32nd Annual INCOSE international symposium
hybrid event
Detroit, MI, USA
June 25 - 30, 2022

Systems Engineering Competency Expectations, Gaps, and Program Analysis

Jon Wade, Hortense Gerardo, and Harold Sorenson
University of California, San Diego

Entering Industry 4.0

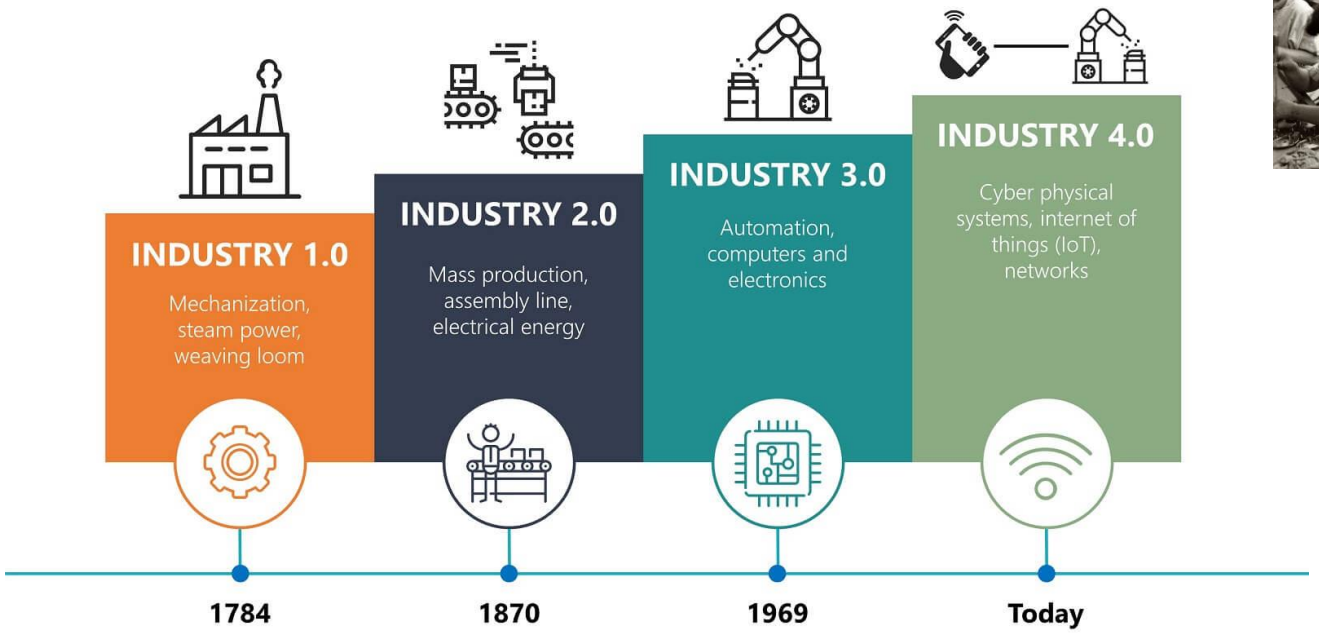


Image Credit: International Business Times

Moving from Education 2.0

To Education 4.0

Dynamically Adaptive Education

Systems Engineering Education Ecosystem

UC San Diego JACOBS SCHOOL OF ENGINEERING

	Program & Course Design	Classroom Experience	Individual Learning
Graduate Students	- Institution application & enrollment - Degree/major selection - Course selection - Class/instructor selection	- Determination of when and how to study - Selection of learning materials (lectures, reading, videos, etc.) - Determination of where to work to use skills	- Determination of personal interests - Development of knowledge production skills (e.g., Web search) - Selection of online resources for knowledge acquisition

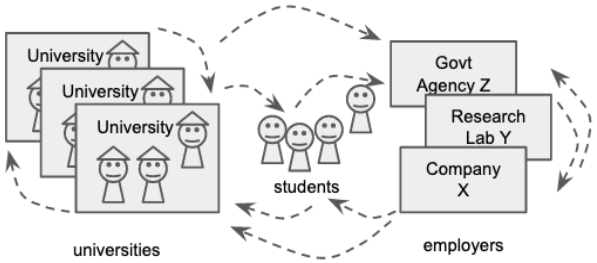
	Program & Course Design	Classroom Experience
Academic Institution & Instructors	- Program topic and target student selection - Program learning outcomes and objectives specification - Course topic: outcomes and objectives specification - Course design: curricula, pedagogy, and assessment - Determination of which educational applications to provide to instructors - Determination of whom to admit into programs and classes - Allocation of resources, including assignment of instructors to classes, room assignments, lab, funding of TA's, tutors, graders - Determination of tuition and other educational costs	- Determination of how to present materials - Determination of which educational applications to use in instruction - Determination of how to answer questions and interact with students - Determination of how to update and add to course materials - Determination of how to assess students and provide feedback - Determination and application of grading policy

	Program & Course Design
Employers	- Determination of necessary skills for employees in the workplace - Determination of which schools to support with partnerships and funding - Determination of which schools to actively recruit students - Determination of which students to interview - Determination of which students to hire as interns, coops and permanent employees - Determination of which programs are eligible for professional education reimbursement - Determination of which employees to reimburse for professional education

INCOSE IS 2022

PROGRAMS

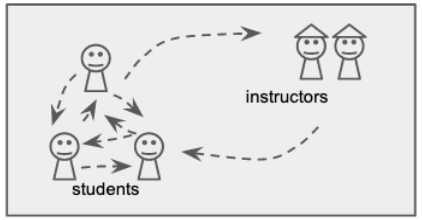
Educational Program Evolution (EPE)



Diversifying and expediting feedback exchange between students, universities, and employers to accelerate the evolution of educational programs.

CLASSROOMS

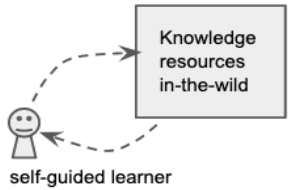
Social Real-time Learning (SLR)



Making the feedback loop b/n students and instructors more relevant, timely, automated and actionable

INDIVIDUALS

Personalized Knowledge Discovery (PKD)



Creating and testing new feedback mechanisms to support self-guided learning by graduate students

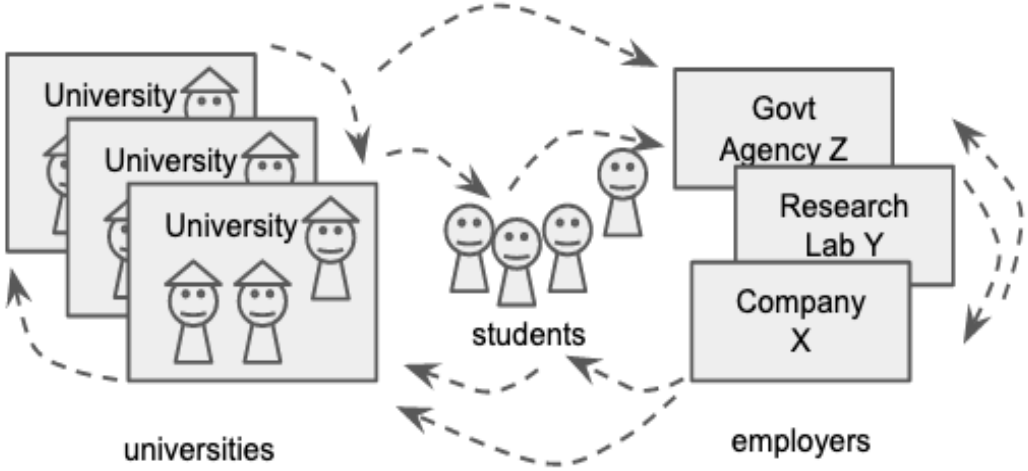
Educational Program Evolution

Objective: Create the feedback loops by which educators, students and employers can communicate their specific educational capabilities, desires and needs, to provide the dynamic feedback necessary to accelerate the evolution of educational programs.

Hypothesis: A non-profit website can be developed that presents specific graduate engineering program information which, accompanied with analytic tools, can assist students, educators, and employers to efficiently and effectively make education, program and employment decisions.

Systems Engineering Education Ecosystem

Systems Engineering Education Ecosystem (SEEE)



Diversifying and expediting feedback exchange between students, universities, and employers to accelerate the evolution of educational programs.

Our Values

- ***Preserve the uniqueness of SE programs*** that speak to particular varieties of students and professions
- ***Promote commonality*** among programs where it is beneficial
- ***Provide support for program evolution*** *to adapt to changing needs*, and thereby
- ***Enhance the value of all of our programs***.

Competency Framework Requirements

- Focus is on systems graduate education
- Structure should reflect academic classifications
- Need to capture competencies across multiple disciplines:
  - Systems Engineering
  - Industrial Engineering
  - Operations Research
  - Data analytics
  - Engineering Management
- Should provide balanced view of competencies
- Taxonomy should aid in easy navigation
- Language should be jargon free and clear to students/practitioners, employers and academics

INCOSE Competency Framework

Understand	Lead	Realize	Design

CORE COMPETENCIES

Core competencies underpin engineering as well as systems engineering.

Systems Thinking	The application of the fundamental concepts of systems thinking to systems engineering;
Lifecycles	Selection of the appropriate lifecycles in the realization of a system;
Capability Engineering	An appreciation of the role the system of interest plays in the system of which it is a part;
General Engineering	Foundational concepts in mathematics, science and engineering and their application;
Critical Thinking	The objective analysis and evaluation of a topic in order to form a judgement;
Systems Modeling and Analysis	Provision of rigorous data and information including the use of modeling to support technical understanding and decision making.

PROFESSIONAL COMPETENCIES

Behavioral competencies well-established within the Human Resources (HR) domain. To facilitate alignment with existing HR frameworks, where practicable, competency definitions have been taken from well-established, internationally-recognized definitions rather than partial or complete re-invention by INCOSE.

Communications	The dynamic process of transmitting or exchanging information;
Ethics and Professionalism	The personal, organizational, and corporate standards of behavior expected of systems engineers;
Technical Leadership	The application of technical knowledge and experience in systems engineering together with appropriate professional competencies;
Negotiation	Dialogue between two or more parties intended to reach a beneficial outcome where difference exist between them;
Team Dynamics	The unconscious, psychological forces that influence the direction of a team's behavior and performance;
Facilitation	The act of helping others to deal with a process, solve a problem, or reach a goal without getting directly getting involved;
Emotional Intelligence	The ability to monitor one's own and others' feelings and use this information to guide thinking and action;
Coaching and Mentoring	Development approaches based on the use of one-to-one conversations to enhance an individual's skills, knowledge or work performance.

MANAGEMENT COMPETENCIES

The ability to perform tasks associated with controlling and managing Systems Engineering activities. This includes tasks associated with the Management Processes identified in the INCOSE SE Handbook.

Planning	Producing, coordinating and maintaining effective and workable plans across multiple disciplines;
Monitoring and Control	Assessment of an ongoing project to see if the current plans are aligned and feasible;
Decision Management	The structured, analytical framework for objectively identifying, characterizing and evaluating a set of alternatives;
Concurrent Engineering	A work methodology based on the parallelization of tasks;
Business and Enterprise Integration	The consideration of needs and requirements of other internal stakeholders as part of the system development;
Acquisition and Supply	Obtaining or providing a product or service in accordance with requirements;
Information Management	Addresses activities associated with all aspects of information, to provide designated stakeholders with appropriate levels of timeliness, accuracy and security;
Configuration Management	Ensuring the overall coherence of system functional, performance and physical characteristics throughout its lifecycle;
Risk and Opportunity Management	The identification and reduction in the probability of uncertain events, or maximizing the potential of opportunities provided by them,

TECHNICAL COMPETENCIES

The ability to perform tasks associated primarily with the suite of Technical Processes identified in the INCOSE SE Handbook.

Requirements Definition	To analyze the stakeholder needs and expectations to establish the requirements for a system;
System Architecting	The definition of the system structure, interfaces and associated derived requirements to produce a solution that can be implemented;
Design for…	Ensuring that the requirements of all lifecycle stages are addressed at the correct point in the system design;
Integration	The logical process for assembling a set of system elements and aggregates into the realized system, product or service;
Interfaces	The identification, definition and control of interactions across system or system element boundaries;
Verification	A formal process of obtaining objective evidence that a system fulfils its specified requirements and characteristics;
Validation	A formal process of obtaining objective evidence that the system achieves its intended use in its intended operational environment;
Transition	Integration of a verified system into its operational environment including the wider system of which it forms a part;
Operation and Support	When the system is used to deliver its capabilities, and is sustained over its lifetime.

INTEGRATING COMPETENCIES

This competency group recognizes Systems Engineering as an integrating discipline, joining activities and thinking from specialists in other disciplines to create a coherent whole.

Project Management	Identification, planning and coordinating activities to deliver a satisfactory system, product, service of appropriate quality;
Finance	Estimating and tracking costs associated with the project;
Logistics	The support and sustainment of a product once it is transitioned to the end user;
Quality	Achieving customer satisfaction through the control of key product characteristics.

Competency Areas

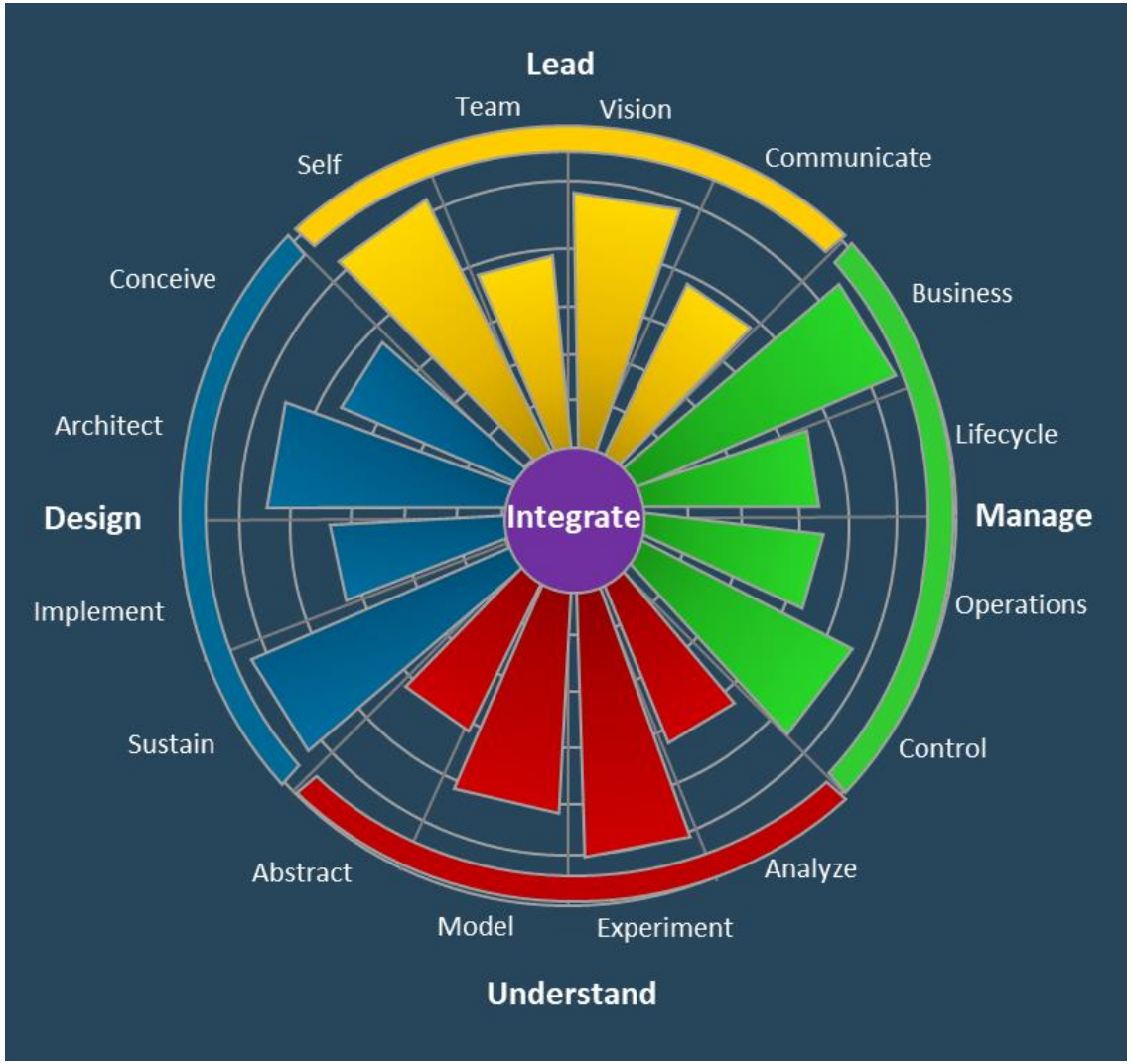
Lead – Personal and interpersonal competencies related to emotional IQ, ethics and professionalism, critical thinking, teamship and communication skills. These capabilities serve to amplify the impact of the other competencies. This is traditionally the domain of the Arts and Humanities.

Design – Synthesis competencies that enable 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. This is traditionally the domain of Engineering.

Understand – Analytical competencies 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. This is traditionally the domain of the Sciences.

Realize – Management and control competencies 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. This is traditionally the domain of Business and Management

SE Competency Framework



Focus on the discipline of Systems Engineering (SE) which in its nascence is extremely broad, ill-defined, and rapidly changing.

- Superset of INCOSE framework
- Consists of 37 base competencies
- Five proficiency levels:
  - Awareness
  - Supervised Practitioner
  - Practitioner
  - Lead Practitioner
  - Expert
- Reviewed with employers, academia, and practitioners

SE Competency Survey

- Survey created to record the needs of Jacobs School of Engineering's Corporate Affiliate Program (CAP) corporate partners for systems competencies both for engineering new college graduates and early to mid-career engineers who are working in their organizations.

- For each of these two categories of employees, we requested the CAP sponsors to note their desired and estimated actual professional competency proficiency levels for new college graduates (NCGs) and early to mid-career engineers (MCEs) using a five-point Likert scale for each of the systems competencies.

- An online survey was created that includes 37 competencies, each with five proficiency levels. The respondents were given the INCOSE SE competency framework documentation which contains the definitions of the proficiencies for each competency. Only integer values were entered by the respondents. All of the data is based solely on the perceptions of the respondents.

- There were 17 complete survey responses from 11 different CAP sponsors. These sponsors represent the Aerospace and Defense, Computer Software, Energy Solutions, Information Technology Services, National Research Laboratory, Network and other Communications Equipment, and Scientific Equipment industries. It should be noted that these survey results are not intended to represent industry wide needs, but rather are only intended to pertain to the specific needs of the major sponsors of this educational program.

Proficiency Expectations

Proficiency Expectations and Gaps for SE Competencies vs. General Engineering.

	NCG			MCE		
	Desired	**Actual**	**Gap**	**Desired**	**Actual**	**Gap**
SE Competency Average	1.69	1.04	0.63	3.41	2.62	0.80
Lead	2.01	1.40	0.62	3.49	2.69	0.82
Understand	2.01	1.16	0.82	3.62	2.61	0.98
Design	1.44	0.92	0.49	3.42	2.76	0.66
Realize	1.29	0.69	0.57	3.13	2.44	0.72
General Engineering	2.28	1.82	0.41	3.76	3.19	0.56

Lead Competency Results

Lead Competency Results

	SubArea	ID	INCOSE Competencies	NCG (Mean) D	NCG (Mean) A	NCG (Mean) G	MCE (Mean) D	MCE (Mean) A	MCE (Mean) G
LEAD	Self/Ethics	**L1.1**	Emotional Intelligence	2.11	1.53	0.65	3.44	2.76	0.76
	Self/Ethics	**L1.2**	Ethics & Professionalism	2.78	1.82	1.00	3.94	3.18	0.82
	Vision/Strategy	**L2.1**	Technical Leadership	1.72	1.18	0.53	3.59	2.75	0.88
	Vision/Strategy	**L2.2**	Critical Thinking	2.50	1.82	0.65	3.71	3.13	0.56
	Team	**L3.1**	Team Dynamics	2.33	1.82	0.47	3.47	2.63	0.81
	Team	**L3.2**	Facilitation	1.67	1.18	0.47	3.35	2.38	0.94
	Communication	**L4.1**	Communications	2.39	1.41	1.00	3.65	2.75	0.94
	Communication	**L4.2**	Negotiation	1.44	0.94	0.53	3.12	2.31	0.81
	Communication	**L4.3**	Coaching and Mentoring	1.17	0.88	0.29	3.12	2.38	0.81
			Mean	2.01	1.40	0.62	3.49	2.69	0.82
			Std Dev	0.54	0.38	0.24	0.27	0.31	0.11

Understand Competency Results

Understand Competency Results

	SubArea	ID	INCOSE Competencies	NCG (Mean)			MCE (Mean)		
				D	A	G	D	A	G
UNDERSTAND	Abstraction	**U1.1**	Systems Thinking	2.28	1.00	1.24	3.76	2.75	1.00
	Experimentation	**U2.1**	*Design of Experiments**	2.06	1.29	0.76	3.53	2.69	0.81
	Modeling	**U3.1**	Systems Modeling & Analysis	1.89	1.24	0.65	3.65	2.44	1.19
	Analysis & Decisi	**U4.1**	Decision Management	1.83	1.12	0.65	3.53	2.56	0.94
	General Engineer	**N/A**	General Engineering	2.28	1.82	0.41	3.76	3.19	0.56
			Mean	2.01	1.16	0.82	3.62	2.61	0.98
			Std Dev	0.20	0.13	0.28	0.11	0.14	0.16

Design Competency Results

Design Competency Results

	SubArea	ID	INCOSE Competencies	NCG (Mean) D	NCG (Mean) A	NCG (Mean) G	MCE (Mean) D	MCE (Mean) A	MCE (Mean) G
DESIGN	Conceive	**D1.1**	Capability Engineering	1.25	0.80	0.40	3.25	2.33	0.87
	Conceive	**D1.2**	Requirements Definition	1.75	1.13	0.60	3.88	3.27	0.60
	Architect & Desig	**D2.1**	System Architecting	1.38	0.87	0.47	3.44	2.40	1.00
	Architect & Desig	**D2.2**	Design for…	1.38	0.73	0.60	3.19	2.53	0.67
	Architect & Desig	**D2.3**	Interfaces	1.63	1.20	0.40	3.50	2.87	0.67
	Implement	**D3.1**	Integration	1.50	1.07	0.40	3.50	3.00	0.53
	Implement	**D3.2**	Verification	1.56	1.00	0.53	3.56	3.00	0.53
	Implement	**D3.3**	Validation	1.50	0.93	0.53	3.50	2.80	0.67
	Operate	**D4.1**	Transition	1.25	0.79	0.43	3.19	2.71	0.50
	Operate	**D4.2**	Operation and Support	1.25	0.71	0.50	3.19	2.64	0.57
			Mean	1.44	0.92	0.49	3.42	2.76	0.66
			Std Dev	0.17	0.17	0.08	0.22	0.29	0.16

Realize Competency Results

Realize Competency Results

	SubArea	ID	INCOSE Competencies	NCG (Mean)			MCE (Mean)		
				D	A	G	D	A	G
REALIZE	Business Fundam	**R1.1**	Business and Enterprise Int.	1.06	0.43	0.64	2.94	2.07	0.86
	Business Fundam	**R1.2**	Finance	1.00	0.50	0.50	2.69	1.86	0.79
	Lifecycle Manage	**R2.1**	Lifecycles	1.25	0.71	0.57	3.19	2.43	0.79
	Lifecycle Manage	**R2.2**	Project Management	1.25	0.57	0.64	2.88	2.40	0.40
	Lifecycle Manage	**R2.3**	Planning	1.63	0.93	0.71	3.38	2.71	0.71
	Lifecycle Manage	**M2.4**	Concurrent Engineering	1.50	0.64	0.79	3.31	2.71	0.64
	Monitoring & Co	**R3.1**	Risk and Opportunity Mgmt	1.44	0.86	0.57	3.38	2.57	0.86
	Monitoring & Co	**R3.2**	Monitoring and Control	1.44	0.79	0.64	3.25	2.43	0.86
	Monitoring & Co	**R3.3**	Quality	1.56	1.00	0.50	3.44	2.57	0.86
	Operations	**R4.1**	Acquisition and Supply	0.88	0.50	0.29	2.88	2.27	0.67
	Operations	**R4.2**	Information Management	1.40	0.77	0.62	3.25	2.71	0.64
	Operations	**R4.3**	Configuration Management	1.31	0.71	0.57	3.50	2.79	0.79
	Operations	**R4.4**	Logistics	1.00	0.50	0.43	2.69	2.14	0.57
			Mean	1.29	0.69	0.57	3.13	2.44	0.72
			Std Dev	0.24	0.18	0.13	0.29	0.29	0.14

Competencies with Highest Expectations

Competency with Highest Proficiency Levels for NCGs

Competency	**Proficiency Level**	**Gap**
Ethics & Professionalism	2.78	1.00
Critical Thinking	2.50	0.65
Communication	2.39	1.00
Team Dynamics	2.33	0.47
General Engineering	*2.28*	*0.41*

Competencies with Highest Proficiency Levels for MCEs

Competency	**Proficiency Level**	**Gap**
Ethics & Professionalism	3.94	0.82
Requirements Definition	3.88	0.60
General Engineering	*3.76*	*0.56*

Competencies with Greatest Gaps

Competencies with Largest Proficiency Gaps for NCGs

Competency	**Proficiency Level**	**Gap**
Systems Thinking	2.28	1.24
Ethics & Professionalism	2.78	1.00
Communication	2.39	1.00
Concurrent Engineering	1.50	0.79
Design of Experiments	2.06	0.76
General Engineering	*2.28*	*0.41*

Competencies with Largest Proficiency Gaps for MCEs

Competency	**Proficiency Level**	**Gap**
Systems Modeling & Analysis	3.65	1.19
Systems Thinking	3.76	1.00
System Architecting	3.44	1.00
Communication	3.65	0.94
Decision Management	3.53	0.94
Facilitation	3.35	0.94
General Engineering	*3.76*	*0.56*

Competencies with Greatest Gap Change

Competencies with Gap Reduction from NCG to MCE

Competency	NCG Gap	MCE Gap	Change
Systems Thinking	1.24	1.00	(0.24)
Project Management	0.64	0.40	(0.24)
Ethics & Professionalism	1.00	0.82	(0.18)
Concurrent Engineering	0.79	0.64	(0.15)
Critical Thinking	0.65	0.56	(0.09)
Communication	1.00	0.94	(0.06)

Competencies with Great Gap increases from NCG to MCE

Competency	NCG Gap	MCE Gap	Change
Systems Modeling & Analysis	0.65	1.19	0.54
System Architecting	0.47	1.00	0.53
Coaching and Mentoring	0.29	0.81	0.52
Capability Engineering	0.40	0.87	0.47
Facilitation	0.47	0.94	0.47
General Engineering	*0.41*	*0.56*	*0.15*

AESE Program

- The UCSD's AESE program was developed to educate senior engineers and engineering managers in the problems and emerging solution approaches that can enable their enterprises to better respond to the challenges of globally distributed operations in complex, highly dynamic, event-driven environments.

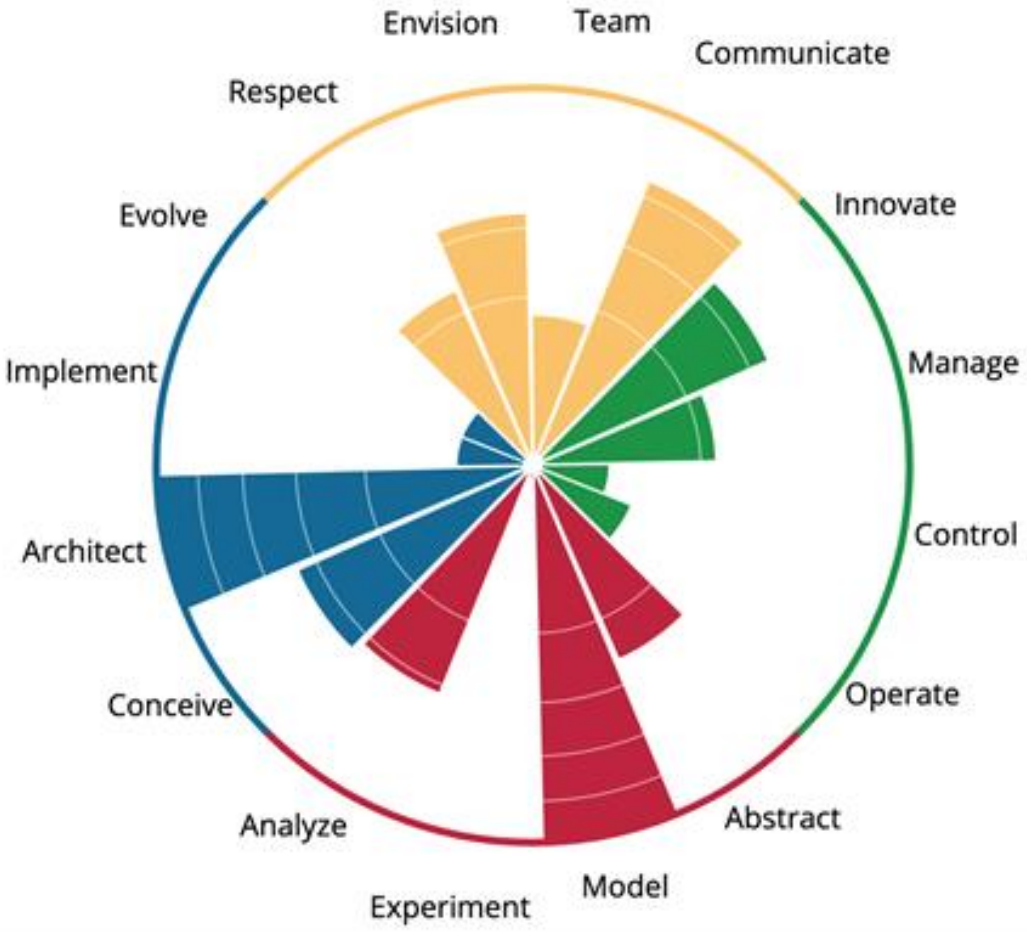
- This program uses an "integrated perspective" that merges the views of management and engineering communities which is increasingly being recognized as one of the cornerstones of a successful approach to enterprise complexity.

- The program was piloted in 2006, deployed in 2010 and has had over 375 graduates at the date of this publication.

AESE Course Structure

Areas	Topics	Architecture of Enterprise Systems	Order
Lead	Self, Team, Vision, Communication	**MGT 406: Leadership Skills, Values, and Team-building**	2
Understand	Abstract, Model, Experiment, Analyze	**AESE 278C: Modeling, Simulation and Analysis**	6
		AESE 241: Decision and Risk Analysis	8
Realize	Business Fundamentals, Lifecycle Management, Monitoring & Control	**MGT 291: Essentials for Business Practice**	1
		AESE 261: Managing Stakeholder Relationships	9
Design Specialize	Conceive	**AESE 278A: Complexity and Large-scale Systems**	3
	Architect	**AESE 278B: Enterprise Architecting**	4
	Implement	**AESE 278D: Engineering Essentials for Distributed Systems**	5
	Evolve	**AESE 278E: Patterns for Enterprise Architecting**	7
Integrate	Use and Expand State of the Art	**AESE 279: Capstone Team Projects**	all

Profile Visualization



SE Competency Classroom Time

Systems Engineering competency area Classroom time percentage

	SubArea	23.20%
LEAD	L1 Self/Ethics	3.9%
LEAD	L2 Vision/Strategy	6.8%
LEAD	L3 Team	2.4%
LEAD	L4 Communication	10.1%
UNDERSTAND	SubArea	26.5%
UNDERSTAND	U1 Systems Thinking	4.8%
UNDERSTAND	U2 Experimentation	0.0%
UNDERSTAND	U3 Modeling & Simulation	15.2%
UNDERSTAND	U4 Analysis & Decision Making	6.5%

	SubArea	23.5%
DESIGN	D1 Conceive	7.1%
DESIGN	D2 Architect & Design	15.2%
DESIGN	D3 Implement	0.6%
DESIGN	D4 Operate	0.6%
REALIZE	SubArea	12.5%
REALIZE	R1. Business Fundamentals	7.1%
REALIZE	R2. Lifecycle Management	3.6%
REALIZE	R3. Monitoring & Control	0.6%
REALIZE	R4. Operations	1.2%

Major Areas of Focus

- Architecture and Design - 15.2%
- Modeling and Simulation- 15.2%
- Communication - 10.1%
- Design Conception - 7.1%
- Business Fundamentals - 7.1%
- Vision and Strategy – 6.8%
- Analysis and Design Making – 6.5%
- Systems Thinking – 4.8%

Lead Competency Classroom Time

Lead Classroom time percentage

LEAD	SubArea	Total	Competencies	23.2%
	L1 Self/Ethics	**3.9%**	L1.1 Emotional Intelligence	2.1%
			L1.2 Ethics & Professionalism	1.8%
	L2 Vision/Strategy	**6.8%**	L2.1 Technical Leadership	4.2%
			L2.2 Critical Thinking	2.7%
	L3 Team	**2.4%**	L3.1 Team Dynamics	1.8%
			L3.2 Facilitation	0.6%
	L4 Communication	**10.1%**	L4.1 Communications	5.1%
			L4.2 Negotiation	2.1%
			L4.3 Coaching and Mentoring	3.0%

Design Competency Classroom Time

Design Classroom time percentage

DESIGN	SubArea	Total	Competencies	23.5%
	D1 Conceive	**7.1%**	D1.1 Capability Engineering	6.5%
			D1.2 Requirements Definition	0.6%
	D2 Architect & Design	**15.2%**	D2.1 System Architecting	14.6%
			D2.2 Design for…	0.3%
			D2.3 Interfaces	0.3%
	D3 Implement	**0.6%**	D3.1 Integration	0.6%
			D3.2 Verification	0.0%
			D3.3 Validation	0.0%
	D4 Operate	**0.6%**	D4.1 Transition	0.0%
			D4.2 Utilization & Support	0.6%
			D4.3 Retirement	0.0%

Understand Competency Classroom Time

Understand Classroom time percentage

	SubArea	Total	Competencies	26.5%
UNDERSTAND	U1 Systems Thinking	4.8%	*U1.1 Conceptual models & abstractions*	2.1%
			U1.2 Complex Adaptive Systems	1.2%
			U1.3 System Identification & Relationships	1.3%
			U1.4 System Dynamics	0.1%
			U1.5 Other	0.0%
	U2 Experimentation	0.0%	*U2.1 Designing Experiments*	0.0%
			U2.2 Single Factor Experiments	0.0%
			U2.3 Factorial Designs	0.0%
			U2.4 Fractional Factorial Designs	0.0%
			U2.5 Other Experimentation	0.0%
	U3 Modeling & Simulation	15.2%	*U3.1 System Computational Modeling Principles*	10.7%
			U3.2 Continuous & Discrete Simulations	0.6%
			U3.3 Decision making: central & distributed, fixed vs. runtime	2.7%
			U3.4 Evaluation of Capability, Effectiveness & Efficiency	1.2%
			U3.5 Other	0.0%
	U4 Analysis & Decision Making (Decision Management)	6.5%	*U4.1 Decision-Making Principles*	3.0%
			U4.2 Data Analytics & Visualization	1.5%
			U4.3 H/M Interaction, AI & ML techniques	0.9%
			U4.4 Uncertainty & Risk Assessment	1.2%

Realize Competency Classroom Time

Realize Classroom time percentage

	SubArea	Total	Competencies	12.5%
REALIZE	**R1. Business Fundamentals**	**7.1%**	R1.1 Business and Enterprise Integration	4.8%
			R1.2 Finance	2.4%
	R2. Lifecycle Management	**3.6%**	R2.1 Lifecycles	1.8%
			R2.2 Project Management	0.0%
			R2.3 Planning	1.8%
			R2.4 Concurrent Engineering	0.0%
	R3. Monitoring & Control	**0.6%**	R3.1 Risk and Opportunity Management	0.0%
			R3.2 Monitoring and Control	0.6%
			R3.3 Quality	0.0%
	R4. Operations	**1.2%**	R4.1 Acquisition and Supply	0.6%
			R4.2 Information Management	0.0%
			R4.3 Configuration Management	0.0%
			R4.4 Logistics	0.6%

Proficiency Gaps vs AESE Classroom Time

Competencies with Largest Proficiency Gaps for MCEs vs AESE % Program time

Competency	Proficiency Level	Gap	AESE Program
Systems Modeling & Analysis	3.65	1.19	15.2%
Systems Thinking	3.76	1.00	4.8%
System Architecting	3.44	1.00	14.6%
Communication	3.65	0.94	5.1%
Decision Management	3.53	0.94	6.5%
Facilitation	3.35	0.94	0.6%
Technical Leadership	3.59	0.88	4.2%
Capability Engineering	3.25	0.87	6.5%
Business and Enterprise Integration	2.94	0.86	4.8%
Risk and Opportunity Management	3.38	0.86	0.0%
Monitoring and Control	3.25	0.86	0.6%
Quality	3.44	0.86	0.0%

Results

The following are some of the significant results from this limited survey.

- *Systems Modeling & Analysis, Systems Thinking, System Architecting*, *Ethics and Professionalism*, and *Communication* are significant gap areas for both NCGs and MCEs.
- The proficiency level expectations for *Ethics & Professional Skills*, *Communication*, and *Team Dynamics* skills ranked higher than *General Engineering* and technical skills for NCGs.
- The gap between actual and desired competencies are greater for the systems engineering competencies than for general engineering skills.
- Most of the competency gaps increased over time, some substantially. Only six of the 37 competencies had proficiency gaps that narrowed over time from NCG to MCE. While one might expect that the gap in certain proficiencies, such as *Communication* might substantially narrow over time, the data did not bear this out.

Reflections

- The SEEE competency framework was a useful tool in the analysis of an existing systems engineering program. The results highlighted the focus of the SE program and how it compared with the surveyed needs of the program sponsors.
- The process of performing this analysis served as an aid in understanding the program of interest both for updates and for the creation of new programs.
- The analysis work uncovered some areas in which the competency framework might evolve.
    - *Business Insight* and *Strategic Thinking* were competencies that were identified that did not have a clear home in the current competency framework.
    - *Technical Leadership* was the placeholder that was used for this.
    - *Cybersecurity* was another competency topic that did not have a clear home. While this could fall into the *Architecture* competency, some aspects of this might fall into *General Engineering* as well.
    - *Design Process* does not have a clear home in this competency framework. The *Conceive* competency became the placeholder for these skills.

Future Use

The approach used in this project will be used in the future in three areas.

- The first will be in the development of new systems engineering program specializations and the update of the current program. These specializations will target a different student demographic and system type than the existing AESE program. This work will enable the new specializations to more closely meet the needs of the students and those who will eventually employ them.
- The second area will be in furthering the development of the Systems Engineering Education Ecosystem portal and its governance to ensure that it meets the evolving needs of its stakeholders.
- Finally, as the installed base of employer and academic programs grows, this feedback will facilitate the evolution of the SE competency framework and the focus areas for the future of systems engineering.

Get Involved!

If you interested in getting involved in the SEEE project contact:

Jon Wade – jpwade@ucsd.edu

Cihan Dagli - dagli@mst.edu

Hortense Gerardo – hgerardo@ucsd.edu

32nd Annual INCOSE international symposium

hybrid event

Detroit, MI, USA

June 25 - 30, 2022

www.incose.org/symp2022