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Translational Engineering Skills Program (TESP): Training innovative, adaptive, and competitive graduate students for the 21st century work force

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Senior level manager with substantial experience in leading global teams, technology development, product design and introduction. Proven innovation skill set with over 25 US patents issued. Highly developed skill set for budget and schedule management, staff development and efficient work processes. Frequently pushes the envelope to break through barriers and achieve new levels of success. Frequent global traveller. Excellent written and verbal communication skills have resulted in repeated success at global collaboration and leadership of global teams and partnerships.

As the ASSIST Industry Liaison, responsible to recruit, manage and develop industry relationships. Foster collaboration between member universities, researchers, students and industry. Drive research towards practical and profitable commercialization. Support IP generation and licensing. Create a culture of innovation and mentor students and small businesses working within the Center. Through educational and industry outreach help build new markets and products from the foundational nanotechnology, nanofabrication, sensor, energy harvesting, low power electronics and medical research conducted in ASSIST.

The NSF sponsored engineering research center is focused on improving societal health through development of self-powered, wearable devices that monitor environmental and physiological metrics for enabling individualized wellness management.

Prof. Chunlei Wang, Florida International University

Chunlei (Peggy) Wang is an associate professor in the Mechanical and Materials Engineering Department at Florida International University. She received her MS (1993) and PhD (1997) in Solid State Physics from Jilin University (China). Before joining FIU, she held various research positions at Osaka University (1995-2001) and University of California Irvine (2001-2006). At FIU, her group focuses on the development of micro and nanofabrication methods for building novel micro and nanostructures and synthesizing nanomaterials that have unique structures and useful properties for energy and biological applications. She published in 5 book chapters, 90 peer reviewed journal publications, 30 proceedings, 206 conference abstracts, 10 patent and 31 disclosures. She is a recipient of FIU faculty award in research and creative activities (2013), FIU Kauffman Professor Award (2009), and DARPA Young Faculty Award (2008). She was a co-founder of Carbon Microbattery Corporation (now: Enevate Corp), a consultant at Intel Lab, and a guest scientist at Max Planck Institute.

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Translational Engineering Skills Program (TESP): Training innovative, adaptive, and competitive graduate students for the 21st century work force

Introduction

The center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) was established in September 2012 as a Nanosystems Engineering Research Center (NERC) with funding from the National Science Foundation (NSF). The lead institution of the center is North Carolina State University and the partnering institutions are Pennsylvania State University, University of Virginia and Florida International University. The highly multi-disciplinary nature of ASSIST brings together faculty and students from a diverse array of engineering disciplines including electrical and computer engineering, materials science and engineering, mechanical and aerospace engineering, chemical and biomolecular engineering, biomedical engineering and textiles engineering.

ASSIST will develop and employ nano-enabled thermoelectric or piezoelectric body energy harvesters, efficient supercapacitors for energy storage, low-power nano-devices and sensors as well as intelligent power management strategies and wireless communication systems to create innovative, battery-free, body-powered, and wearable energy-autonomous health monitoring systems.

The research includes two system test-beds: (i) Exposure Tracking - Correlation of health and environmental exposures for understanding chronic conditions such as allergies and autoimmune diseases, and (ii) Wellness Tracking - Continuous monitoring of individual health for specific purposes (i.e., treatment management, lifestyle habit changes, stroke prediction, emergency search and rescue, triage, and first responder tracking). These are being implemented using various wearable platforms such as a wrist band and chest patch. We believe that these test-beds, propelled by innovative technologies and informed by industrial, environmental, medical and social science practitioners, will directly address the Grand Challenges in Engineering in Advanced Health Informatics. Moreover, we are committed to training our graduate students to meet these grand challenges and achieve the vision of nanotechnology for the year 2020[1].

Background and Motivation

The ASSIST center's educational goal is to provide students with a comprehensive array of technical, professional, and translational skills that will make them innovative, adaptive, and competitive engineers for today's global economy. Within the center, students gain technical skills primarily though their thesis research as well as the graduate and undergraduate curricula (minors, concentrations, and/or certificates in nano-science and technology). However, recent literature shows an increased acknowledgement of the need to provide engineering students with a range of skills and attributes beyond the basic technical knowledge.

Perhaps the most well-known of these is the National Academy of Engineering publication, The Engineer of 2020[2] which outlines the following desirable attributes: strong analytical skills, practical ingenuity, creativity, communication, business and management, leadership, ethics and professionalism, flexibility, and lifelong learning. A range of additional literature echoes these findings and attempts to define and categorize the essential skills and attributes needed for success.

Global competency is one of the major skill categories found in literature. Rajala[3] summarizes the desired attributes of a global engineer from several sources[4,5], showing that the lists of attributes is extensive and often varies from study to study. Three attributes that consistently rank near the top of these lists are: (i) can appreciate other cultures, (ii) understands the bigger picture context of engineering work, cross-disciplinary aspects, business, ethical, and social implications, and (iii) is able to communicate with, work in, and direct teams of ethnic and cultural diversity.

In addition, there is a range of non-technical skills commonly known as "soft skills" that are often categorized together. Stephens[7], a former Senior Vice President of Human Resources and Administration at the Boeing Company brings up these soft skills emphasizing that students rarely lack the technical competencies, but often fail to succeed in industry due to lack of creativity, teamwork, and communication skills. Also, they need the ability to create products that are useful in the "real world". Nair et al[8], discuss the mismatch between recent graduates' skills and employers' expectations. Their case study confirms that the biggest gaps exist in the following skills: communication, capacity to analyze and solve problems, capacity for innovation and teamwork skills.

Adding the traditional technical skills, we see three major categories emerging: Hard, Soft, and Global competencies as defined by Patil et al.[6]. The hard skills relate to fundamental knowledge, research, and design skills. The soft skills deal with communication, teamwork, leadership, ethics, creative (real-world) problem solving, safety and sustainability skills. The global skills deal with the capacity to consider engineering solution in a global context and understand ethnic and cultural diversity.

In this paper, we propose a fourth dimension of required skills in addition to the soft, hard, and global competencies. This skill set, particularly applicable to nanotechnology, is called *Translation*. This is the ability to transform fundamental research into complete engineering systems. The vision for nanotechnology in 2020 is to achieve translation from the research labs to consumer use[1]. While the past decade focused on fundamental research and scientific discovery, the goal now is application-driven research leading to new technologies and industries.

We believe that promoting translation requires a combination of three competencies: (i) The ability to view and solve problems from a holistic systems perspective, (ii) strong entrepreneurial skills in order to translate out of the laboratory, and (iii) an understanding of current industry and manufacturing processes.

By combining the skills prevalent in literature (Soft and Global skills) with the three translational skills, we outline a set of seven competencies that are key to the development of future scientists and engineers. Together, these competencies are referred to as the Translational Engineering Skills.

(i) Systems Thinking – The ability to view problems and develop solutions from a systems-level perspective. Understanding the complex technical, industrial, social, and ethical implications.
(ii) Entrepreneurship and Innovation – The ability to develop and commercialize creative and innovative solutions. Entrepreneurial and business skills. Creativity, practical ingenuity, an ability to create real world solutions, and the flexibility to apply knowledge to new contexts also fall under this skill.
(iii) Industry and Manufacturing – Experience with standard industry and manufacturing processes will enable the development of practical solutions. Within ASSIST, there is a focus on the medical device industry. Nanotechnology has been described as the bridge between engineering and medicine[9], and a medical background is needed for translation in the medical field.
(iv) Mentoring, Teamwork and Leadership – The ability to manage, mentor, train others, lead teams, and also collaborate well particularly in ethnically and culturally diverse groups.
(v) Communication – The ability to share ideas effectively both orally and in written form.
(vi) Engineering Ethics – A foundational background in engineering ethics that equips students to handle the potential societal and ethical issues that can arise in the field of nano-technology. Developing a sense of professionalism and high ethical standards.
(vii) Diversity Awareness – Understanding of cultural and ethnic diversity that enables the engineer to excel in all of the above skills in a global engineering ecosystem.

The objective of the program described here, is to provide students with the above skills, in an environment that promotes continuous and life-long learning, the final attribute of the Engineer of 2020.

Program Design

The Translational Engineering Skills Program (TESP) was developed to teach the set of seven strategic translational engineering skills through experiential learning interventions. These activities broaden students' understanding outside of the academic curriculum and research activities. The TESP program is designed for graduate students within the ASSIST center, but the long term aim is to disseminate the program outside of the center for others to adopt or adapt for their use. Figure 1 shows a high level model of the program.

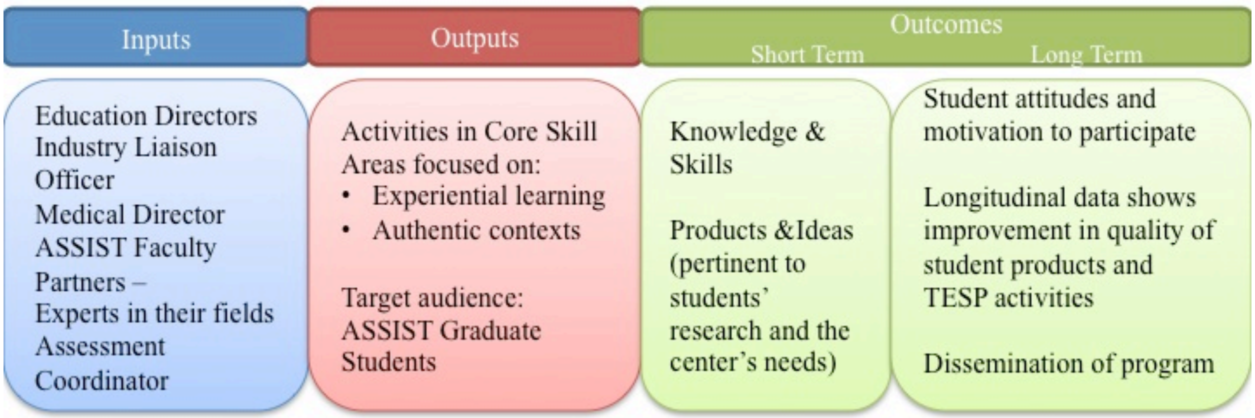

Figure 1: Summary of TESP Program description

The seven translational engineering competencies are described as Skill Blocks and are composed of a series of activities specifically designed to increase students' knowledge and experience in that particular area as shown in Figure 2.

The TESP activities are developed by combining the expertise of ASSIST faculty, education and diversity directors, industry liaison officer (ILO), medical director, and outside collaborators. The activities are meant to be hands-on, experiential learning sessions. In designing these activities, we recognize the importance of effective learning environments that focus on practice and the application of knowledge in authentic contexts[10]. Therefore, activities never take the form of simple lectures or seminars. While it is understood that some form of presentation or lecture may be needed as an instructional tool, the aim is to learn by doing. Moreover, we aim to provide real-world, meaningful problems rather than abstract scenarios.

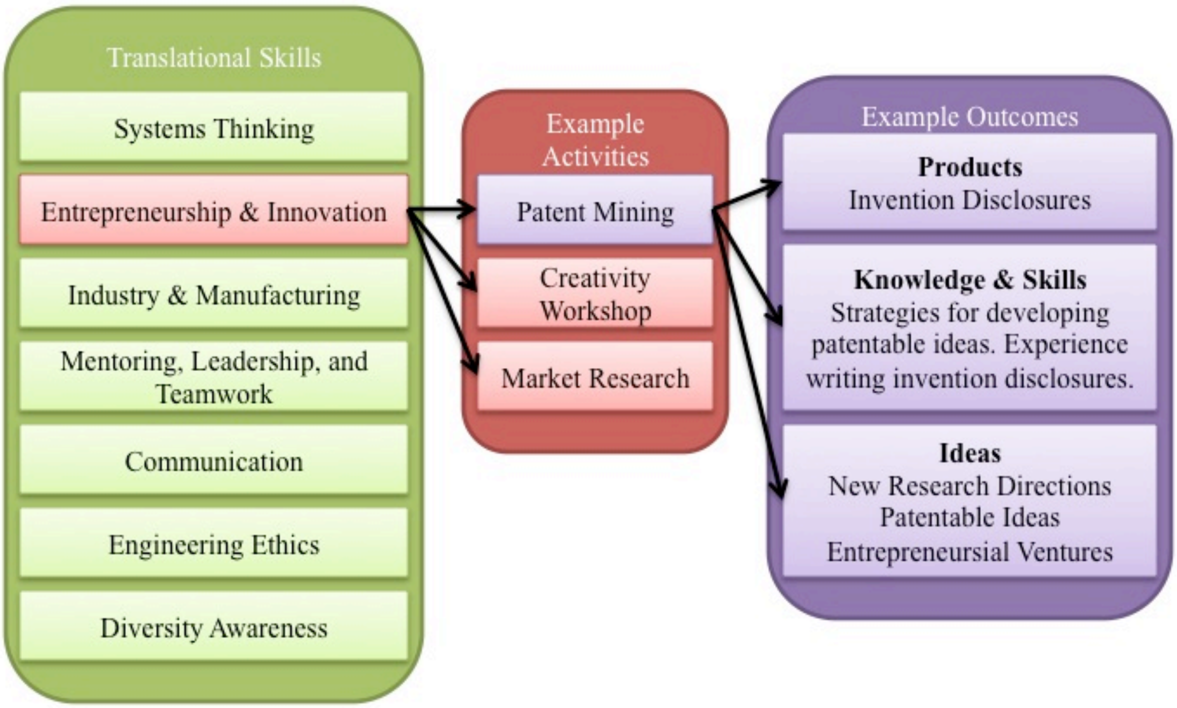

Figure 2: List of Translational Skills, Example Activities, and Example Outcomes

The primary outcome of TESP is to increase students' proficiencies in the seven core skill areas. While we believe these skills will make our students more creative, adaptive, and competitive as future engineers and academicians, we also look for immediate and useful outcomes for the center, and for students' research. These outcomes are in the form of products, ideas, and motivations. For example, some activities may result in invention disclosures, publications, or presentations by students. Activities may also result in ideas such as: new research directions, entrepreneurial ventures, center gaps identified, or new connections to industry or medical partners. Finally, we hope the activities will lead to students' increased understanding of the importance of these translational skills and the benefits of participating in a program which complements the specific technical education they are pursuing.

Program Structure and Implementation

In order to complete the program, students are required to participate in a minimum of ten TESP activities, and those activities must span across at least 5 skill blocks. For example, a student will not get credit for participating in 10 activities if they are all from the Entrepreneurship Block. However, students are allowed and encouraged to continue participating after the 10 activities have been completed. One of our goals is to ensure that we are providing meaningful experiences in which students find value and are excited to attend throughout their graduate career.

One of our primary challenges is in balancing the TESP requirements with students' research and course work commitments. We have put significant effort into designing activities that are focused and make efficient use of the students' time. Generally, TESP activities take the form of half-day workshops however some activities may require additional time commitment. Completion of the entire TESP program requires between 40 and 80 hours of effort from each student over the course of their entire graduate career.

However, we must highlight the fact that TESP activities are aimed to enhance the student's technical education, not take time away from it. With input and support from the center's faculty and leadership team, we are designing activities that advisors agree are important to the student's growth as a researcher. A great example is the patent mining activity described later in this paper. In this activity, students learn about intellectual property and practice developing patentable inventions – a skill which advisors find a useful part of the student's technical training. One of our communication activities is a peer manuscript review, in which groups of students provide feedback on each-other's technical papers. This activity improves the students' technical writing skills while easing the editing burden on the advisor.

The various TESP activities are offered monthly at all partner institutions. Some activities can be shared among institutions via online teleconferencing technologies (WebEx, Google Hangouts, Skype), but many are implemented individually by faculty at the partner institutions. In order to maintain uniformity of the experience across sites, activities are proposed and discussed with the Education Leaders at the partner campuses. The activities are all evaluated using the same metrics and rubrics across the campuses.

TESP implementation began with the fall semester of 2013. Due to the interactive, hands-on nature of the activities, most were piloted in fairly small groups (usually 6-10 students per session). In the next section, we provide examples of specific activities in different skill blocks.

Example TESP Activities

Patent Mining - The patent mining activity falls within the Entrepreneurship and Innovation skill block. This is a two part activity. The first component is a seminar which provides students with the basic background knowledge about filing patents and invention disclosures. At NC State University, this seminar was given by the associate director of the Office of Technology Transfer. The main part of the activity is a patent mining session that emulates the dedicated patent mining activities that many companies conduct in order to build their patent portfolios. In a hands-on approach, students brainstorm, discuss possible invention ideas, and go through the process of writing and grading an invention disclosure. Some outcomes of this activity are:

- Knowledge and Skills: Familiarity with technology transfer process. Basic understanding of what is a patentable invention and how to prepare a good invention disclosure.
- Products: Each student prepares a mock invention disclosure. The session could result in an actual invention disclosure related to the center's research.

- Ideas: Potential patentable ideas developed through the brainstorming, developing, and critiquing process.

Mind Mapping - This is an activity within the Systems Thinking skill block. The activity begins with a short overview of concept mapping as a tool for organizing and understanding complex systems[11]. Students are introduced to a basic mind mapping software (we used Xmind, but there are numerous options available). The facilitator then guides students through the creation of a mind map of the ASSIST center. Students work together to understand and graphically depict the entire ASSIST system including the numerous connections between the center's research thrusts, individual research projects, industry partners, test beds, and how all of these fit into the mission and vision of the center. Some outcomes of this activity are:

- Knowledge and Skills: Systems level understanding of the center. Experience with mind mapping as a systems visualization tool. Mind mapping software skills. (Xmind).
- Products: Systems level mind map of the ASSIST center showing relevant connections between projects, thrusts, test-beds, industry, etc.
- Ideas: Potential new research directions, research gaps, connections to industry or medical partners identified.

Market Research - A part of the Industry and Manufacturing skill block, this activity is led by the center's Industry Liaison Officer (ILO). Individual students work with the ILO to design a market research project of a depth and breadth that is pertinent to the student's research area. While giving students practical experience in market research, this activity also helps keep a close eye on how the ASSIST center's research benchmarks against industry. Additionally, students gain an ecosystem wide perspective of how the wearable sensor device market develops. Activity outcomes include:

- Knowledge and Skills: Practical experience conducting market research, analyzing, and presenting data. In depth understanding of the wearable electronic market and the ASSIST center's potential impact in this space.
- Products: Summary and presentation of the research findings.
- Ideas: Potential new research directions, entrepreneurial ventures, or new connections to industry partners could result from a deeper understanding of the market.

Creativity Workshop – A part of the Innovation and Entrepreneurship skill block, this workshop is based on the claim that that creativity can be taught. The content of the workshop is based on the "innovation engine", a model developed by the Stanford University Professor, Dr. Tina Seelig[12] to explain the relationship between different inside/outside factors that influence creativity. Students engage in a series of hands-on activities to demonstrate techniques that can be used to stimulate imagination – the catalyst that turns knowledge to ideas. The activities include a guided brainstorming session and a demonstration of design heuristics, a system of prompts developed by researchers at University of Michigan and Iowa State University[13] to encourage design space exploration during generation of new concepts. The activity outcomes are:

- Knowledge and Skills: Tools and techniques that help students actively focus on being more innovative.
- Products: Guided brainstorming session can lead to various products. For example, the first session at NCSU yielded an ASSIST online game aimed at helping students become more engaged and learn about the center in a fun and competitive format.
- Ideas: Guided brainstorming and can lead to new research ideas or innovative ways to solve existing problems.

Mentoring for Diversity Workshop – A part of the Diversity Awareness training, this workshop focusing on teaching techniques for mentoring diverse students is valuable to faculty as well as graduate students who often serve as mentors for undergraduates in their labs, REU students, or K-12 outreach activities. The half-day workshop will feature discussions including participants' perceptions of the climate in their departments, unconscious bias, gender and race biases, and mentoring students with family responsibilities. The workshop also features several presentations by experts in the field.

Evaluation

In order to evaluate the effectiveness of TESP we gather data related to student skills, attitudes, products, and ideas. The TESP evaluation approach is three-pronged: self-assessment, reflection, and skills assessment (Fig. 3). Every activity includes a student self-assessment of skills and attitudes using a 5 point Likert scale. After each activity, students write a 1-2 paragraph

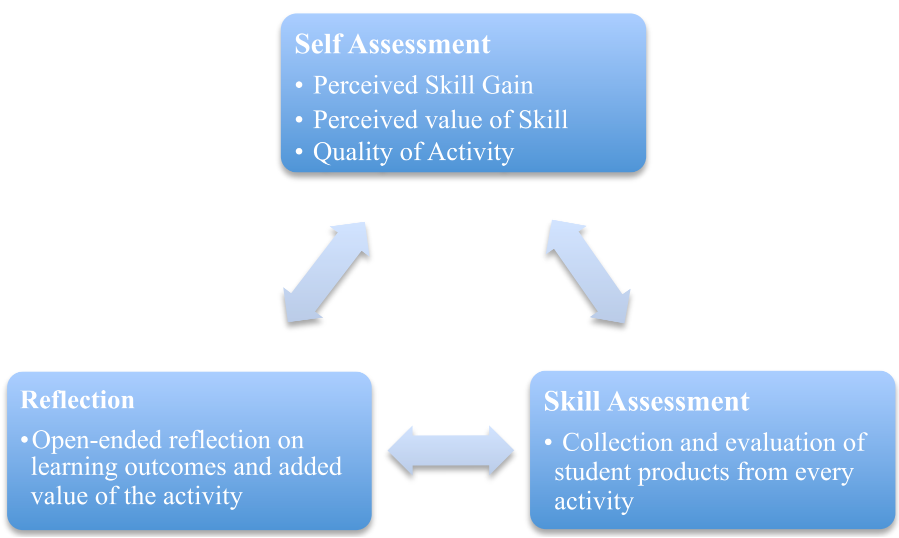

Figure 3: TESP Evaluation Plan

reflection. Finally, for every activity, samples of student work, including mind maps, invention disclosures, and publications are collected and analyzed to gauge student learning.

Triangulating the different types of data enables us to assess and compare students' self-efficacy, their attitudes toward the activities, and the instructors' perception of skill gains. Samples of student work will be compared with the students' self-reported skill gains and opinions in order to better understand what students are learning and optimize activities accordingly. Longitudinal data will show changes in student skill gain over time as activities are evaluated, redesigned, and optimized. Over time, we are looking for improvement in the quality of student products, as well as correlations between the quality of the product and the self-evaluation and reflection metrics.

Preliminary Results

Over the first semester of program implementation, we have gathered preliminary data on activities primarily within the Entrepreneurship and Innovation and Systems Thinking skill blocks. Within the Systems Thinking skill block, our ILO hosted two mind mapping sessions (one at NC State and one at Florida International University). The education leaders at Penn State University hosted a similar activity for their students, and University of Virginia hosted a three day workshop on system level design and implementation with experts from Cadence. A variety of workshops in Entrepreneurship and Innovation were held at three of our four campuses. These took the form of patent mining sessions, a creativity workshop, an Intellectual Property and Patent workshop, and an entrepreneurship seminar and discussion group.

At the end of every activity, students were asked to complete a survey. Each of the eight skill blocks has an individual survey. Figure 4 shows a summary of the Systems Thinking survey, which includes primarily the mind mapping activities. Other surveys have similar questions but related to the other skill blocks.

The survey questions aim to determine three factors: students' perceived skill gain, students' attitudes toward the value of the skill, and opinions on the quality of the activity. In both Systems Thinking, and Entrepreneurship/Innovation surveys, a majority of participants (over 63%, and up to 88% for specific activities) noticed at least some skill gain. A majority of respondents also claimed to have previous experience with Entrepreneurship and Systems Thinking which points towards the conclusion that the activities were useful even for those students who already had some prior skills.

In terms of their attitudes toward learning the skills, an overwhelming majority of respondents agreed that Systems Thinking (89%) and Innovation and Entrepreneurship (95%) were important in their research or career, and that employers value these skills. In terms of the activities themselves, over 80% of respondents in both surveys agreed that the activities were well organized, had clear objectives, and met their needs. Over 94% of respondents said they would recommend the activities to their peers.

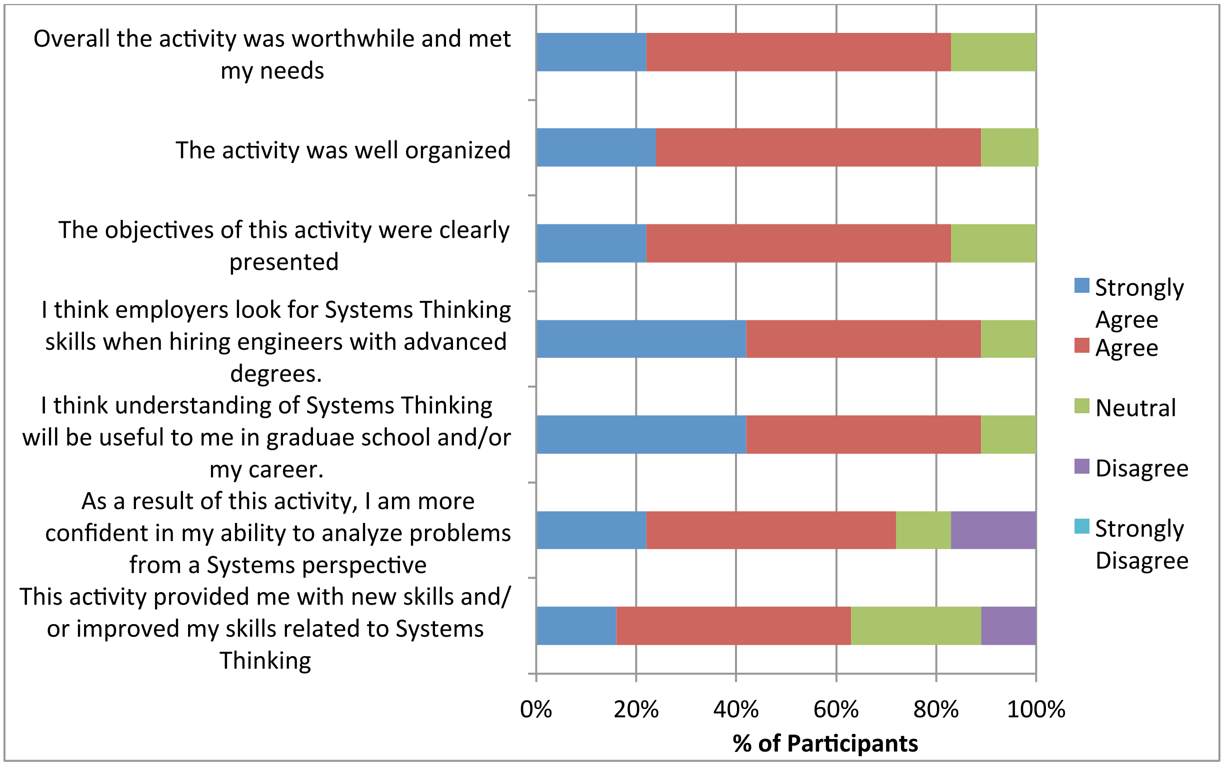

Figure 4: Summary of responses to the Systems Thinking Survey

Overall, these preliminary findings point to the conclusion that our activities are generally well-received by the participants, meaningful, and well-designed. While student reflections and comments about the best and worst parts of the activities generally show the same trend, it is clear that students are not hesitant to discuss the perceived weaknesses of certain activities. Their feedback will be valuable in improving the activities as we offer them again to new groups of students.

In addition to the surveys and reflections, we also collected samples of student products from each activity to ensure students self-reported skill gains correlate well with the quality of the work. Comparing these products over time as more students complete the activities will allow us to meaningfully gauge improvement in student skill and depth of understanding.

Summary

The Translational Engineering Skills Program (TESP) was developed and implemented to teach a set of strategic skills to graduate students through experiential learning interventions that enhance the academic curricula and research activities, and broaden students' understanding. The goals of the program are to increase proficiencies in the translational skills, impact attitudes towards learning these skills, and promote voluntary, long-term participation. Strategic activities are designed for each of seven skill blocks: *Systems Thinking, Entrepreneurship and Innovation, Industry and Manufacturing, Mentoring Teamwork and Leadership, Communication, Diversity Awareness, and Engineering Ethics.* After preliminary implementation of activities in the

Systems Thinking and Entrepreneurship and Innovation skill blocks, we see evaluation trends that suggest students are increasing their skills and knowledge, have positive attitudes regarding the importance of learning these skills, and would recommend these activities to their peers. As we continue developing the program, improving activities, and designing new ones, we hope to see continued and increased participation by students. We hope to see a variety of outcomes from student participation in TESP, including new research ideas, industry connections, and career choices. Over time, longitudinal data will demonstrate the value of teaching translational skills to engineering students.

Acknowledgements

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References

1. Roco, M. C., Mirkin, C. A., & Hersam, M. C. (2011). Nanotechnology research directions for societal needs in 2020: summary of international study. *Journal of Nanoparticle Research*, 13(3), 897-919.

2. National Research Council. (2004). The Engineer of 2020: Visions of Engineering in the New Century. Washington, DC: *The National Academies Press.*

4. Parkinson A. (2009). The rationale for developing global competence. *Online Journal for Global Engineering*, 4(2).

5. Chan A, Fishbein J. (2009). A global engineer for the global community. *The Journal of Policy Engagement*, 1(2), 4-9.

6. Patil A, Codner G. (2007). Accreditation of engineering education: review, observations and proposal for global accreditation. *European journal of engineering education,* 32(6), 639-651.

7. Stephens R. (2009). Aligning Engineering Education and Experience to Meet the Needs of Industry and Society. *The Bridge*, 43(2), 2013.

8. Nair C, Patil A, Mertova P. (2009). Re-engineering graduate skills–a case study. *European Journal of Engineering*, 34(2), 131-139.

9. Petrosko SH, et al. (2013). *N*anotechnology: An Enduring Bridge Between Engineering and Medicine. T*he Bridge*. 43(3), 7-15.

10. Redish E, Smith K. (2008). Looking beyond content: Skill development for engineers. *Journal of Engineering Education*, 97(3), 295-307.

11. Novak J, Cañas A. (2006). The theory underlying concept maps and how to construct them. *Florida Institute for Human and Machine Cognition*.

12. Seelig, T. L. inGenius: A crash course on creativi*ty*. Hay House, Inc, 2012.

13. Daly S, Christian J, Yilmaz S. (2012). Assessing Design Heuristics for Idea Generation in an Introductory Engineering Course. *International Journal of Engineering Education,* 28(2), 463.