Educational Convergence: The Anthropology, Performance, and Technology (APT) Program

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***Abstract*— This Work in Progress paper notes that the 21st century is a time of existential challenges and great social change. It is an anthropogenic era in which human society is firmly at the center of change at all scales. The future of our civilization depends on the ability of humankind to respond to these challenges. Whereas technology was once seen as the solution to these challenges, it has become evident that only by coupling technology in an appropriate cultural context can it be successful. The Anthropology, Performance, and Technology (APT) program is an intersectional bridge between these three disciplines designed to nurture the creation of innovative solutions to socially relevant problems in the 21st century. This paper describes the vision and objectives of the APT program, and the current status.**

***Keywords*— anthropology, performing arts, engineering languages, transdisciplinary education**

I. Introduction

A. Motivation

The 21st century is a time of existential challenges and great social change. For better or worse, it is an anthropogenic era in which human society is firmly at the center of change at all scales. The future of our civilization depends on the ability of humankind to respond to these challenges. Whereas technology was once seen as the solution to these challenges, it has become evident that only by coupling technology in an appropriate cultural context can it be successful.

The UC San Diego Jacobs School of Engineering is committed to launching one of the first modern systems engineering programs designed to prepare our graduates to be leaders and innovators in tomorrow's rapidly advancing, and globally connected organizations. This transformation has already begun and will continue to accelerate over the next decade as industry, government and academia take a systems approach to solve the planet's grand challenges. Industry is leading a revolution in complex, massively distributed, data-driven systems that rely on new data streams, analytics, and machine learning and modeling to constantly evolve and improve, during ever-shorter iterations. In our globally-connected socioeconomic ecosystem, the stakes are high, and our engineers must be able to manage known risks, and reduce the impact of unintended consequences.

Industry partners from multiple industry sectors are demanding a new breed of systems engineer and systems engineering education. Traditional systems engineering processes, built around the relatively long and controlled design cycles in aerospace and defense, will need to evolve to satisfy today's complex and dynamic environment.

The Jacobs School is known for providing strong engineering fundamentals in a collaborative research environment. Our bold vision is to couple the discipline-specific education offered in our engineering departments with a relevant and modern complex systems curricula. Our goal is to teach our students how to think differently: how to ask the right questions; see the big picture as it evolves; and embrace ambiguity as they make decisions in uncertain environments. Engineering students with these skills will learn how to create cognitive models to visualize, intuit, and innovate complex systems, and how to orchestrate and rapidly integrate new, complex components. They will learn about iterative and agile engineering design. Students in the program will practice business, leadership, ethics, and teaming skills as they work together on practical systems projects both in class and onsite during Co-ops with industry partners.

While engineers have proficiency in a number of different languages including: (1) Euclidean Geometry – Diagrammatic Languages, (2) Mathematics – Analytical Languages and (3) Digital Languages – Computational Models; there is a need to develop a proficiency in languages that can be understood and internalized by the general public.

The arts are a principle avenue for human inspiration which is necessary to make the necessary societal changes. In particular, as these are dynamic problems that require active human intervention, the performing arts, particularly in interactive forms are an ideal form for this inspiration. The human narrative, and storytelling in particular, have found their way into the development of technology, as this approach is ideal for the description and communication of complex problems and solutions. As such, transdisciplinary approaches are necessary to provide this fusion of anthropology, the performing arts, and technology.

B. Program Overview

The APT program is an intersectional bridge between anthropology, performance, and technology, designed to nurture the creation of innovative solutions to socially relevant problems in the 21st century. Each of these three components are supported by their own specific languages:

- Anthropology – provides a unique perspective to systems thinking, particularly with a methodological approach to understand how interactions between culture and technology define society, its behavior and evolution. It enables engineering students to communicate in effective language to convey subjective human experience. The human narrative, and storytelling in particular, have found their way into the development of technology, including the role of speculative arts and worldbuilding as tools to improve futures literacy (understanding)
- Performance – enables engineers to describe the experiential sense of a system by bridging the subjectivity of anthropology and the objectivity of technology in a product or service (designing)
- Technology – an objective language of precision and mathematics informed by human-centric design to generate innovative systems and to enhance empathy and compassion (product use)

This program provides the structure and support for students to learn and exercise these languages to broaden their understanding and collaborate in these areas to realize solutions for positive social change. As such, transdisciplinary pedagogical approaches are necessary to promote an interactive fusion of anthropology, the performing arts, and technology.

The program is starting at a small scale and growing organically through its successful interactions with students, faculty, social and citizen groups, governmental agencies, and industry. These activities take the form of course related educational experience as APT modules in existing engineering courses, in workshops, and in new transdisciplinary courses. Practical experiences include senior collaborative projects, master's projects and doctoral dissertations. Finally, social interaction is supported through public outreach, colloquia and guest lectures.

This work in progress paper describes the foundations and role of the APT program in creating and instructing performance and the experiential language of engineering, as well as the learnings to date in its institution and execution.

II. APT Program Foundations

A. Engineering Competencies

While the APT program is applicable to a broad range of engineering disciplines, it is initially using a systems engineering competency framework that was developed by the Systems Engineering Education Ecosystem (SEEE) program sponsored by the Academic Council in the International Council on Systems Engineering. This competency framework is based on a thorough review of existing systems engineering and engineering competency frameworks [1-11], interviews with industry, and anticipation of the future needs of the discipline. The resultant framework consists of all of the INCOSE framework [1], with some notable additions, categorized into the four major categories:

- **Lead** – Personal and interpersonal competencies (9) related to emotional IQ, ethics and professionalism, critical thinking, teamship and communication skills. These capabilities serve to amplify the impact of the other competencies through others.
- **Understand** – Analytical competencies (4) relating to understanding, creating and using systems models, including systems thinking, modeling and simulation, experimentation, and analysis and decision making. These competencies provide support for decision making.
- **Design** – Synthesis competencies (10) that enable the system design through the lifecycle of conceptualization, architecture, implementation and sustainment. These competencies support the creative design process including design thinking, engineering design, and systems engineering.
- **Realize** – Management and control competencies (13) that support the actual realization of systems including business fundamentals, lifecycle management, monitoring and control, and operations. These competencies enable the realization and execution of the engineering of systems.

B. APT Focus Areas

A competency survey was conducted with 11 companies that are involved in systems development with a total of 22 respondents. Each respondent noted the desired and actual perceived competency proficiency levels, on a 5-point Likert scale, for new college graduates (NCG) and mid-career engineers (MCE) in each of the 37 SEEE competencies. The difference between the actual and perceived areas is the competency gap that each company experiences. The top five gaps for each group were found to be in the following areas (competencies supported by APT are in **boldface**):

- New College Graduates:
    1. **Systems Thinking – 1.24 gap**
    2. **Ethics & Professionalism – 1.0 gap**
    3. **Communications – 1.0 gap**
    4. Concurrent Engineering – 0.79 gap
    5. Design of Experiments – 0.76 gap
- Mid-Career Engineers:
    1. Systems Modeling & Analysis – 1.19 gap
    2. **Systems Thinking – 1.0 gap**
    3. System Architecting – 1.0 gap
    4. **Communications – 0.94 gap**
    5. **Facilitation – 0.94 gap**

Note that for NCGs, the top three gap areas are related to APT elements, while for MCEs three of the top five are related to APT elements.

III. APT Program Implementation

The APT Program was created as a response to a corporate affiliate program systems engineering survey which sought to learn the self-described expected and actual competencies of new graduates and mid-career engineers. The analysis demonstrated a significant difference in the perceived versus actual competencies in the areas of: Ethics and Professionalism, Communication, Critical Thinking, Emotional Intelligence, and Negotiation. These competencies will be taught through independent modules in existing undergraduate and graduate engineering courses and in the new MS of Systems Engineering program.

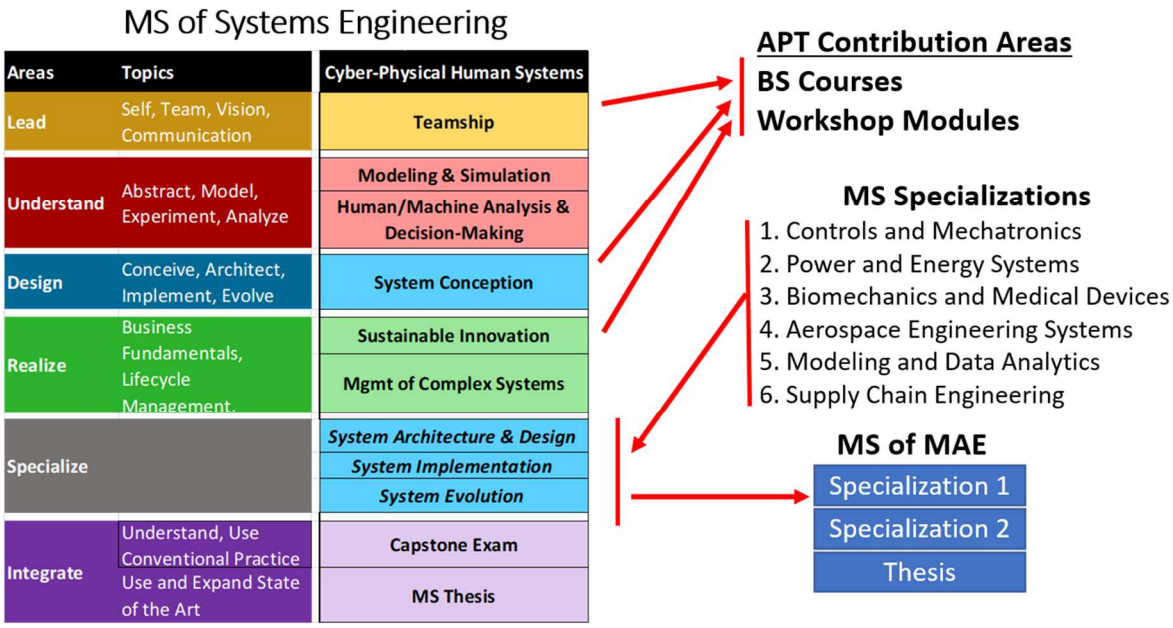

Figure 1. Relationship of APT Contribution Areas to MS of Systems Engineering Program

The relationship of these course areas is shown in Figure 1.

A. New MS of Systems Engineering Program

As shown above, the APT programs contributions will be primarily in the Teamship, Systems Conception and Sustainable Innovations courses. The APT course modules in these courses are shown below.

Teamship:

A. Self

1. Understanding Self
2. Emotional Intelligence
3. Foundations of Ethics and Ethical Decision Making
4. Critical Thinking

B. Team

5. Team Dynamics and Roles
6. Facilitation, Coaching, and Mentoring
7. Change management

C. Communication

8. Visioning
9. Communication: Story Telling
10. Communication: Presentation and Persuasion

Systems Conception

A. Business/Product Concepts

1. Business models - demand creation, markets, revenue, and monetization
2. The Agile MBA: Finance, Marketing, and Legal basics
3. The Product Development Life-cycle

Systems Conception (cont'd)

B. Product/Customer Fundamentals

4. Product/Market/Organizational Fit
5. The design of a competitive strategy
6. Lean testing: Data-driven market, channel, and customer analytics

C. Conceptualization

7. Concept Design
8. Concept of Operations & Use Case Scenarios
9. Concept: Systems Requirements
10. The art of the pitch

Sustainable Innovation:

A. Systems Fundamentals

1. Systems & Sustainability Perspectives
2. Systems Relationships
3. Systems Dynamics

B. Sustainability Fundamentals

4. People - Social
5. Planet – Environmental
6. Profits – Economic
7. Ethical frameworks for balancing 3 P's

C. Innovation

8. Innovation Intelligence: metrics that matter
9. Innovation strategy: designing competitive products and business models

B. *Existing Engineering Courses*

Because the existing course load has proven to be successful in preparing undergraduates in the technical aspects of their education, the required competencies were intended to be introduced in required courses where faculty determined their courses would benefit from the introduction of these competencies as an organic part of their ten-week quarter. So far, APT-related content in areas such as Storytelling, Storyboarding, Communication skills, and Teamship building has been deployed in Product Engineering, Design for Development, Aerospace Structural Mechanics, and is slated for introduction in senior level lab courses in mechanical engineering, particularly with respect to ethics and professionalism.

C. *Outside of the Classroom*

Outside of the classroom, APT-related content, collectively being referred to as the 'APT Etudes', have been prepared for presentation in student organizations such as the Women in Electrical and Computer Engineering (WECE) and the Office of Academic Support and Information Services (OASIS), groups that have been formed by women and underrepresented groups in the areas of Presentation of Self in Everyday STEM Life and How Art can Effect Social Change.

On the level of community outreach, the APT Roundtable Discussion and Educational Network Talk (ARDENT) Series has been created as a way for the academic community, corporate affiliates, and the greater community to be involved in discussion with invited speakers on systemic problems such as Gender Parity in STEM, Eco-conscious Design, and Data-Informed Public Art.

A newly proposed Masters Program in Systems Engineering will allow the development of full courses in the areas of Intra/Entrepreneurship, Teamship, and System Conception.

IV. Conclusions and Future Work

Anthropology is increasingly recognized as providing a foundational skill set in approaching today's complex, anthropogenic challenges. Anthropologists offer methodological expertise, human-centered and global perspectives, professionalization, and systems thinking to complement the disciplinary perspectives of our colleagues in engineering, computer science, technology studies, and the hard sciences. Performance is the experiential language of engineering. The arts are a principle avenue for human inspiration which is necessary to accomplish and establish societal change. We face dynamic problems that require active human intervention and the performing arts, particularly in interactive genres, are an ideal source for this inspiration. Human society is driven in part by its relationship to technology, The human narrative, and storytelling in particular, have found their way into the development of technology, as this approach is ideal for the description and communication of complex social problems and solutions. Civilization is the emergent outcome of the interaction between culture and technology. [12]

The objective of the APT Program is to generate new ways of seeing and experiencing the world from the point of view of multiple cultural, social, generational, and engendered perspectives as a way to inform a new breed of engineers and artists, and to generate truly innovative ways of addressing complex solutions through multidisciplinary collaboration. This program will support synergistic research and education that will prepare its participants to address contemporary issues utilizing skill sets developed through the program that would nurture their strengths and prepare them for informed, technologically innovative, and ethically-driven careers in the arts and engineering.

The APT program aims to groom a new generation of socially-engaged, culturally relevant, and artistically as well as scientifically creative thinkers through innovative pedagogical methods that will propel the Jacobs School of Engineering forward into the twenty-first century.

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