# TUEE Transforming Undergraduate Education in Engineering

## Phase IV: Views of Faculty and Professional Societies


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

Ashok Agrawal, Rocio Chavela, Christine Grant, Russell Korte, John Krupczak, Ingrid St. Omer, Ray Phillips

# 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

# Delphi Study

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)

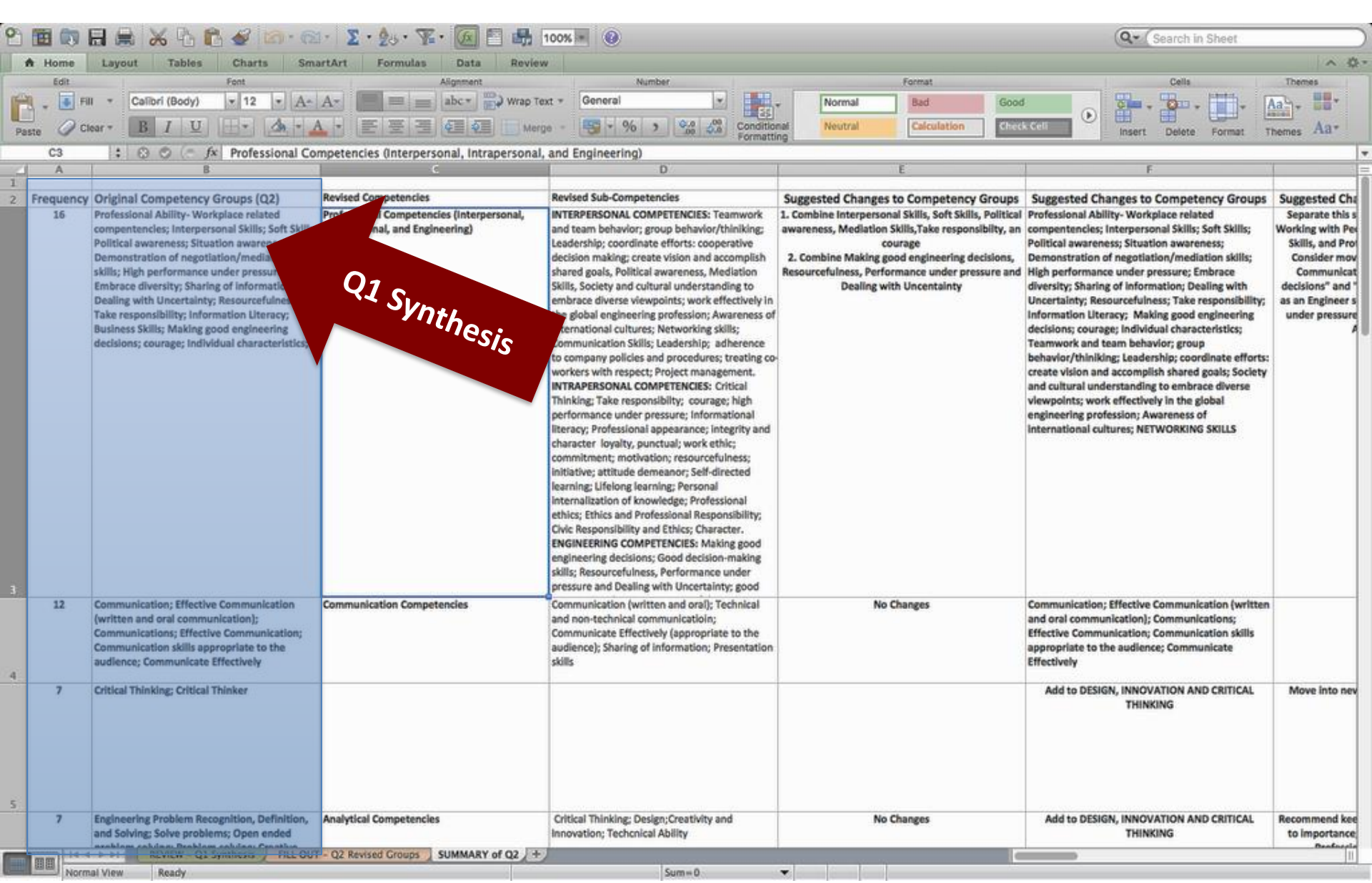
# Delphi Study

**Consider a definition of a competency** as having two dimensions: 1) personal attributes and 2) work requirements.

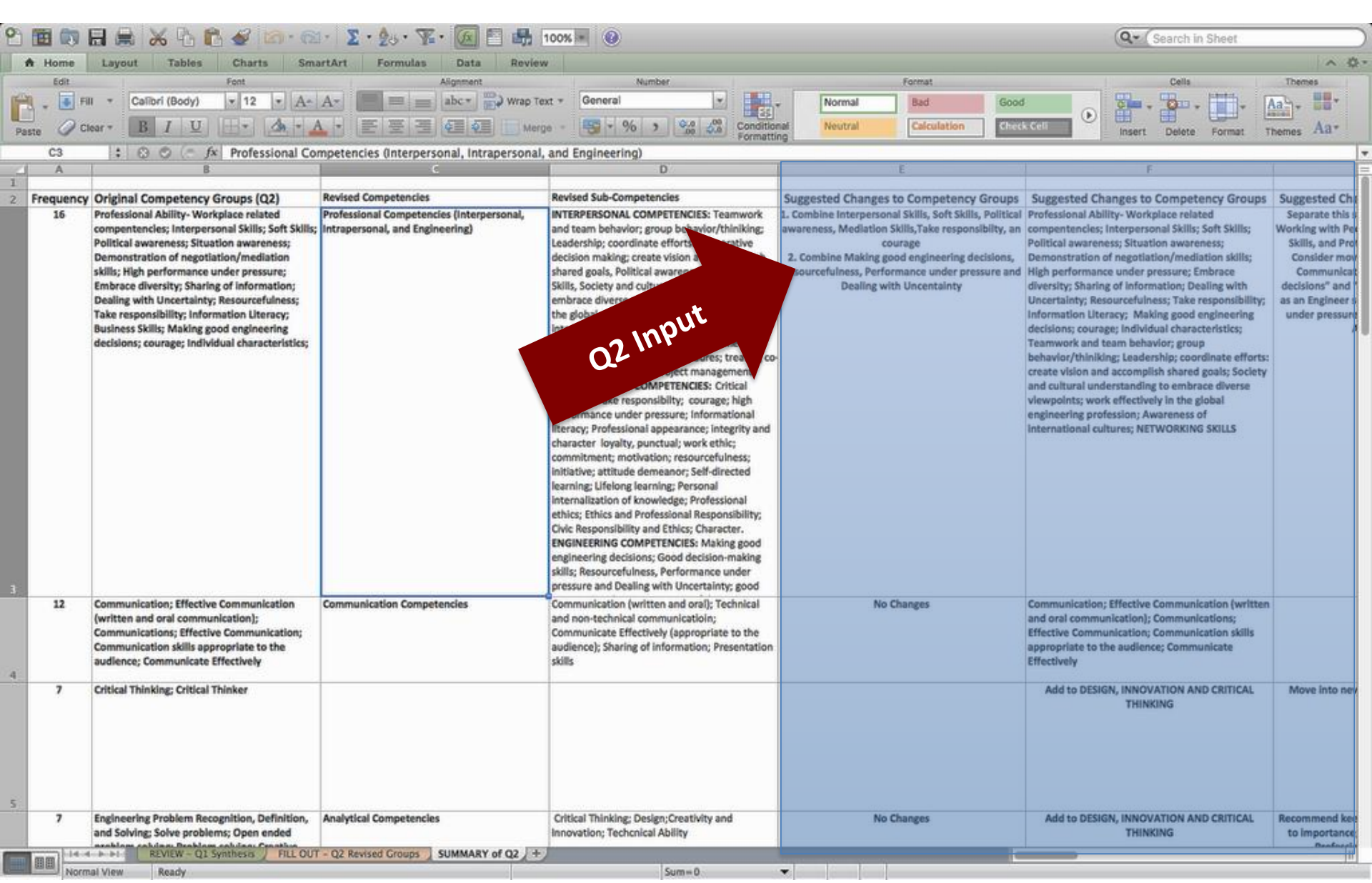
Because work is extremely variable and unpredictable, we want to focus on key competencies **at the personal level** (student undergraduate).

**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*.

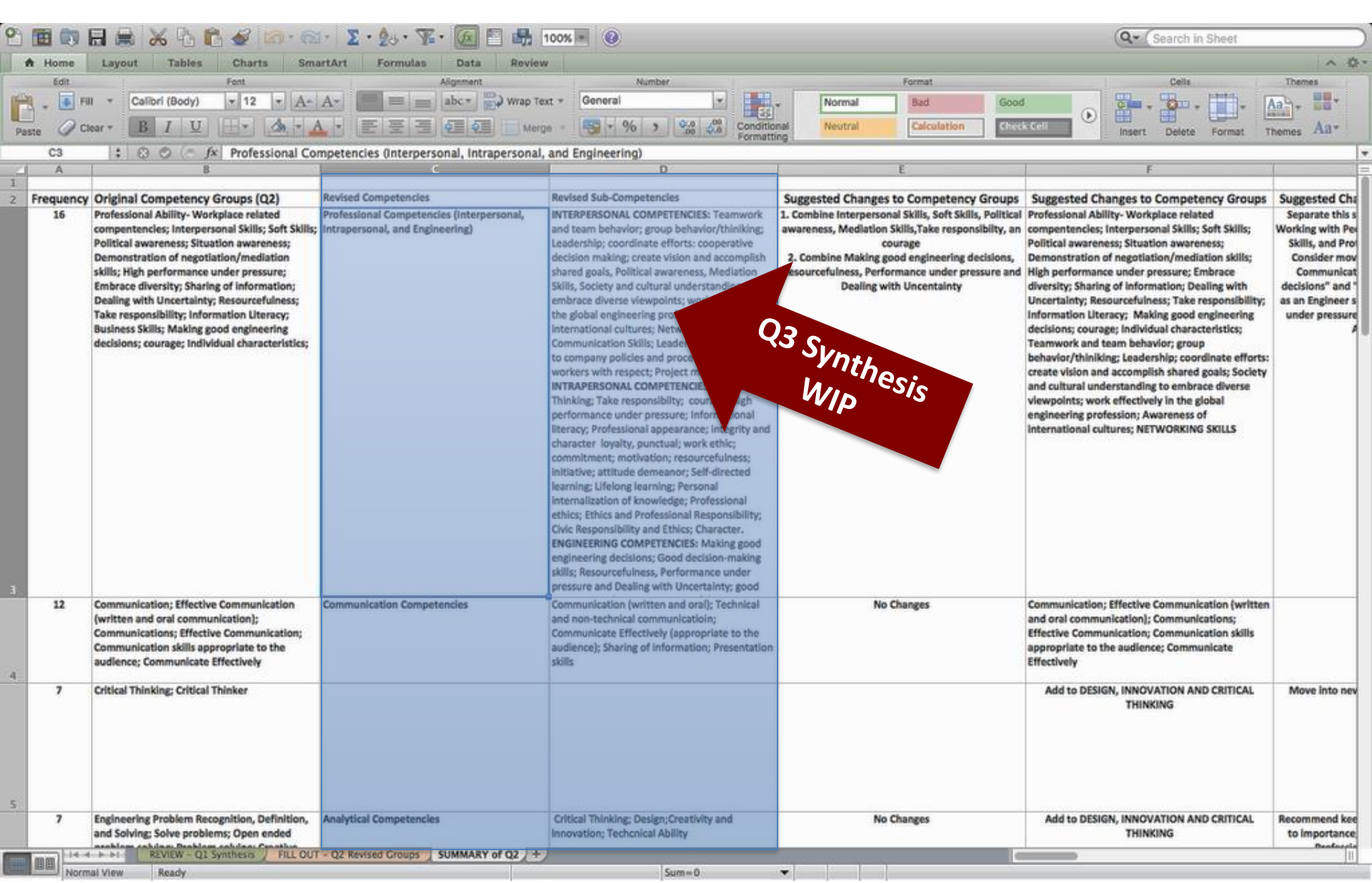
For example: the competency of teamwork might include a set of **knowledge** of group dynamics and . . . , **skills** in collaboration, negotiation, and . . . **personality/attitude** for empathy, respect and . . .




| Frequency | Original Competency Groups (Q2) | Revised Competencies | Revised Sub-Competencies | Suggested Changes to Competency Groups | Suggested Changes to Competency Groups | Suggested Cha |
|---|---|---|---|---|---|---|
| 16 | Professional Ability- Workplace related compentencies; 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; | Professional Competencies (Interpersonal, Intrapersonal, and Engineering) | **INTERPERSONAL COMPETENCIES:** Teamwork and team behavior; group behavior/thinking; Leadership; coordinate efforts: cooperative decision making; create vision and accomplish shared goals, Political awareness, Mediation Skills, Society and cultural understanding to embrace diverse viewpoints; work effectively in the global engineering profession; Awareness of international cultures; Networking skills; Communication Skills; Leadership; adherence to company policies and procedures; treating co-workers with respect; Project management. **INTRAPERSONAL COMPETENCIES:** Critical Thinking; Take responsibilty; courage; high performance under pressure; Informational literacy; Professional appearance; integrity and character loyalty, punctual; work ethic; commitment; motivation; resourcefulness; initiative; attitude demeanor; Self-directed learning; Lifelong learning; Personal internalization of knowledge; Professional ethics; Ethics and Professional Responsibility; Civic Responsibility and Ethics; Character. **ENGINEERING COMPETENCIES:** Making good engineering decisions; Good decision-making skills; Resourcefulness, Performance under pressure and Dealing with Uncertainty; good | 1. Combine Interpersonal Skills, Soft Skills, Political awareness, Mediation Skills,Take responsibilty, an courage<br>2. Combine Making good engineering decisions, Resourcefulness, Performance under pressure and Dealing with Uncentainty | Professional Ability- Workplace related compentencies; 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; Making good engineering decisions; courage; Individual characteristics; Teamwork and team behavior; group behavior/thinking; Leadership; coordinate efforts: create vision and accomplish shared goals; Society and cultural understanding to embrace diverse viewpoints; work effectively in the global engineering profession; Awareness of international cultures; NETWORKING SKILLS | Separate this s Working with Pe Skills, and Pro Consider mov Communicat decisions" and " as an Engineer s under pressure |
| 12 | Communication; Effective Communication (written and oral communication); Communications; Effective Communication; Communication skills appropriate to the audience; Communicate Effectively | Communication Competencies | Communication (written and oral); Technical and non-technical communicatioin; Communicate Effectively (appropriate to the audience); Sharing of information; Presentation skills | No Changes | Communication; Effective Communication (written and oral communication); Communications; Effective Communication; Communication skills appropriate to the audience; Communicate Effectively | |
| 7 | Critical Thinking; Critical Thinker | | | Add to DESIGN, INNOVATION AND CRITICAL THINKING | | Move into nev |
| 7 | Engineering Problem Recognition, Definition, and Solving; Solve problems; Open ended | Analytical Competencies | Critical Thinking; Design;Creativity and Innovation; Techcnical Ability | No Changes | Add to DESIGN, INNOVATION AND CRITICAL THINKING | Recommend kee to importance |




| Frequency | Original Competency Groups (Q2) | Revised Competencies | Revised Sub-Competencies | Suggested Changes to Competency Groups | Suggested Changes to Competency Groups | Suggested Ch |
|---|---|---|---|---|---|---|
| 16 | Professional Ability- Workplace related compentencies; 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; | Professional Competencies (Interpersonal, Intrapersonal, and Engineering) | **INTERPERSONAL COMPETENCIES:** Teamwork and team behavior; group behavior/thiniking; Leadership; coordinate efforts ative decision making; create vision a shared goals, Political aware Skills, Society and cult embrace divers the glob ures; trea co- ject management **OMPETENCIES:** Critical ake responsibilty; courage; high rmance under pressure; Informational literacy; Professional appearance; integrity and character loyalty, punctual; work ethic; commitment; motivation; resourcefulness; initiative; attitude demeanor; Self-directed learning; Lifelong learning; Personal internalization of knowledge; Professional ethics; Ethics and Professional Responsibility; Civic Responsibility and Ethics; Character. **ENGINEERING COMPETENCIES:** Making good engineering decisions; Good decision-making skills; Resourcefulness, Performance under pressure and Dealing with Uncertainty; good | 1. Combine Interpersonal Skills, Soft Skills, Political awareness, Mediation Skills,Take responsibility, an courage<br>2. Combine Making good engineering decisions, ourcefulness, Performance under pressure and Dealing with Uncentainty | Professional Ability- Workplace related compentencies; 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; Making good engineering decisions; courage; Individual characteristics; Teamwork and team behavior; group behavior/thiniking; Leadership; coordinate efforts: create vision and accomplish shared goals; Society and cultural understanding to embrace diverse viewpoints; work effectively in the global engineering profession; Awareness of international cultures; NETWORKING SKILLS | Separate this Working with Pe Skills, and Pro Consider mov Communicat decisions" and as an Engineer under pressur |
| 12 | Communication; Effective Communication (written and oral communication); Communications; Effective Communication; Communication skills appropriate to the audience; Communicate Effectively | Communication Competencies | Communication (written and oral); Technical and non-technical communicatioin; Communicate Effectively (appropriate to the audience); Sharing of information; Presentation skills | No Changes | Communication; Effective Communication (written and oral communication); Communications; Effective Communication; Communication skills appropriate to the audience; Communicate Effectively | |
| 7 | Critical Thinking; Critical Thinker | | | | Add to DESIGN, INNOVATION AND CRITICAL THINKING | Move into new |
| 7 | Engineering Problem Recognition, Definition, and Solving; Solve problems; Open ended | Analytical Competencies | Critical Thinking; Design;Creativity and Innovation; Techcnical Ability | No Changes | Add to DESIGN, INNOVATION AND CRITICAL THINKING | Recommend kee to importance |



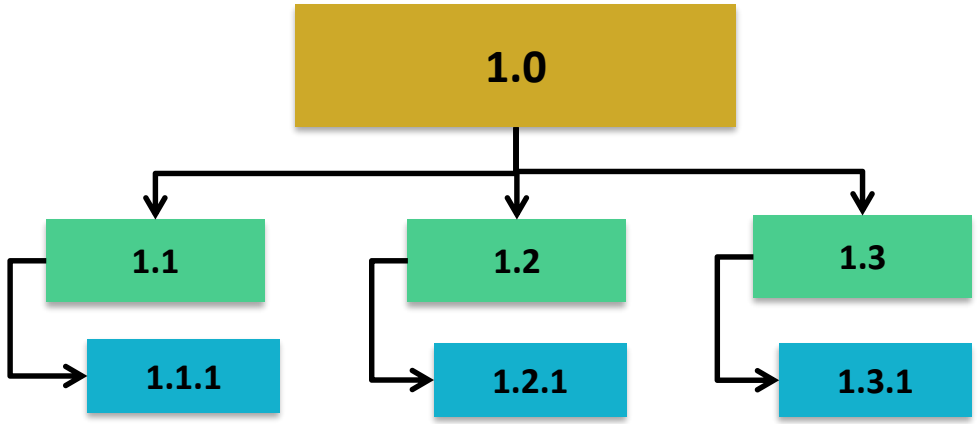

| Frequency | Original Competency Groups (Q2) | Revised Competencies | Revised Sub-Competencies | Suggested Changes to Competency Groups | Suggested Changes to Competency Groups | Suggested Cha |
|---|---|---|---|---|---|---|
| 16 | Professional Ability- Workplace related compentencies; Interpersonal 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; | Professional Competencies (Interpersonal, Intrapersonal, and Engineering) | INTERPERSONAL COMPETENCIES: Teamwork and team behavior; group behavior/thinking; Leadership; coordinate efforts: cooperative decision making; create vision and accomplish shared goals, Political awareness, Mediation Skills, Society and cultural understandi… embrace diverse viewpoints; wo… the global engineering pro… international cultures; Netw… Communication Skills; Leade… to company policies and proc… workers with respect; Project m… INTRAPERSONAL COMPETENCIE… Thinking; Take responsibilty; cour… gh performance under pressure; Infor… onal literacy; Professional appearance; integrity and character loyalty, punctual; work ethic; commitment; motivation; resourcefulness; initiative; attitude demeanor; Self-directed learning; Lifelong learning; Personal internalization of knowledge; Professional ethics; Ethics and Professional Responsibility; Civic Responsibility and Ethics; Character. ENGINEERING COMPETENCIES: Making good engineering decisions; Good decision-making skills; Resourcefulness, Performance under pressure and Dealing with Uncertainty; good | 1. Combine Interpersonal Skills, Soft Skills, Political awareness, Mediation Skills,Take responsibilty, an courage<br>2. Combine Making good engineering decisions, esourcefulness, Performance under pressure and Dealing with Uncentainty | Professional Ability- Workplace related compentencies; 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; Making good engineering decisions; courage; Individual characteristics; Teamwork and team behavior; group behavior/thinking; Leadership; coordinate efforts: create vision and accomplish shared goals; Society and cultural understanding to embrace diverse viewpoints; work effectively in the global engineering profession; Awareness of international cultures; NETWORKING SKILLS | Separate this s… Working with Pe… Skills, and Pro… Consider mov… Communicat… decisions" and "… as an Engineer s… under pressure… A… |
| 12 | Communication; Effective Communication (written and oral communication); Communications; Effective Communication; Communication skills appropriate to the audience; Communicate Effectively | Communication Competencies | Communication (written and oral); Technical and non-technical communicatioin; Communicate Effectively (appropriate to the audience); Sharing of information; Presentation skills | No Changes | Communication; Effective Communication (written and oral communication); Communications; Effective Communication; Communication skills appropriate to the audience; Communicate Effectively | |
| 7 | Critical Thinking; Critical Thinker | | | | Add to DESIGN, INNOVATION AND CRITICAL THINKING | Move into nev… |
| 7 | Engineering Problem Recognition, Definition, and Solving; Solve problems; Open ended | Analytical Competencies | Critical Thinking; Design;Creativity and Innovation; Techcnical Ability | No Changes | Add to DESIGN, INNOVATION AND CRITICAL THINKING | Recommend kee… to importance… |

# Competency Mapping

**Identify essential competency categories**

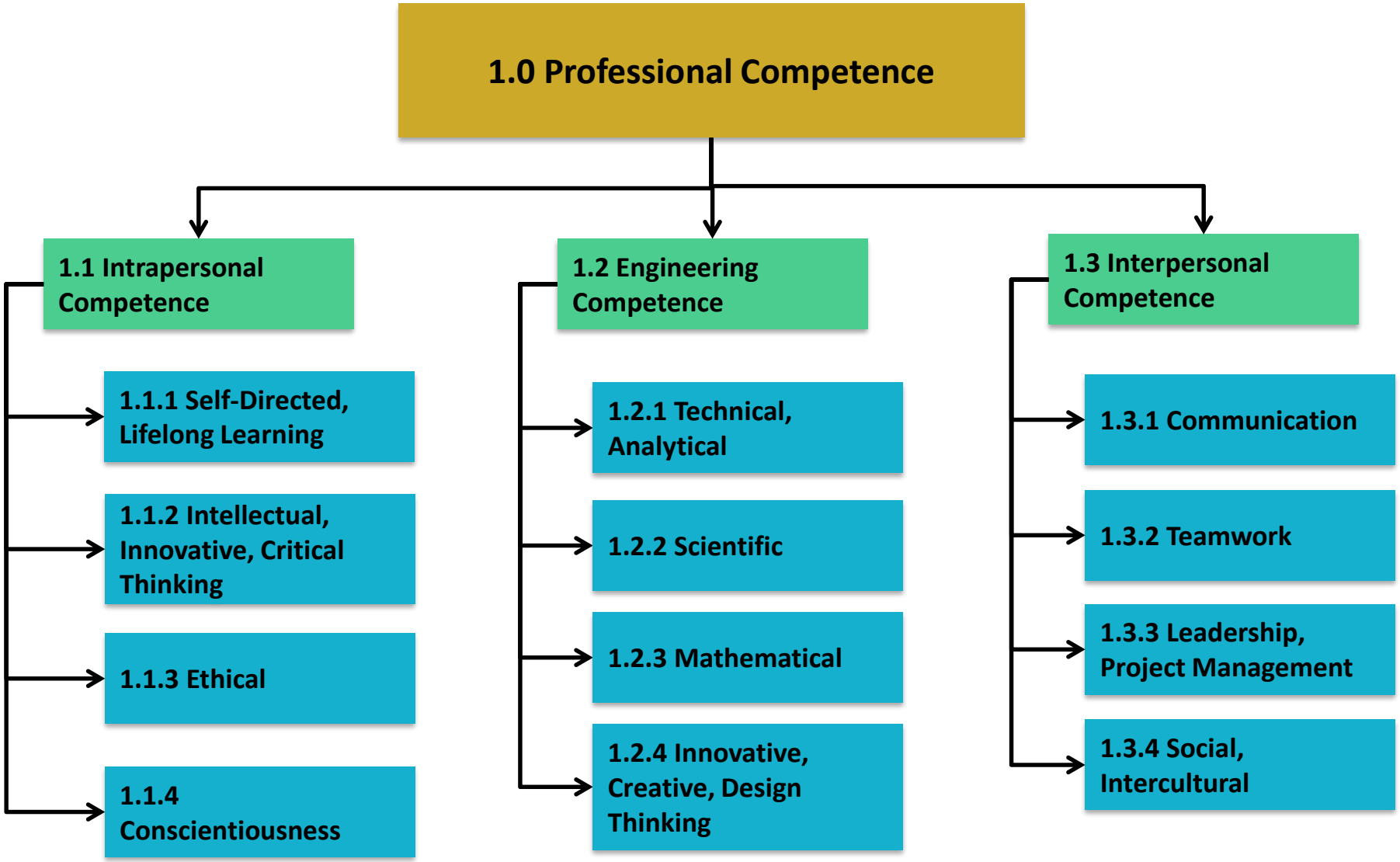
1.0 Professional

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




**Structure and level the categories** (Generality vs. Specificity)

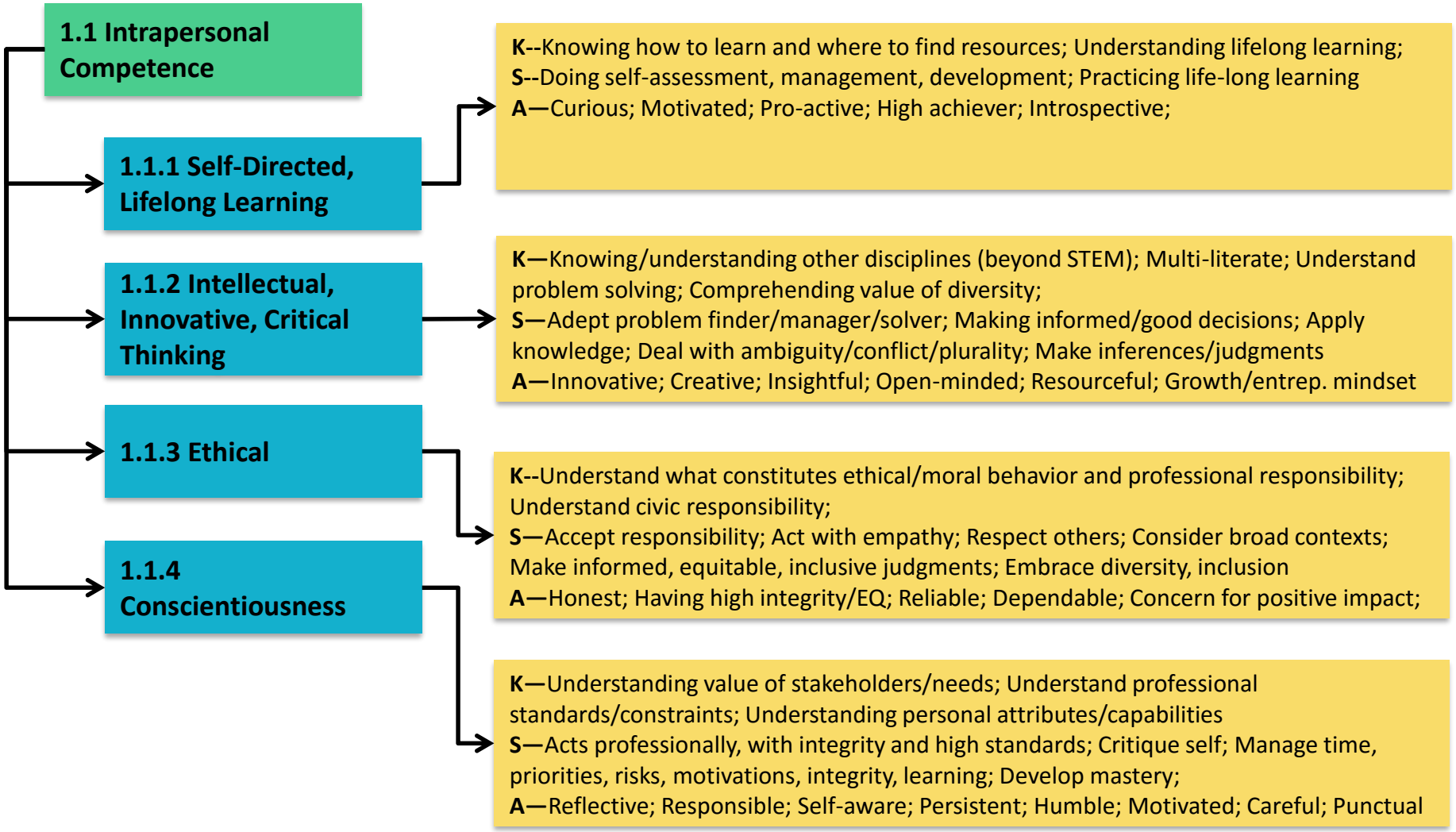
- Primary (very general)
- Secondary (less general/more specific)
- Tertiary (more specific)




**OVERALL COMPETENCY MAP**
**Working Draft 16 April 2017**

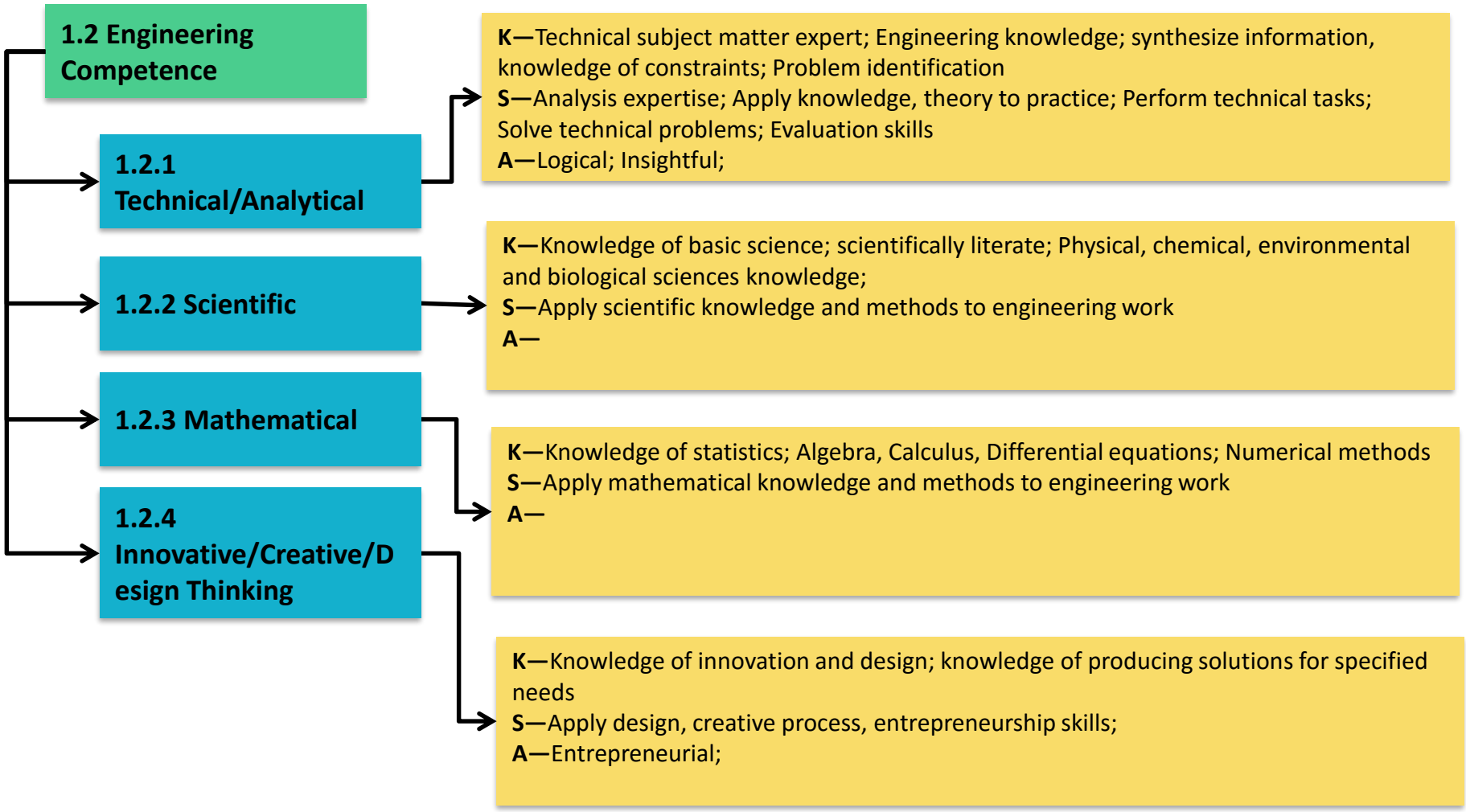
# KSAs of Intrapersonal Competencies

**Working Draft 16 April 2017**



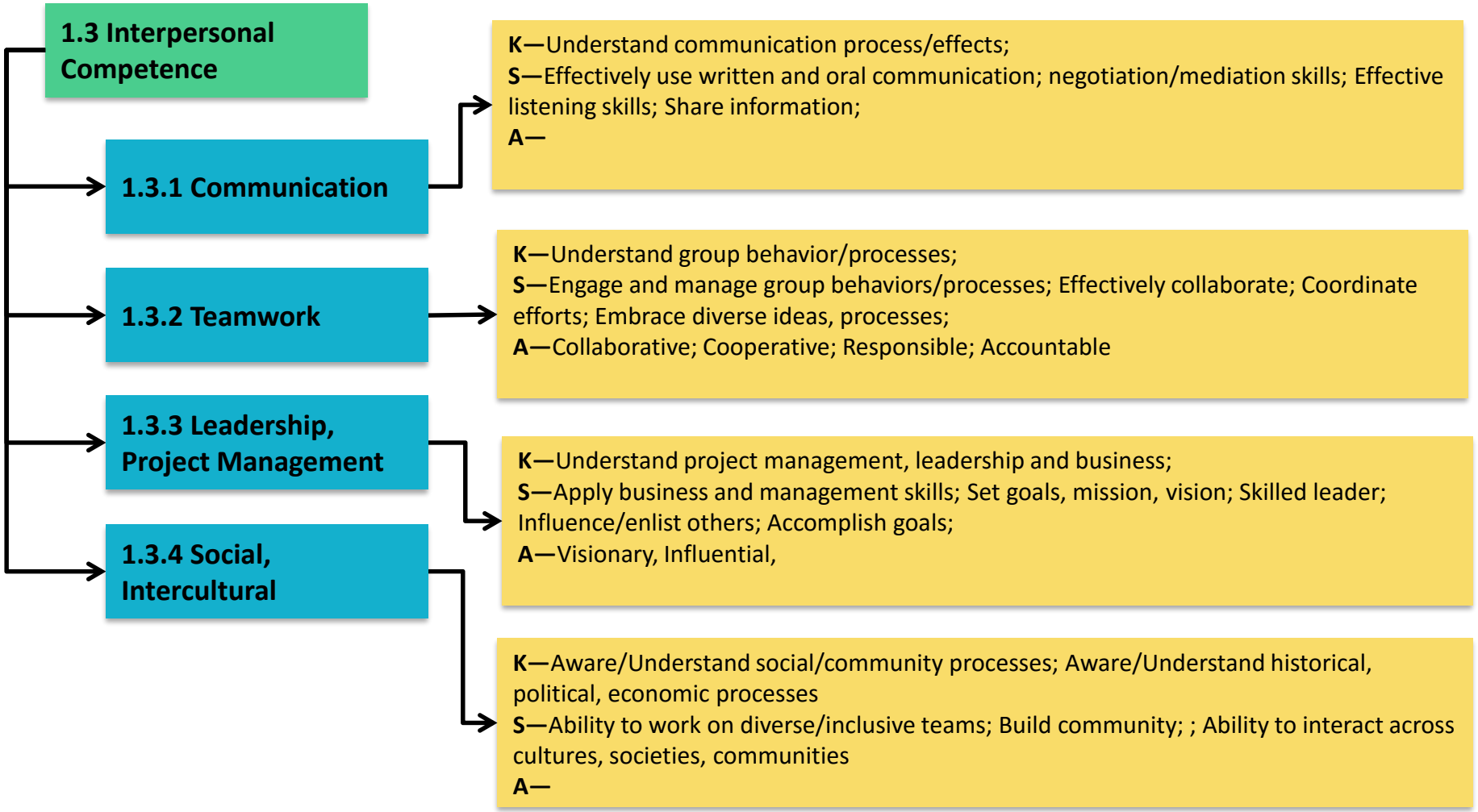
# KSAs of Engineering Competencies

**Working Draft 16 April 2017**



# KSAs of Interpersonal Competencies

**Working Draft 16 April 2017**



# References


Campion, M. A., Fink, A. A., Ruggeberg, B. J., Carr, L., Phillips, G. M., & Odman, R. B. (2011). Doing competencies well: Best practices in competency modeling. *Personnel Psychology, 64,* 225-262.

Dreyfus, S. E. (2004). The five-stage model of adult skill acquisition. *Bulletin of Science, Technology & Society, 24*(3), 177-181.

Kegan, R. (1994) *In over our heads.* Cambridge, MA: Harvard University Press.

Krathwohl, D. R. (2002): A Revision of Bloom's Taxonomy: An Overview. *Theory Into Practice*, 41:4, 212-218

McAuliffe, G. (2006). The evolution of professional competence. In C. Hoare (Ed.), *Handbook of Adult Development and Learning,* Chapter 21, pp. 476-496. Oxford: Oxford University Press.

Passow, H. (2012). Which ABET competencies do engineering graduates find most important in their work? *Journal of Engineering Education, 101*(1), 95-118.

Pikkarainen, E. (2014). Competence as a key concept of educational theory: A semiotic point of view. *Journal of Philosophy of Education, 48*(4), 621-636.

Schippmann, J. S. (1999). *Strategic job modeling: Working at the core of integrated human resources.* Mahwah, NJ: Lawrence Erlbaum Associates.

Schippmann, J. S., Ash, R. A., Battista, M., Carr, L., Eyde, L. D., Hesketh, B., Kehoe, J., Pearlman, K., Prien, E. P., & Sanchez, J. I. (2000). The practice of competency modeling. *Personnel Psychology, 53,* 703-740.

Torbert, W. R. (1981). Interpersonal competence. The Modern American College: Responding to the New Realities of Diverse Students and a Changing Society, San Francisco: Jossey-Bass, 172-190.

Walther, J., Kellam, N., Sochacka, N., & Radcliffe, D. (2011). Engineering competence? An interpretive investigation of engineering students professional formation. *Journal of Engineering Education, 100*(4), 703-740.