Transforming Undergraduate Education in Engineering

Phase IV: Views of Faculty and Professional Societies

TUEE

APRIL 18-19, 2017 • WAHSINGTON, DC
Mapping Engineering Competencies

*also known as: KSAs*

An initial report from our Delphi Study

ASEE TUEE IV Planning Committee
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Agenda

• Background on competencies?
• Mapping competencies from your Delphi Study
• Additional information
Competency modeling

• Linked to professional objectives/goals
• Formulating sets of KSAOs that support high performance
• Used to differentiate levels of performance/performers
• Deductively developed
• Describe future states
• Can unify a profession
• Used for development
• Develop practical theories of effective performance
Professions

Professions entail high uncertainty, complex work, and social responsibility

Professions own exceptional body of knowledge, provide high level of autonomy, and selectively regulate entry

Professions require high levels of judgment, higher order thinking, flexibility, communication, learning, context sensitivity, problem solving, principled action, and self direction
Conceptual evolution

Academic, discipline-based competencies
(e.g., science, math)

Operational, work-based competencies
(e.g., teamwork, communication)

Competencies for living in a complex, pluralistic, dynamic worlds
(e.g., life-long learner, resourcefulness).
Definitions
Merriam-Webster.com

**Competence**—the ability to do something well; the quality or state of being competent

**Competent**—having the necessary knowledge, skills, and ability; able to do something well or well enough to meet a standard

**Competency**—a set of knowledge, skills, and attitudes along with other elements required to do something well (KSAOs)*

* Competency has also included beliefs, values, attributes, qualification, ability, capability, motivations, interests, experience, among others.
Definitions
Merriam-Webster.com

“Can do” competencies

Knowledge—acquaintance with or knowing/understanding something
(See cognitive taxonomies)

Skills—ability to use one’s knowledge effectively, especially in the performance of a task
(See psychomotor skills taxonomies)

“Will do” competencies

Attitude—a feeling or emotion toward something
(See affective taxonomies)
Conceptual difficulties

Tensions between simplicity/usefulness and details

Confounding of competence and performance

Criticisms of the competency concept
  • conceptually weak and ambiguous
  • measuring economic results of education
  • narrowly focused on labor market

Alternatives: Learning outcomes; capabilities
Competencies as heuristics

Despite different notions of competency, it is useful for analytic purposes (useful heuristic)

How individuals act/behave depends on their environment and their competence.

Education has little effect on environments
Education can effect individual competence
Articulating Professional Competence for Engineering Education is the overall aim.

**Survey Process**
- **Q1**—Broad collection of ideas *(January)*
- **Q2**—Review and refinement of Q1 *(March)*
- **Q3**—Review, refinement, articulation of Q2 *(April workshop)*

**Analysis Process**
- **Categorizing**
  - Constant-comparative method
  - Discipline specific vs. broad competencies
  - Internal vs. external competencies

- **Structuring and Leveling**
  - Higher level concepts (general, abstract)
  - Lower level concepts (specific, concrete)
Consider a definition of a competency as having two dimensions: 1) personal attributes and 2) work requirements. Because work is extremely variable and unpredictable, we want to focus on key competencies at the personal level (student undergraduate).

Competencies are multi-dimensional, and in the personal dimension are sets of “can do” components of knowledge and skills, and “will do” components of personality and attitudinal traits.

For example: the competency of teamwork might include a set of knowledge of group dynamics and . . . , skills in collaboration, negotiation, and . . . personality/attitude for empathy, respect and . . .
<table>
<thead>
<tr>
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<th>Revised Competencies</th>
<th>Revised Sub-Competencies</th>
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<td>Engineering Problem Recognition, Definition, and Solving; Solve problems; Open ended problem solving; Problem solving Creative</td>
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Suggested Changes to Competency Groups

1. Combine Interpersonal Skills, Soft Skills, Political awareness, Mediation Skills, Take responsibility, and courage
2. Combine Making good engineering decisions, Resourcefulness, Performance under pressure and Dealing with Uncertainty

Suggested Changes to Competency Groups

1. Separate this
2. Working with People Skills, and Professional Communicating decisions and as an Engineer under pressure

Q1 Synthesis
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**Q2 Input**

- Professional Ability- Workplace related competencies
- Interpersonal Skills
- Soft Skills
- Political awareness
- Situation awareness
- Demonstration of negotiation/mediation skills
- High performance under pressure
- Embrace diversity
- Sharing of information
- Dealing with Uncertainty
- Resourcefulness
- Take responsibility
- Information Literacy
- Business Skills
- Making good engineering decisions
courage
- Individual characteristics

**Communication Competencies**

- Communication (written and oral)
- Technical and non-technical communication
- Communicate Effectively (appropriate to the audience)
- Sharing of information
- Presentation skills

**Analytical Competencies**

- Critical Thinking
- Design, Creativity and Innovation
- Technical Ability
### Professional Competencies (Interpersonal, Intrapersonal, and Engineering)

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**Suggested Changes to Competency Groups**

- **INTERPERSONAL COMPETENCIES**: Combine Interpersonal Skills, Soft Skills, Political awareness, Mediation Skills, Take responsibility, and courage.
- **INTRAPERSONAL COMPETENICES**: Combine Making good engineering decisions, Resourcefulness, Performance under pressure and Dealing with Uncertainty.

**Suggested Changes to Communication Groups**

- **Communication**: Add to DESIGN, INNOVATION AND CRITICAL THINKING

**Suggested Changes to Engineering Groups**

- **Engineering Problem Recognition, Definition, and Solving**: Add to DESIGN, INNOVATION AND CRITICAL THINKING

**Suggested Changes to Analytical Groups**

- **Analytical Competencies**: Add to DESIGN, INNOVATION AND CRITICAL THINKING

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Q3 Synthesis

WIP
Competency Mapping

Identify essential competency categories

1.0 Professional
- 1.1 Intrapersonal (self)
- 1.2 Engineering (discipline)
- 1.3 Interpersonal (social)

Structure and level the categories (Generality vs. Specificity)
- Primary (very general)
- Secondary (less general/more specific)
- Tertiary (more specific)
1.0 Professional Competence

1.1 Intrapersonal Competence
   - 1.1.1 Self-Directed, Lifelong Learning
   - 1.1.2 Intellectual, Innovative, Critical Thinking
   - 1.1.3 Ethical
   - 1.1.4 Conscientiousness

1.2 Engineering Competence
   - 1.2.1 Technical, Analytical
   - 1.2.2 Scientific
   - 1.2.3 Mathematical
   - 1.2.4 Innovative, Creative, Design Thinking

1.3 Interpersonal Competence
   - 1.3.1 Communication
   - 1.3.2 Teamwork
   - 1.3.3 Leadership, Project Management
   - 1.3.4 Social, Intercultural

OVERALL COMPETENCY MAP
Working Draft 16 April 2017
KSAs of Intrapersonal Competencies

Working Draft 16 April 2017

1.1 Intrapersonal Competence

1.1.1 Self-Directed, Lifelong Learning

- **K**—Knowing how to learn and where to find resources; Understanding lifelong learning
- **S**—Doing self-assessment, management, development; Practicing life-long learning
- **A**—Curious; Motivated; Pro-active; High achiever; Introspective;

1.1.2 Intellectual, Innovative, Critical Thinking

- **K**—Knowing/understanding other disciplines (beyond STEM); Multi-literate; Understand problem solving; Comprehending value of diversity
- **S**—Adept problem finder/manager/solver; Making informed/good decisions; Apply knowledge; Deal with ambiguity/conflict/plurality; Make inferences/judgments
- **A**—Innovative; Creative; Insightful; Open-minded; Resourceful; Growth/entrep. mindset

1.1.3 Ethical

- **K**—Understand what constitutes ethical/moral behavior and professional responsibility; Understand civic responsibility
- **S**—Accept responsibility; Act with empathy; Respect others; Consider broad contexts; Make informed, equitable, inclusive judgments; Embrace diversity, inclusion
- **A**—Honest; Having high integrity/EQ; Reliable; Dependable; Concern for positive impact;

1.1.4 Conscientiousness

- **K**—Understanding value of stakeholders/needs; Understand professional standards/constraints; Understanding personal attributes/capabilities
- **S**—Acts professionally, with integrity and high standards; Critique self; Manage time, priorities, risks, motivations, integrity, learning; Develop mastery
- **A**—Reflective; Responsible; Self-aware; Persistent; Humble; Motivated; Careful; Punctual
KSAs of Engineering Competencies

Working Draft 16 April 2017

1.2 Engineering Competence

1.2.1 Technical/Analytical
- **K:** Technical subject matter expert; Engineering knowledge; synthesize information, knowledge of constraints; Problem identification
- **S:** Analysis expertise; Apply knowledge, theory to practice; Perform technical tasks; Solve technical problems; Evaluation skills
- **A:** Logical; Insightful;

1.2.2 Scientific
- **K:** Knowledge of basic science; scientifically literate; Physical, chemical, environmental and biological sciences knowledge;
- **S:** Apply scientific knowledge and methods to engineering work
- **A:**

1.2.3 Mathematical
- **K:** Knowledge of statistics; Algebra, Calculus, Differential equations; Numerical methods
- **S:** Apply mathematical knowledge and methods to engineering work
- **A:**

1.2.4 Innovative/Creative/Design Thinking
- **K:** Knowledge of innovation and design; knowledge of producing solutions for specified needs
- **S:** Apply design, creative process, entrepreneurship skills;
- **A:** Entrepreneurial;
KSAs of Interpersonal Competencies

1.3 Interpersonal Competence

1.3.1 Communication
- Understand communication process/effects;
- Effectively use written and oral communication; negotiation/mediation skills; Effective listening skills; Share information;

1.3.2 Teamwork
- Understand group behavior/processes;
- Engage and manage group behaviors/processes; Effectively collaborate; Coordinate efforts; Embrace diverse ideas, processes;
- Collaborative; Cooperative; Responsible; Accountable

1.3.3 Leadership, Project Management
- Understand project management, leadership and business;
- Apply business and management skills; Set goals, mission, vision; Skilled leader; Influence/enlist others; Accomplish goals;
- Visionary, Influential,

1.3.4 Social, Intercultural
- Aware/Understand social/community processes; Aware/Understand historical, political, economic processes
- Ability to work on diverse/inclusive teams; Build community; Ability to interact across cultures, societies, communities

Working Draft 16 April 2017
References


