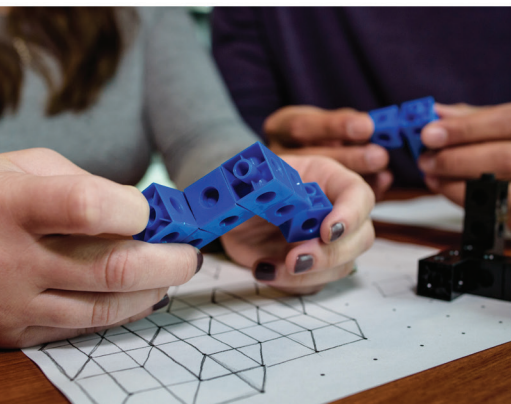




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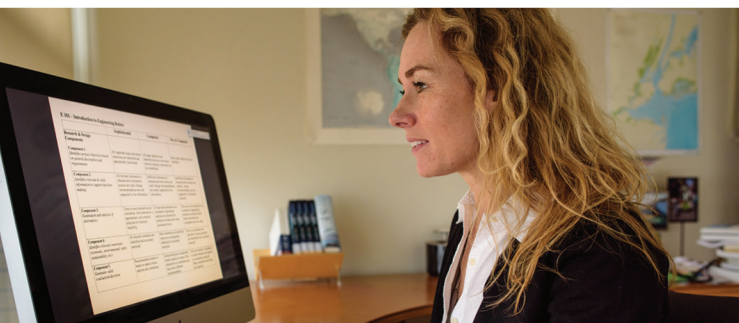
engage

Engaging Students in Engineering

www.engageengineering.org



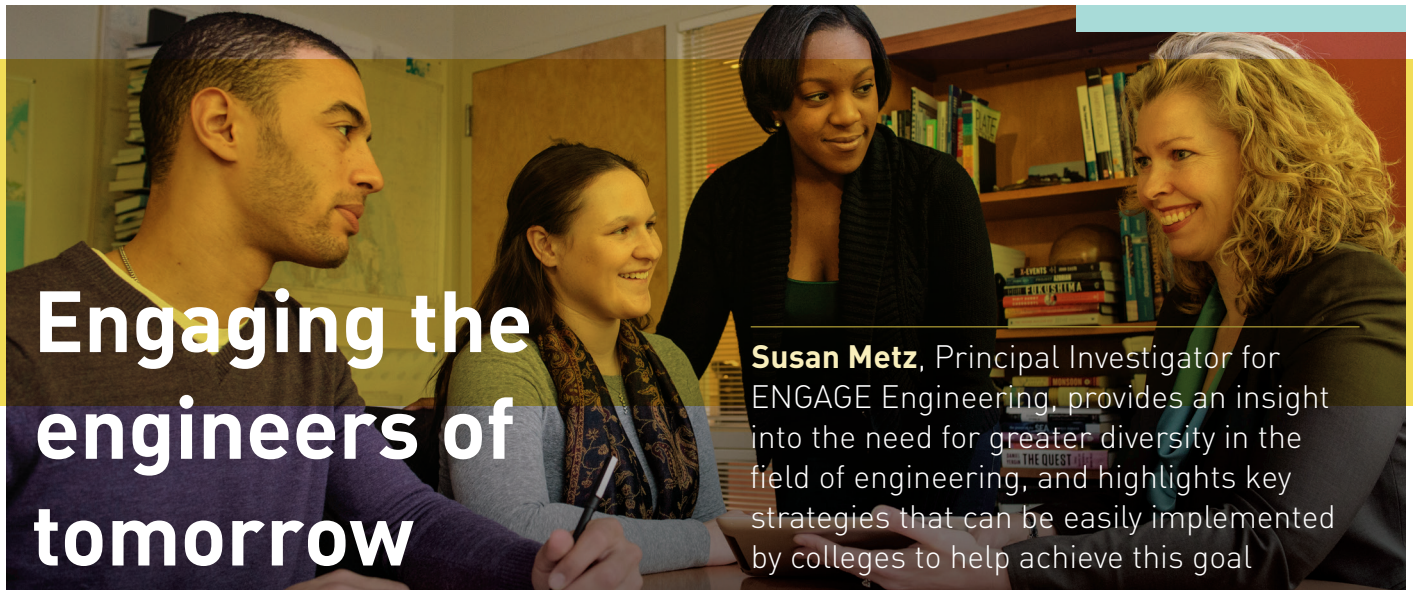
Faculty members across **634 institutions** and others have downloaded ENGAGE's easy-to-use, online resources more than **230,000 times!**



Keep engineering students engaged!
ENGAGE Engineering highlights effective research-based strategies to increase retention and diversity in undergraduate engineering programs



This material is based upon work supported by the National Science Foundation under Grant No. 0833076. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.



Engaging the engineers of tomorrow

Susan Metz, Principal Investigator for ENGAGE Engineering, provides an insight into the need for greater diversity in the field of engineering, and highlights key strategies that can be easily implemented by colleges to help achieve this goal

Could you begin by introducing ENGAGE Engineering and its core aims?

ENGAGE is focused on increasing retention of engineering students, particularly in the first and second years of their degree when students are most likely to leave engineering study. The project disseminates three research-based strategies, primarily for use by faculty members, to increase student engagement. The approaches we use improve the academic experience for all students, but are particularly effective for women and members of other underrepresented groups.

What approaches are being taken by this project to spark interest in engineering and encourage student retention?

ENGAGE disseminates its three research-based strategies through workshops, webinars and other e-communications. The strategies – using Everyday Examples in Engineering (E²s) to teach technical concepts, increasing Faculty-Student Interaction (FSI), and improving Spatial Visualization Skills (SVS) among students who are not proficient – were chosen because there is a rigorous body of research indicating that implementing these strategies impacts student retention for all students, and has a disproportionately positive impact on retention of women and members of other underrepresented groups. Furthermore, individual faculty members can implement ENGAGE strategies in their classrooms with a relatively low level of time and resources, and without needing to go through the bureaucracy of committee approvals.

In the past half century, women's representation in many industries, such as law, business and medicine, has made considerable improvements. In engineering, however, progress towards the equal

representation of genders has been markedly slow. Why is this?

There are many reasons. Engineering is a large and diverse profession that plays a role in almost every aspect of our lives, but most people either do not know what engineers do or else are only familiar with traditional engineering roles such as building bridges or creating electronic devices. There are also engineering stereotypes that still prevail – for example, that engineers can be nerdy or prefer working with machines more than people.

The National Academy of Engineering conducted a study called 'Changing the Conversation' to identify key messages about engineering that appealed to women. The four top messages were: engineers are creative problem solvers; engineers make a world of difference; engineering is essential to our health, happiness and safety; and engineers help shape the future. This perspective of engineering is right on target, yet largely uncommunicated, which has contributed to a lack of interest in the field among women.

Then there is the fact that the engineering curriculum is restrictive and jam-packed, typically requiring students to know that they want to study engineering when they graduate high school. For students who discover a preference for engineering after their first year, transferring into the major generally requires additional coursework, extending the number of years to graduation, which is costly.

ENGAGE is working with over 80 engineering schools across the US to improve student retention. Can you tell us what progress has been made so far?

ENGAGE is committed to disseminating its strategies as broadly as possible and

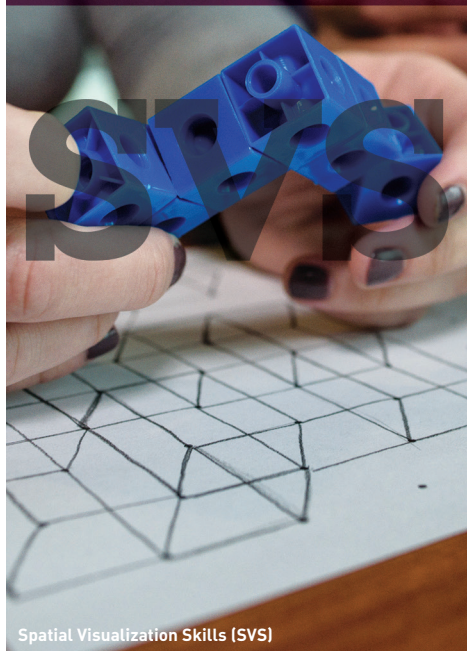
getting faculty to implement them. We know faculty members are using our approaches and sharing them with their colleagues – there are 230,000 downloads to date and interest in ENGAGE's resources continues to grow.

Universities introduced to spatial skills assessment and training by ENGAGE, such as the University of Colorado Boulder, are continuing to implement this process among all entering engineering students, and offer training to those who are not proficient. Some faculty who become familiar with ENGAGE strategies are encouraging their engineering schools and faculty colleagues to use them. Others create their own materials such as E²s based on ENGAGE principles.

In the next decade, to what extent do you think representation of women and individuals from ethnic minorities and/or low socioeconomic backgrounds in engineering will improve?

For the US to remain competitive, it has to change! The demographics dictate this shift. We exist in a technologically complex global world and face significant challenges in security, environment, healthcare, transportation, energy, infrastructure, knowledge management, defence, etc. Underrepresented minority populations and the number of students from low socioeconomic backgrounds are growing. Women represent more than half of the US population and can no longer be left in the margins; they are a large and influential intellectual resource with essential perspectives and contributions that are shaping the future of our country. Academia, industry, and government alike are beginning to realise the critical need to draw on all of our citizens to contribute to this enterprise.

Three simple strategies



Spatial Visualization Skills (SVS)



ENGAGE is committed to providing free, research-based resources for use by STEM faculty to improve student retention and increase diversity in undergraduate programs



Faculty-Student Interaction (FSI)

FAR TOO MANY students who choose to study engineering in college switch majors within their first two years. A 2012 publication by the American Society of Engineering Education, titled 'Going the Distance', notes the six-year US graduation rate of Asian Americans is 66.5 per cent, Caucasians 59.7 per cent, Hispanics 44.4 per cent, Native Americans 38.6 per cent, African Americans 38.3 per cent and women 61 per cent. Engineering majors are losing large numbers of students at a time when our globalised and diverse society is increasingly dependent on equally diverse experts in technology and engineering to solve the critical problems of the 21st Century.

A THREE-PART SOLUTION

It was with this need in mind that ENGAGE Engineering was launched in 2009. Funded by the US National Science Foundation (NSF), its mission is simple: to provide STEM faculty with resources to support the implementation of three evidence-based strategies to increase retention of undergraduate engineering students – particularly during students' first and second years of study.

ENGAGE's strategies are straightforward and can be implemented by faculty in the classroom. The strategies are scalable; require a low level of time and cost investment; and have been rigorously demonstrated by research to significantly increase student engagement and retention, especially among women and other underrepresented groups.

EVERYDAY EXAMPLES IN ENGINEERING

The first strategy promoted by ENGAGE is Everyday Examples in Engineering (E³s). In STEM courses, faculty typically use traditional examples, which tend to be abstract and unfamiliar to illustrate complex technical concepts to students. E³s replace these traditional examples with relatable, real-world examples that are familiar to students. The E³s strategy is based on the findings of numerous studies, all of which indicate that students respond better to examples that are familiar to them and can be easily visualised, as opposed to the abstract examples conventionally employed in STEM education.

ENGAGE provides easy-to-access resources for faculty to implement this strategy in the classroom. On the ENGAGE website (www.engageengineering.org), E³s are organised by subject area – from chemistry, to physics, to thermodynamics – and are accompanied by video demonstrations that show instructors how to present the example in class. ENGAGE also provides engineering ideas and a downloadable step-by-step toolkit so faculty can create their own E³s.

FACULTY-STUDENT INTERACTION

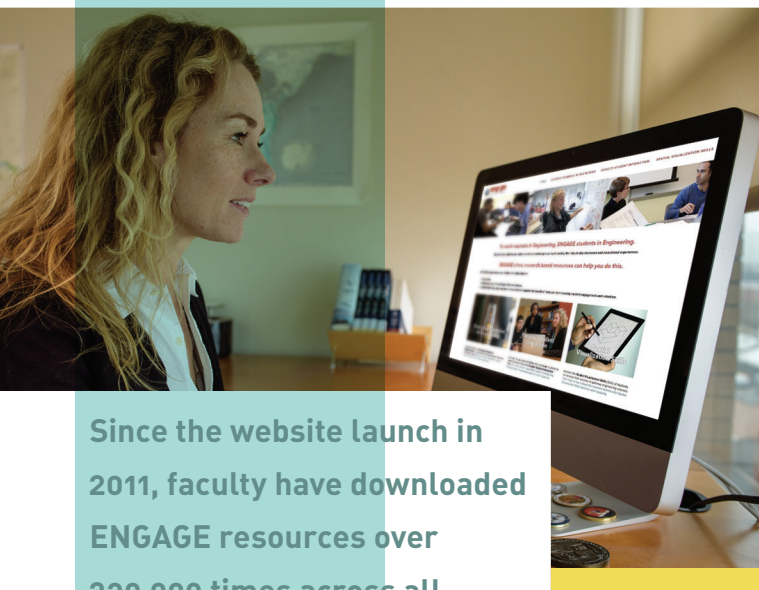
ENGAGE's second strategy is Faculty-Student Interaction (FSI), which aims to increase faculty approachability and encourage student participation. "FSI directly impacts students' perceptions of their ability to succeed, influencing grade point average,

USING EVERYDAY EXAMPLES IN ENGINEERING: WHY IS THE STATUE OF LIBERTY BLUE-GREEN?

Faculty can use the Statue of Liberty to demonstrate the concept of oxidation reaction in their chemistry lectures.

Ask students whether they have seen the Statue of Liberty and why they think it is blue-green. The Statue of Liberty grounds the lesson in a familiar example for students, who then have a concrete visual for the type of oxidation reaction that gave the formerly copper statue a blue-green patina. Now that students are engaged, faculty can elaborate on other types of oxidation reactions, building upon the Statue of Liberty model used.

This lesson plan has been downloaded over 37,000 times! Download this and other E³ lesson plans at: www.engageengineering.org/e3s/takeaction



Since the website launch in 2011, faculty have downloaded ENGAGE resources over 230,000 times across all three strategies!

ENGAGE ENGINEERING

OBJECTIVE

To provide STEM faculty with three research-based strategies – Everyday Examples in Engineering, Faculty-Student Interaction and Spatial Visualization Skills – that improve student retention and diversity in undergraduate majors.

KEY COLLABORATORS

Diane Matt, Executive Director and CEO, Women in Engineering ProActive Network (WEPAN), USA

Patricia B Campbell, PhD, President, Campbell-Kibler Associates, Inc., USA

FUNDING

US National Science Foundation (NSF)

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CONNECTIONS CLASSES: COOKIES IN THE CLASSROOM

As part of its work with ENGAGE Engineering, the University of Texas at Austin created 'Connection Classes: Cookies in the Classroom', a technique to improve faculty-student interaction. The concept is simple: take 20 minutes to share cookies with students at the start of a new course as a quick and effective way to break the ice.

Since 2011, 143 Connection Classes have been held at the University of Texas at Austin, reaching over 7,400 students.

Faculty members interested in hosting their own Connections Classes can download a free toolkit at:

www.engageengineering.org/fsi/cookie-connections

academic confidence and retention rates," says ENGAGE's Principal Investigator Susan Metz. "When faculty members engage with students, students are more motivated and fun to teach. When this type of interaction occurs, students rate their faculty more highly as well."

Barriers such as lack of time, large class sizes and competing priorities often limit faculty members' abilities to meaningfully engage with undergraduate students. ENGAGE's FSI strategy identifies easy, time-effective techniques that faculty can use to improve student perceptions of their approachability and access. ENGAGE's website offers resources in the form of quick tips faculty can use in the classroom.

SPATIAL VISUALIZATION SKILLS

Spatial visualization skills include the ability to imagine what an object would look like from a different vantage point. Proficiency in this skillset is connected with student persistence in engineering. For students who struggle with spatial visualization, gateway undergraduate engineering courses such as engineering graphics can be a barrier to success in engineering majors.

ENGAGE's third strategy, Spatial Visualization Skills (SVS), aims to improve students' skills through testing and training. Numerous studies have identified various activities – from participating in certain sports to playing video games or with construction toys – as being useful in developing SVS. "ENGAGE's SVS strategy relies on Dr Sheryl Sorby's research that spatial visualization, a cognitive skill, is malleable and can be improved with training in about 14 hours," says Metz. Training has also been effective in eliminating gender differences in SVS.

ENGAGE has made it easy for faculty to implement SVS testing and training in engineering programs. The SVS section of

the ENGAGE website provides a detailed how-to guide for faculty, accompanied by links to access-related resources. ENGAGE's SVS resources leverage the Purdue Spatial Visualization Test: Rotations for evaluating students, and Dr Sheryl Sorby's Developing Spatial Thinking curriculum, developed with funding from NSF, for training students.

A NATIONWIDE EFFECT

Since its launch, ENGAGE has worked with over 81 US engineering schools to implement its E³s, FSI and SVS strategies. Nearly 700 faculty members from these and other institutions across the US have used ENGAGE resources, each impacting hundreds of students.

All of ENGAGE's resources are available to access and download on the ENGAGE website (www.engageengineering.org). "We want faculty to use these resources, and to know that they are easy to use and that they benefit students and faculty alike," emphasises Metz. "It's a win-win situation."

Most engineering faculty have highly developed 3D spatial skills [...] falsely believing that this particular skill is one that a person is either born with or not. They don't understand that they probably developed these skills over many years.

Dr Sheryl Sorby, creator of the Developing Spatial Thinking curriculum