricular support.

Benefits to Participating Colleges and Universities

- Directly impact the training and preparation of teachers within their geographic area.
- Inspire students to understand how engineering is used in everyday life, and to encourage them to consider applying to their college or university for their postsecondary studies.
- Potentially recruit from a diverse population of high school students, and encourage students to explore one of the engineering majors within their college or university.

Recruitment Webinars

Our next webinar will take place on Wednesday, November 6, 2019 at the times noted below:

Prospective High School/District Partners: 6:00 - 7:00 p.m. (Eastern Time)

Prospective University Partners: 3:00 - 4:00 p.m. (Eastern Time)

Prospective partners can visit e4usa.umd.edu to join.

Oct 2019 High School/District Webinar Participants:

- Albuquerque, NM
- Anne Arundel County, MD
- Chattanooga, TN
- Dallas, TX
- Durham, NC
- Nashville, TN
- Union County, NJ

Oct 2019 University Webinar Participants:

- Boise State
- Colorado School of Mines
- Hofstra University
- Mathworks
- New Jersey Institute of Technology
- New Mexico State
- Northeastern University
- Penn State
- Texas State
- The College of New Jersey
- University of Colorado
- University of Michigan
- University of Missouri
- University of Pittsburgh

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Next Steps

- Apply to be an *E4USA* college/university partner by **Friday, November 15th** at e4usa.umd.edu
- The E4USA team is working on a process on how RET schools can partner with the program and we hope to let all of you know at a later date how this will work and what resources might be available.
- Contact Dr. Bruk Berhane at bberhane@fiu.edu or e4usa@umd.edu

Credit and Placement

Mr. Kevin Calabro

University of Maryland

Motivation

- Create a national pathway for high school students to earn college credit for engineering coursework
  - Limited engineering curricula exist today
  - Limited teacher education programs exists today

- 110+ Deans of Engineering signed a pledge to work toward this goal on their campuses!

Background: 2018 National Workshop

- Concerns over competing E4USA goals of **for credit** and **for all**
  - 1 course vs. 2 course sequence?
  - engineering vs. general education course equivalency?
  - impact of students not taking the unique first-year engineering course on their campus on retention? acclimation to campus/college? Etc.

- The E4USA course developed is envisioned as the first course in a two course sequence that is accessible to all students (low math/science prerequisite background) and that will yield college credit outside of the engineering degree requirements

Short-Term Credit & Placement Pathways

- Credit-by-exam
  - Available at ASU, Morgan State, UMD, VTech, Vanderbilt

- UMD Case Study:
  - Develop/teach an undergraduate course equivalent to E4USA
    - Satisfy one or more degree requirements (I-Series, DSSP)
  - Administer a design portfolio review and examination once the students arrive on campus
    - Student pays a small non-refundable fee (~$30)

UNIVERSITY OF MARYLAND

Medium-Term Credit & Placement Pathways

- Disseminate transfer equivalency processes developed at the E4USA grant partner institutions to 25-50 additional higher education institutions

- Collect feedback to better understand what administrators at these institutions find as compelling evidence for granting credit for a general education engineering course.
  - Focus groups
  - Surveys

Long-Term Credit & Placement Solutions

- A national assessment is needed (e.g., AP, IB, or CLEP)
  - Through-course performance tasks (design portfolio)
  - Summative written examination
  - Team project / presentation
- Engineering Design Process Portfolio Scoring Rubric (EDPPSR)
  - Rubric with 5 components and 14 elements
- Reliability and validity tested measures are needed with cut scores that can be trusted by institutions to ensure credit granted is consistent with the institution's performance expectations.
- Assessment will ideally be curriculum-independent.

Research Assessment & Evaluation

Dr. Matt Miller, Loyola University Chicago
Dr. Stacy Klein-Gardner, Vanderbilt University

E4USA Research Aims

- Our research aims focusing on answering the question: **For whom and under what conditions does E4USA work?**

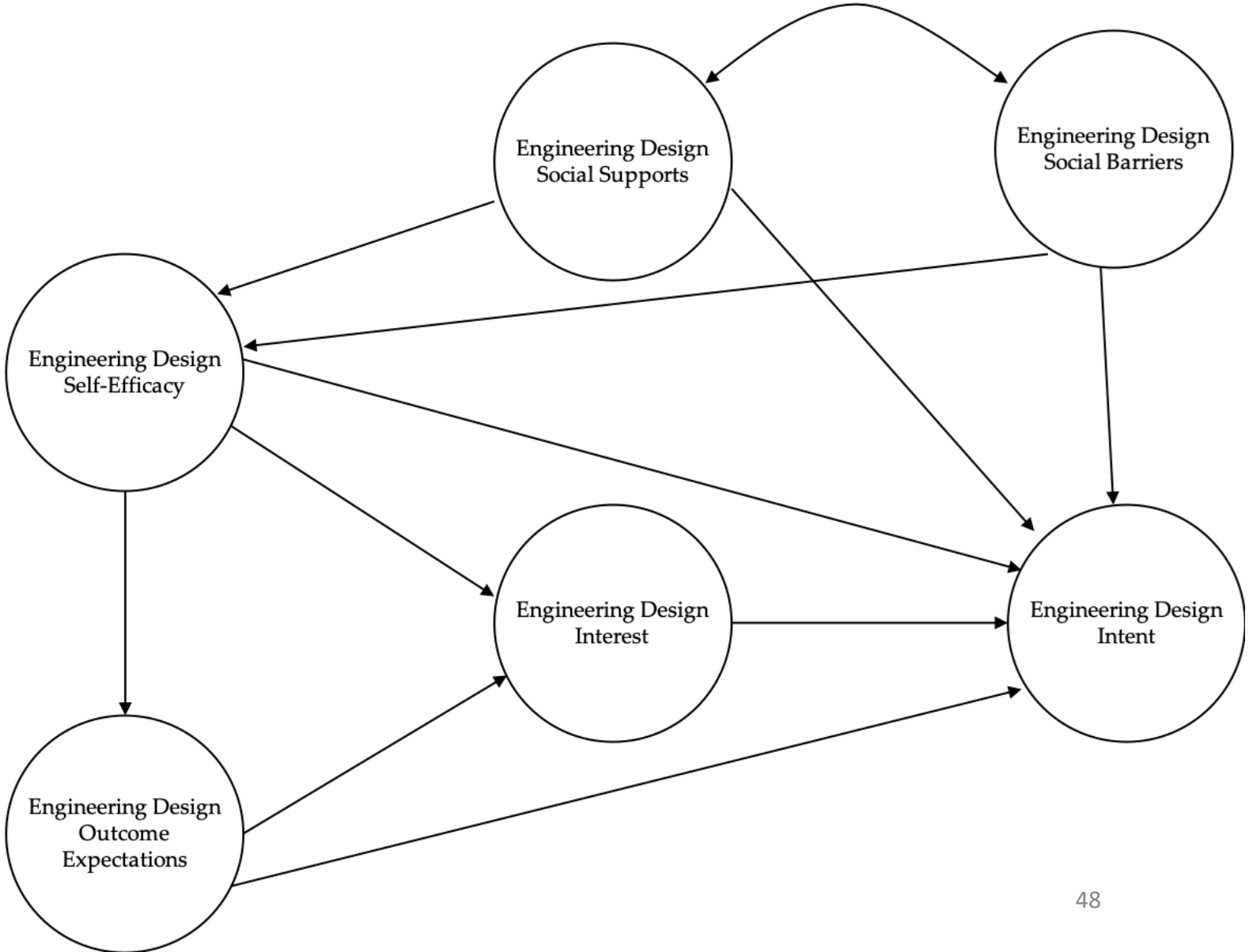
- **Whom?**
  - Teachers with and without engineering background
  - Students from underrepresented populations
- **What conditions?**
  - online, in-person, and hybrid PD platforms
  - highly resourced vs. under-resourced school systems

E4USA Research Lines and Data

- **Line 1:** Pilot test of effectiveness (***does it work***) of E4USA PD (for teachers) and curriculum (for students) using quasi-experimental methods.
- **Line 2:** Test theory-driven hypotheses predictive hypotheses regarding individual and contextual factors that facilitate or hinder engineering outcomes using quantitative (e.g., structural equation modeling) methods
- **Line 3:** Explore nuanced and individualized E4USA experiences and outcomes using qualitative methods
- **Line 4:** Obtain real time feedback and input in order to refine and enhance content and delivery using qualitative and quantitative methods

E4USA Research Conceptual Frameworks and Constructs

Social Cognitive Career Theory (Lent et al., 1994) and Understanding by Design (Wiggins & McTighe, 2005) → *Translating engineering design learning experiences into pursuit of engineering*



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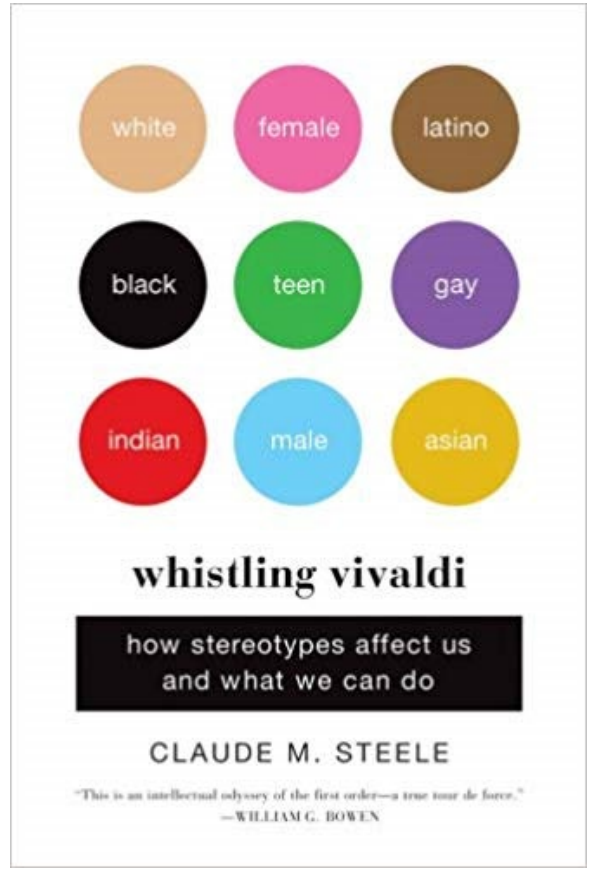
E4USA Initial Findings

Whistling Vivaldi Study

Goals:

- Understand how high school teachers conceive their roles and responsibilities with regard to engineering related stereotypes, stereotype threats, and implicit biases.
- Help teachers make positive changes in their classrooms to ultimately affect student pathways to higher education institutes.



Preliminary findings:

- Recognition of the magnitude of the problem
- Making connections with personal experiences
- Feeling of having limited influence due to other societal messages
- Feelings of guilt associated with awareness of engaging in stereotyping behavior

Partnering with E4USA Research Effort

- Research collaboration is **NOT** required in order to participate in the broader E4USA program
- Research collaboration requires
  - Partnering with a local high school
    - Assisting with university, high school district and/or school level IRB or equivalent approval processes
    - Assisting with consent and assent form distribution and collection
    - Assisting with E4USA data collection protocols involving teachers and students
  - Economy vs. Luxury
- Research collaboration opportunities and benefits
  - Participate in ongoing E4USA program wide research efforts OR develop a smaller scope (e.g., specific to a single teacher, classroom, or district) project with support of E4USA team
  - Presentations and publications
  - Research mentoring from senior scholars

E4USA Research: Where Are We Now?

- IRB approval in four school districts (MD, TN, VA, AZ); IRB approval in other districts in progress
- In-class student data collection ongoing and/or in development
- Pre/post teacher PD data collected in summer/fall 2019; ongoing
- Teacher PD focus group data collected summer/fall 2019; ongoing
- Teacher and student focus groups/interviews to be scheduled mid/late fall 2019

Project Evaluation

Goal 1: Finalize the draft *E4USA* curricular framework, design project guidelines, gain IRB approvals and initiate pilot in the 2019 academic year.

- Review alignment to PD Standards, local/state standards, and framework
- Review curriculum with respect to inclusiveness
- Review IRB protocols and which HEI have approved them
- Review instruction, recruitment, and selection practices at K-12 sites in MD, AZ, TN, DC, PA and VA

Project Evaluation

Goal 2: Implement the UMD data collection protocols across collaborating higher education institutions, school districts and high schools (pilot sites) and train the teachers.

- Observe PD in action at a variety of sites
- Create focus group protocols and conduct focus groups with teachers
- Focus groups with HEI, NASA, other organizations
- Focus groups with students
- Employ quasi-experimental design to test efficacy of PD
- Review progress on creation of data collection system
- Test data collection procedures and monitor results as they are reported

Project Evaluation

Goal 3: Support pilots within the up to 30 collaborating RET Sites

- Prepare focus group plans
- Quarterly and Annual Reports

Where do we want to be?

In Year 2 and beyond, we want to monitor student and teacher development as it relates to our research hypotheses around confidence, knowledge, etc.

We will rely on moving this project to scale in Year 2 so that we have adequate sample sizes

How do we get there?

Create and disseminate protocols to teachers for collecting and submitting research instruments and participating in focus groups.

Anticipated challenges:

- Logistics of collecting all of this data
- Recruitment of schools/districts willing to participate fully
- Compliance of students, teachers, and schools

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THANK YOU!