

# CASTLE

Center for the Advancement of STEM  
Teaching and Learning Excellence

## Annual Report



# Our Strategic Vision

There is demonstrated need for improving STEM education nationally, to: generate a larger and more diverse STEM workforce and a better educated public, address achievement gaps among different racial and ethnic groups, improve performance of U.S. students on STEM related exams compared with their international peers, and enhance the quality of STEM educators. Yet despite significant national dialogue and funding for STEM education, sustained improvements have not been achieved. As an interdisciplinary initiative, leveraging existing programs and Drexel's commitment to STEM education and civic engagement, CASTLE is positioned to be a

leader in transforming university STEM teaching and learning both locally and nationally. CASTLE programs and research are transforming STEM teaching and learning at Drexel. These efforts enhance Drexel's ability to recruit, retain and effectively train students. Through the research activities of CASTLE, we are improving academic excellence, intensifying and improving the student experience, providing opportunities to grow Drexel's enrollment by offering new programs and activities for students, enhancing Drexel's global impact through our collaborations, and creating an innovation nexus centered around STEM education.

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# A word from Director Adam Fontecchio

The Center for the Advancement of STEM Teaching and Learning Excellence (CASTLE), founded in 2014, is currently home to fourteen funded initiatives centered on translational pedagogies. CASTLE is housed in the 3401 Market St building in the heart of the University City Innovation Neighborhood. The center is rooted in Drexel's long history of experiential learning and innovation in STEM education, embodied by both the Co-Op program and the E4 program, an NSF-funded, inquiry-based curriculum pioneered by the College of Engineering in the 1980s.

Since its founding, CASTLE has not only been successful in securing new funding for STEM education initiatives, but also in becoming part of large, national programs focused on improving STEM education, including the

UTeach and CIRTl (Center for the Integration of Research, Teaching and Learning) National networks which combined encompass 71 of the Nation's top universities. These network partnerships are positioning CASTLE and Drexel to lead a national STEM transformation. There is a demonstrated need for improving STEM education nationally, to: generate a larger and more diverse STEM workforce, engender a better educated public, address achievement gaps among different racial and ethnic groups, improve performance of U.S. students on STEM related exams compared with their international peers, and enhance the quality of STEM educators. Despite significant national dialogue and funding for STEM education, sustained improvements in these areas have not yet been achieved.



I welcome everyone to join us in our quest to improve the state of STEM education throughout Philadelphia, the tri-state region, and the entire nation. Stop by and listen to one of our seminar speakers, join us for a rousing discussion at a Pedagogical Happy Hour, or just come chat with us about your ideas and how we can work together. We look forward to seeing you and hearing your ideas for excellence in the STEM transformation!

Dr. Jennifer Stanford  
Co-Director, CASTLE



Jennifer Stanford PhD's research interests focus on evaluating and improving approaches to teach STEM content in higher education environments to promote student learning, engagement in STEM courses, and STEM student retention. Her current work focuses on: evaluating approaches to increase student access to undergraduate research opportunities, incorporating evidence-based thinking

into diverse learning environments, and developing practical training opportunities to support STEM student professional development.

Dr. Jason Silverman  
Co-Director, CASTLE



Jason Silverman PhD's research interests include mathematics teacher education and supporting the pedagogical development of pre-service STEM teachers. His current work focuses on the role of mathematical understandings in teachers' instructional practice, understanding how technology, collaboration, and community can support teaching and learning, supporting teachers' integration of science, tech-

nology, engineering and mathematics (STEM), and better understanding and capitalizing on the commonalities between undergraduate and K-12 STEM education.

# To achieve its mission, CASTLE's efforts center on three major initiatives:

1

Modernizing STEM learning through a focus on experiential and inquiry-based education

2

Transforming STEM teaching by changing the culture of STEM educator training

3

Institutionalizing the regular use of data to make decisions about teaching and curricula



This strategic approach will transform STEM teaching and learning at Drexel. Not only will this improved culture enhance Drexel's ability to recruit, retain and effectively train students, but it will also serve as an exemplar in the national conversation about revolutionizing STEM education.



# CASTLE's Impact



CASTLE's DARE program, ExCEL, focuses on an important area of interdisciplinary research in STEM education, which is the study of experiential learning. Experiential learning is defined as students learning from direct experiences. Opportunities of this type include: mentored research, cooperative education (Co-op), internships, service learning, volunteering, and study abroad, among other experiences. While there is research on the impact of undergraduate research programs on student learning, retention and skills, there is limited research on the impact of Co-op and other experiential learning opportunities and the benefits students gain from these experiences. As well, there is limited research on the impact of experiential learning opportunities on graduate student training.

Drexel University is a unique testbed for studying experiential learning, as it is one of the premier institutions offering entrenched experiential learning through programs such as Co-op and Students Tackling Advanced Research. As a result, by studying these programs at Drexel, we can contribute significantly to understanding the benefits of experiential learning and what makes for an effective experiential learning opportunity. Our work in this area will allow development of models for experiential learning that have national impact.

The ExCEL project includes faculty and staff from across the university, including staff from the Office of Undergraduate Research, SCDC, the Study Abroad Office, Institutional Research, and other offices and individuals that are not typically involved in education research, for example

## Featured above:

Graduate students enrolled in the CASTLE PROFESS program raising attention to Sexual Assault Awareness Month by wearing "Not a bystander." shirts, in solidarity with survivors of sexual assault. This campaign was sponsored by Drexel's Office on Equality and Diversity (OED).

disciplinary faculty. The collaboration between education researchers, assessment specialists and faculty and staff who work carefully with experiential learning programs is allowing for the development of a more comprehensive picture of experiential learning at Drexel. This will allow us to carefully document outcomes across experiential learning opportunities and programs.

# DragonsTeach

## A collaborative effort to support Undergraduates exploration of STEM Education

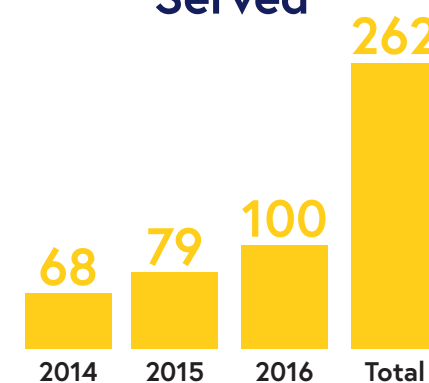
DragonsTeach is a Drexel University program designed to address the national need for science, technology, engineering and mathematics (STEM) teachers by offering STEM majors the opportunity to experience secondary teaching and obtain secondary teaching certification alongside their STEM major. Through active recruitment; a compact, research-based instructional program; and intensive experiences working with master teachers in local schools, DragonsTeach will break down the traditional barriers

that prevent STEM students from obtaining teaching certification. DragonsTeach is a collaborative effort of the College of Arts and Sciences, the College of Engineering, and the School of Education and is supported by a \$1.45 million grant from the National Math and Science Initiative to replicate the UTeach program. UTeach universities, expected to number 45 by 2015, will produce more than 9,000 new teachers by 2020, contributing to the national goal of 100,000 new STEM teachers by 2021.

# Innovate/ Collaborate

CASTLE at Drexel is leading the Innovate/Collaborate CAA grant initiative. This initiative is a collaboration across three member institutions: College of Charleston, Drexel University, and the University of North Carolina Wilmington. Each of these institutions has dedicated considerable resources to distinctive approaches in experiential learning, and each has wrestled with the challenges of assessing learning in connection with those efforts. Collaboratively, the project leverages the diversity and strengths of these Alliance members to carry out something we could not do individually. This project is meant to engage faculty, staff, and students in the implementation, assessment and strengthening of key initiatives on experiential learning through intentional collaboration and communication. This project will advance and measure the effects of experiential education, which is already a major component of the co-curricular path for students at all three of the collaborating institutions. It is expected to enrich the academic environment and advance student success by deepening our understanding of how to optimize experiential learning at the individual student level. We intend to improve student success by gathering data through this initiative to allow informed advising around experiential learning opportunities.

## Drexel Students Served



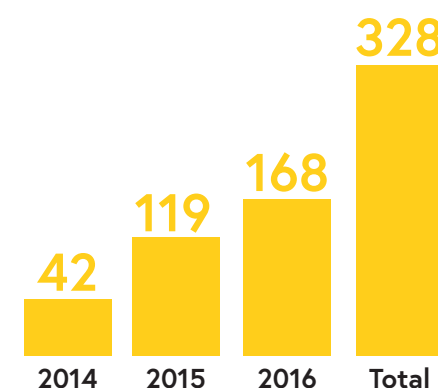
## Student Impact Survey

DT Courses Increase Confidence in:

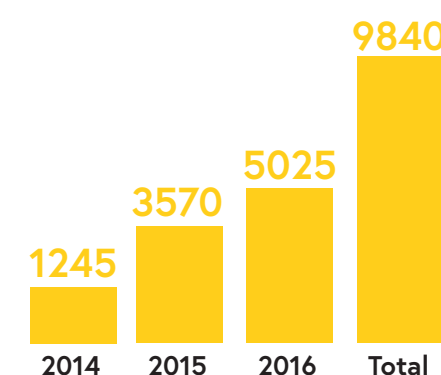
- Public Speaking
- Leadership and Mentoring
- Becoming a Better Learner
- Making a Difference
- Choice to Enroll in Drexel

## Community Impact

### Inquiry Lessons in SDP



### SDP Students Impacted (est.)





# Our 3 Major Initiatives - Expanded

## VISION



The vision of Drexel University's Center for the Advancement of STEM Teaching and Learning Excellence (CASTLE) is to affect institutional change in STEM teaching and learning across the educational spectrum - from Kindergarten through faculty development - by conducting, catalyzing and supporting fundamental research.

## MISSION



Core to CASTLE's mission is the discovery, development, and evaluation of innovative approaches to improve STEM teaching and learning.

## AUDIENCE



CASTLE research and innovation serves as the foundation for the Center's work with the primary stakeholders: faculty, graduate and undergraduate students, post-doctoral fellows, future teachers, and K-12 students.

CASTLE partners with organizations who are best positioned to make the case for educational change on a local and national platform.

## Who are we?

The Center for Advancement of STEM Teach and Learning Excellence (CASTLE) is interested in improving STEM education across the educational spectrum from Kindergarten through faculty development; all through research to understand how to effectively:

- Modernize STEM learning with a focus on experiential and inquiry-based education
- Transform STEM teaching by changing the culture of STEM educator training
- Institutionalize the regular use of data to make decisions about teaching and curricula

In its brief history, CASTLE has been successful in securing new funding for STEM education initiatives, and in integrating with large, national, programs focused on improving STEM education, including the UTeach and CIRTl (Center for the Integration of Research, Teaching and Learning) National Networks which encompass 78 of the top research-intensive universities.

## What are we trying to do?

Through our work, we generate new educational initiatives and programs and assess and research outcomes to generate: publications, presentations, workshops and other activities to disseminate our findings to stakeholders and the broader national STEM education communities.



# Projects

## Funded in CASTLE

CASTLE was founded in 2014, and is currently home to sixteen funded projects centered on these goals. CASTLE is housed at Drexel University, which has a long history of experiential learning and innovation in STEM education, embodied by both the Co-Op program and the E4 program, an NSF-funded, inquiry-based curriculum pioneered by the College of Engineering in the 1980s. Recently, CASTLE has not only been successful in securing new funding for STEM education initiatives, but also in becoming

part of large, national, programs focused on improving STEM education, including the UTeach and CIRTl (Center for the Integration of Research, Teaching and Learning) National Networks which encompass 42 top universities. These networks position Drexel to lead a STEM transformation nationally, across universities including Columbia, Cornell, Johns Hopkins, Michigan State, Northwestern, UCLA, UC Berkeley, UC Boulder, UT Austin, UW Madison, and Yale.

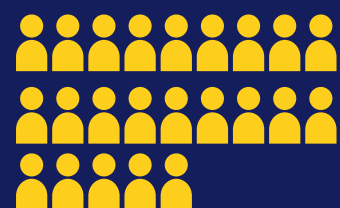
## CIRTl: Center for The Integration of Research

Preparing future academics to be effective teachers and skilled mentors

 **42** member research intensive consortium

 **20%**

of the country's new STEM faculty each year



In AY2016-17, 23 graduate students completed their Associate Level Certificates.

### Did you know?

Drexel University houses the CIRTl program through a shared partnership between Graduate College and CASTLE: the Center for the Advancement of STEM Teaching and Learning Excellence

**52%** of students who completed their certificate were **Women**

## PROFESS National Science Foundation

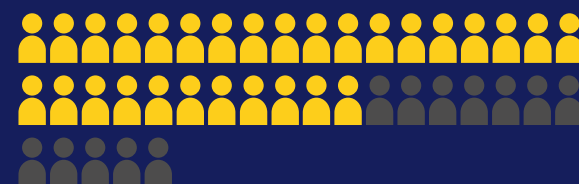
The prerequisite course for PROFESS is Foundations in Evidence-Based STEM Pedagogy and it has enrolled 41 students over two offerings.

**Out of 41 students there were:**

**16** female students

**4** students of underrepresented minorities

**9** international students



**79%** indicated they were interested in a career in academia

**82%** of the interested students considered teaching an important part of their career

**63%** of the respondents would be interested in engaging in the PROFESS program

**35%** of the respondents wanted to work towards a Master's Degree

# Lockheed Engineering Leadership Scholars Program

The focus of the Lockheed Engineering Leadership Scholars Program is to help students cultivate valuable communication, organizational, and leadership skills that will enable them to work collaboratively, lead teams, and thrive in a competitive global economy.

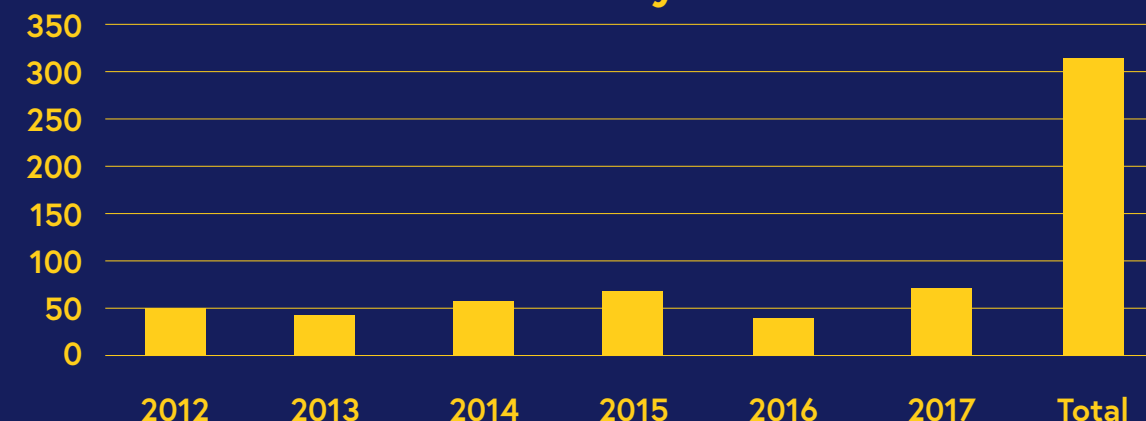
## Participation

The Lockheed Engineering Leadership Scholars program consists of 89 Upper Level College of Engineering students who take a series of leadership-focused classes and serve as peer mentors during their sophomore year.

## Student Activities

- Each fall, approx. 20 ELS mentors serve as peer mentors to incoming students
- Students complete capstone course which connects technical skills to a need in the community during their senior year
- Past community partners have included Bartrams Garden and Science Leadership Academy at Beeber

## Freshman Served by ELSMentors



## Academic Advantage

ELS Courses provide foundation in:

- Mentorship
- Leadership
- Motivating teams
- Communication

Teaching and Learning National Science Foundation

International Harmonization & Integration Federal Aviation Administration

Drexel University Office of the Provost

Sustaining Excellence Program Howard Hughes Medical Institute

The Colonial Academic Alliance IN/CO Grant Program

Engineering Leadership Program Lockheed Martin Corporation

The STEM Curricula for Authentic Learning Experiences The Arthur Vining Davis Foundation

Velay Fellows The Panaphil and Uphill Foundation

Wearable Technology in the Classroom The Earl P. Allabach Charitable Agency

DARE ExCEL – Experiential Learning through the Cooperative Education Lifecycle

ExPERTS The Chappell-Culpepper Foundation, The Colonial School District



# hhmi

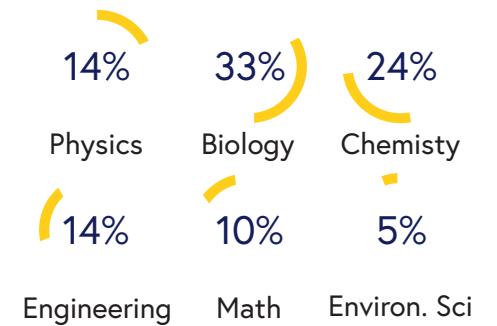
## Howard Hughes Medical Institute

The Howard Hughes Medical Institute (HHMI) Sustaining Excellence Program at Drexel University is focused on improving the retention of STEM undergraduates through two strategies:

- 1 Building mentored intellectual and social communities for STEM undergraduates that focus on student identity development
- 2 Modification to the University 101 course to incorporate: peer mentors, inquiry projects, and team activities

- 1 faculty member was awarded the Evidence-Based Teaching Award
- 2 faculty members were awarded STEM Education Travel Awards
- 6 faculty members completed the HHMI Faculty Course
- 7 faculty members presented at a Pedagogical Happy Hour
- 12 faculty members taught the modified UNIV 101 course
- 36 faculty and staff members attended a Pedagogical Happy Hour

### Dept. of Faculty Members who completed the HHMI Faculty Course

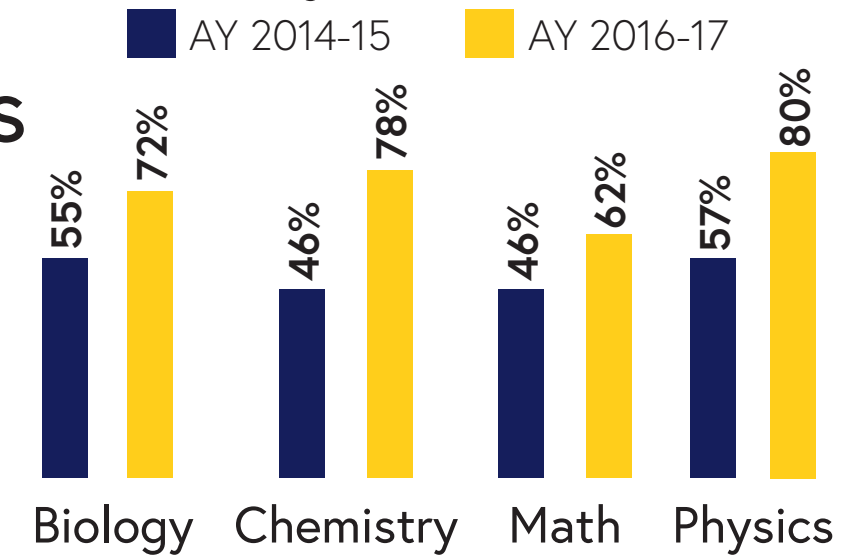


## Student Participation

27 peer mentors

245 freshman served directly

### Within Major Retention Rates



All of CASTLE's projects and initiatives are interdisciplinary. This is intentional, as our work focuses on understanding the similarities and differences in effective learning environments across the STEM disciplines and the educational spectrum. Bringing together disciplinary-based STEM education, faculty development, K-12 and higher education researchers is an uncommon and much needed approach to promote change in STEM education. This interdisciplinary focus allows the identification and development of best practices for STEM education, the study of new and

existing best practices in different settings to discover the contexts in which new and existing approaches may be integrated and work most effectively, and the dissemination of these discoveries back into various stages of the educational system. Ultimately, these approaches allow CASTLE to develop paradigms for STEM curricular reform and resources to support the incorporation of models of effective STEM education at Drexel and other institutions.



# Faculty Achievements

As a center, we currently have 16 active grants. This is a remarkable achievement considering the short time that CASTLE has been in existence. External funding has come from eleven distinct organizations in the form of federal, private foundation and collaborations with school districts. We have collectively published 13 articles/papers, and presented 30 talks/workshops/posters over the past two years on research relating to CASTLE projects. We hosted a national workshop at CASTLE last Fall (Bridging UTeach & Engineering), and have two additional regional workshops planned for this Fall.

In close collaboration with the Deans of the College of Arts and Sciences and the School of Education, this past academic year, we were able to support the hiring of a joint Physics and Science Education faculty member and CASTLE collaborator. While there are a variety of faculty members with research interests and activities focused on improving STEM Education through experiential learning, this new faculty member, Dr. Eric Brewe, is the first with a joint appointment (75% in Physics; 25% in School of Education). We are excited about the early successes of Dr. Brewe's collaboration with CASTLE, and particularly with him serving as PI for a recent NSF S-STEM grant proposal (pending), and look forward to the potential for expanding our reach and impact through additional strategic joint hires in support of CASTLE activities.

Additionally, we have been able to staff our initiatives through hiring program coordinators and other staff members that span multiple funding sources, ensuring continuity across programs and activities as well as robust staff knowledge.



**Kapil Dandekar, PhD**

CASTLE Collaborator

Associate Dean

Research & Graduate Studies

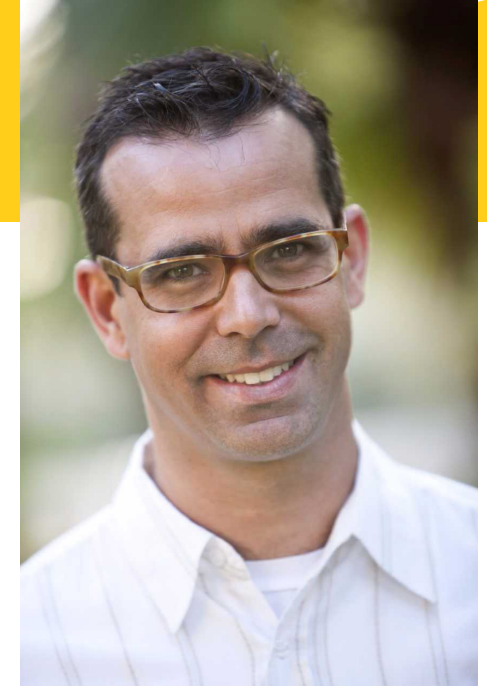
College of Engineering

Speaking at Pedagogical Happy Hour

# Dr. Eric Brewe

Dr. Eric Brewe is an Associate Professor in Physics and Science Education at Drexel University. His research into the teaching and learning of physics at the university level includes developing curriculum for the Modeling Instruction course, leading inquiries into the role of Modeling Instruction in promoting student learning, participation, retention & persistence, enhanced attitudes toward science and equity. This research has led to describing the role of participation in learning using primarily quantitative measures including the use of Network Analyses, and recently Functional Magnetic Resonance Imaging. In addition to research on postsec-

ondary physics, Dr. Brewe has been involved in preparing future physics teachers through Modeling Workshops, and as co-editor of the PhysTEC sponsored book, Recruiting and Educating Future Physics Teachers: Case Studies and Effective Practices. Dr. Brewe helped to found the American Physical Society's Topical Group on Physics Education Research (GPER) and served as the founding Chair of GPER. He recently co-edited the Focused Collection on Gender in Physics published by Physical Review – Physics Education Research and now serves on the editorial board for Physical Review – PER.



# Dr. Valerie Klein



Valerie Klein serves as an Assistant Clinical Professor and Program Director for the Mathematics Learning and Teaching Program in the School of Education. Her research interests include technologically-mediated teacher preparation, teachers' use of formative assessment in mathematics, creating opportunities for rich problem solving in the classroom, and qualitative research methods. Her recent publications analyze teacher interaction and development in online professional development settings and have been published

in a variety of journals, including The Mathematics Teacher and The Mathematics Teacher Educator. She teaches methods and pedagogy courses to pre-service and in-service teachers and in the DragonsTeach and Profess programs at Drexel. She began her work at Drexel as part of the Math Forum and prior to that worked in the non-profit sector as a program evaluator supporting financial education efforts in Philadelphia for low- and moderate-income households and individuals.



# National Impact

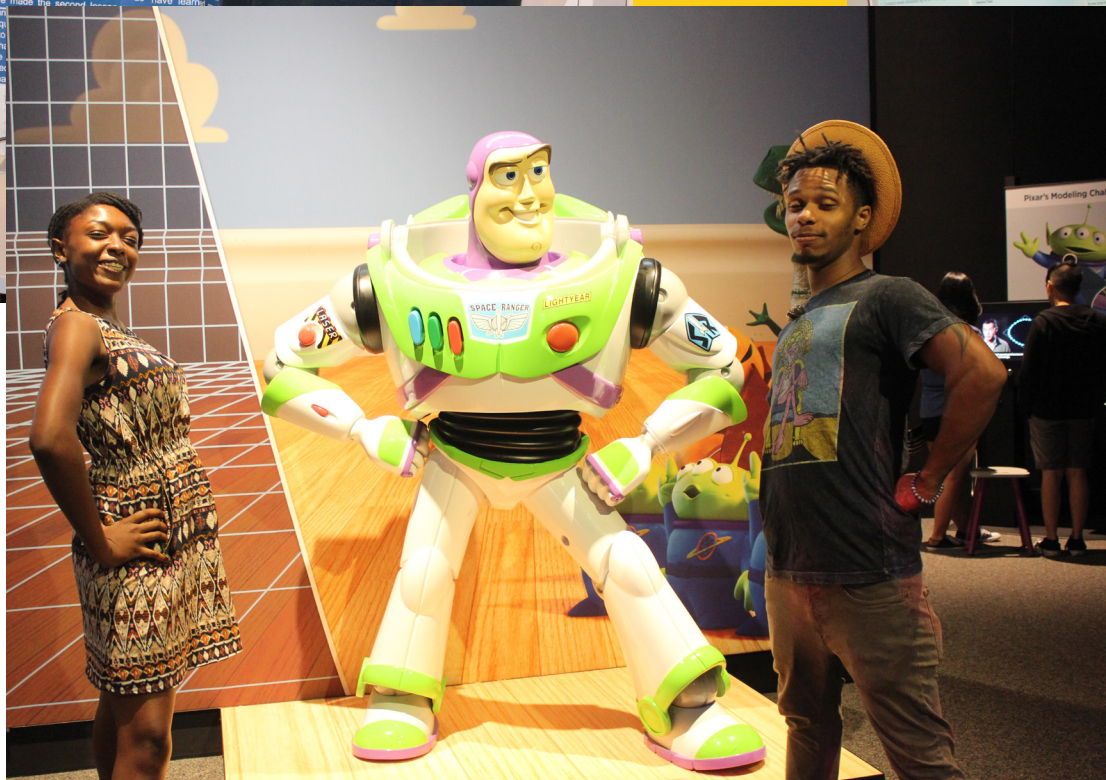
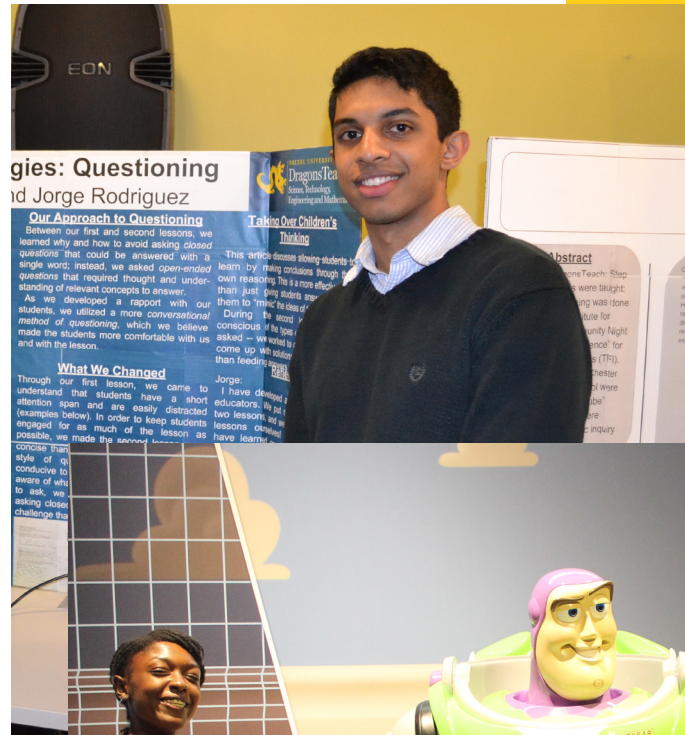
Bridging  
UTeach  
& Engineering  
Workshop

STEM Teaching and Learning Excellence (CASTLE) hosted the inaugural Bridging UTeach and Engineering Workshop from November 9 through 11th. This event was hosted in collaboration with the National Science Foundation, UTeach Institute, University of Colorado at Boulder, and Boise State University.

Expanding the STEM pipeline and increasing college access in the engineering fields is critical to the nation's economic competitiveness in the global economy, as well as the importance of equity in higher education. Drexel University understands this commitment through its dedication to STEM teaching and learning as well as its DragonsTeach program, an implementation of the national UTeach model, an innovative university-based teacher preparation program that works to increase the number of qualified STEM teachers in U.S. secondary schools.

The workshop centered on a conversation on how to increase participation of the Engineering disciplines in the UTeach community. Specifically, the workshop explored the opportunities (and pitfalls!) of expanding or establishing a university's UTeach program to include math and science secondary teacher licensure through an engineering degree pathway.

To help fulfill Drexel's commitment to training the next generation of highly skilled students in the engineering fields, the Center for the Advancement of



Is a PhD  
Right for me?

CASTLE's Director, Dr. Adam Fontecchio, and PhD. Director of Lebow College of Business Dr. Christopher Laincz, were invited to give a talk at the SXSW.EDU conference on March 5, 2017. Along with their colleague Dr. Cora MacBeth from Emory University and Dianne Le from Stanford University, they presented a talk entitled "Is a PhD Right for me?" The talk focused on the process and path for a PhD such as average year for completion, qualifying exams, etc. They also discussed financial aid received over the course of the program.



## DRAGONSTEACH WINS PRESIDENT'S AWARDS FOR CIVIC ENGAGEMENT

On Thursday, November 3, 2016, the DragonsTeach program won Drexel University's President's Award for Civic Engagement. This award is granted to professional staff and faculty with a strong personal commitment to engaging and collaborating with the community. It is distributed bi-annually to individuals who advocate President Fry's mission to be one of the nation's leading universities for civic engagement.



Dedicated to addressing the national need for qualified STEM teachers by offering STEM majors the opportunity to obtain secondary teaching certification alongside their degree and co-op experience. Over the past two years, DragonsTeach has implemented over 100 inquiry-based STEM lessons with elementary, middle, and high-school students in the Philadelphia School District. The program runs monthly Professional Learning Community nights for local educators to hone-in on their practice and enhance their skillset. Furthermore, DragonsTeach has built local partnerships with organizations such as The Franklin Institute, Breakthrough of Greater Philadelphia, and Drexel's Dornsife Center to provide resources for STEM majors and to run initiatives that engage the community's needs.

## DARE TO EXCEL WITH NEW EXPERIENTIAL LEARNING INITIATIVE

The application process was a competitive one. The University received 41 DARE applications and we are thankful that our DARE, Experiential Learning through the Cooperative Education Lifecycle (ExCEL), was one of the five selected. Our core participants include Drs. Abichandani, Dandekar, Fontecchio, Goldberg, Kontsos, Mongan, Rocheleau, Silverman, Stanford, and Smith. The ExCEL DARE focuses on an important area of research in STEM education: Experiential learning in which students learn from direct experiences. Opportunities of this type include: mentored research, cooperative education (Co-op), internships, service-learning, volunteering, and study abroad.

## NSF NOYCE

Drexel Engineering Noyce (DEN) supports the recruitment and preparation of engineering undergraduate students enrolled in DragonsTeach to pursue secondary STEM education as a career through scholarship awards and stipends. The United States need more engineers and scientists, and we believe one DEN graduate has the potential to inspire three to five students a year to become engineers and scientists!

## WHEN STEM EDUCATION TRANSCENDS THE FOUR WALLS OF A CLASSROOM: PRESENTING DR. BERTLEY

CASTLE was excited to host Dr. Bertley to lead a discussion about his current research in STEM education. Dr. Bertley has tremendous experience in creating programs aimed to improve the quality of STEM education and science literacy from K-16, and his contributions transcends the STEM education community as his talk is approachable to the wider non-scientific community of Philadelphia.

Importantly, his talk reviewed the exciting prospects of diversity in STEM teaching and learning in the United States. Dr. Bertley has a prestigious history in academia and is well known for breaking down complex sciences for the community to understand these concepts.

# Thank you to our partners!



## Special Thanks:

President  
**John Fry**

Provost  
**Brian Blake**

Senior Vice Provost  
Office of Research  
**Aleister Saunders**

Founding Graduate Dean  
at Drexel University  
President of University of  
New England  
**James Herbert**

Senior Vice President  
Office of Institutional  
Advancement  
**David Unruh**



# Special Thanks to:

