Board 8: Aligning A.S. Manufacturing/Engineering Curriculum to Industry Needs

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Dr. Marilyn Barger is the Principal Investigator and Executive Director of FLATE, the Florida Regional Center of Excellence for Advanced Technological Education, funded by the National Science Foundation and housed at Hillsborough Community College in Tampa, Florida since 2004. FLATE serves the state of Florida as its region and is involved in outreach and recruitment of students into technical career pathways; has produced award winning curriculum design and reform for secondary and post-secondary Career and Technical Education programs; and provides a variety of professional development for SETM and technology secondary and post-secondary educators focused on advanced technologies. She earned a B.A. in Chemistry at Agnes Scott College and both a B.S. in Engineering Science and a Ph.D. in Civil Engineering (Environmental) from the University of South Florida, where her research focused on membrane separation science and technologies for water purification. She has over 20 years of experience in developing curricula for engineering and engineering technology for elementary, middle, high school, and post secondary institutions, including colleges of engineering. Dr. Barger has presented at many national conferences including American Association of Engineering Education, National Career Pathways Network, High Impact Technology Exchange, ACTE Vision, League of Innovation and others. Dr. Barger serves on several national panels and advisory boards for technical programs, curriculum and workforce initiatives, including the National Association of Manufacturers Educators'Council. She is a Fellow of the American Society of Engineering Education, a member of Tau Beta Pi and Epsilon Pi Tau honor societies. She is a charter member of both the National Academy and the University of South Florida's Academy of Inventors. Dr. Barger holds a licensed patent and is a licensed Professional Engineer in Florida.

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Richard Gilbert is a Professor of Chemical and Biomedical Engineering at the University of South Florida's College of Engineering . Richard is the Co-PI for the grant that supports the NSF designated Center of Excellence for Advanced Technological Education in Florida, FLATE. FLATE, now in its 10 year of operation, addresses curriculum, professional development, and outreach issues to support the creation of Florida's technical workforce. Richard has over 30 years of experience working with the K-14 education community. Other funded efforts include projects for the NIH and the US Department of Education. The latter was for the development of an engineering curriculum for elementary school applications. The former is for development of electric field mediated drug and gene applicators and protocols. This effort has generated over 20 patents and cancer treatment protocols currently in Phase II trials.

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Thirty five (35) years experiences in higher education. Began teaching mechanical engineering, and manufacturing related courses at Murray State University in Murray Kentucky in 1984 for two years. Starting 1986 till 2015 first as assistant professor, and then as professor, taught mechanical engineering, and manufacturing related courses at Eastern Illinois University, School of Technology, in Charleston Illinois. Received tenured in 1992, and Professional Advancement in 2005 while at Eastern Illinois University. Served as engineering technology program director at Polk State College since 2015 till present. Have served as Co-PI in one State funded research grant, two Lumina Foundation grants, and at the present time, serving as a C0-PI on NSF grant dealing with creating simulations to be utilized in both manufacturing and power generating related industries and academic curriculum.

Are We Meeting Industry Needs?
Checking Florida's 2-year Advanced Manufacturing Degree Program

Abstract

Obtaining feedback from industries is vital to reviewing curriculum content of schools preparing a competent and skilled workforce to meet the manufacturing's needs. Following an intense curriculum review of competencies within the Advanced Manufacturing specialization of the Associate of Science (A.S.) Degree in Engineering Technology, a survey for industry was developed by Polk State College (PSC), in partnership with FloridaMakes, the Florida Forum for Engineering Technology (ET Forum) and FLATE (Florida Advanced Technological Education Center of Excellence). The survey was designed to check the alignment of the Curriculum Frameworks and Benchmarks of the A.S. Degree [1] with industry's identified needs as well as captured both an importance level and frequency of use for each. All standards and benchmarks were translated to competencies, educators also applied cognitive indicator levels to each competency. These levels on a scale of 1-8 reflect the level of complex thinking from simple knowledge to decision making and problem solving. The ultimate goal is to refine the program content and appropriate cognitive indicator level of these competencies that industry expect for their manufacturing and production technician workforce.

Background

The Lumina Foundation has supported research and projects to improve the validity, clarity and implementation of competency based post-secondary education for many years. Competency-based education can provide many benefits to technical education programs primarily by providing students a platform for self-paced learning with facilitation by an educator and with assessments for every competency covered in the course and/or program. The competencies of any program are closely aligned to the workplace and employer needs and are assessed individually. Lumina's overall goal is to achieve "an education attainment goal whose achievement is critical to the nation's social progress and its economic future." That goal, Goal 2025, calls for 60 percent of Americans to hold a college degree or other high-quality post-secondary credential within 10 years." [2] The Foundation's effort includes being sure that the post-secondary credentials authentically address the knowledge, skills and abilities needed for a program completer to be successful in the workforce. Therefore, competency-based post-secondary credentials must align with the needs of employers.

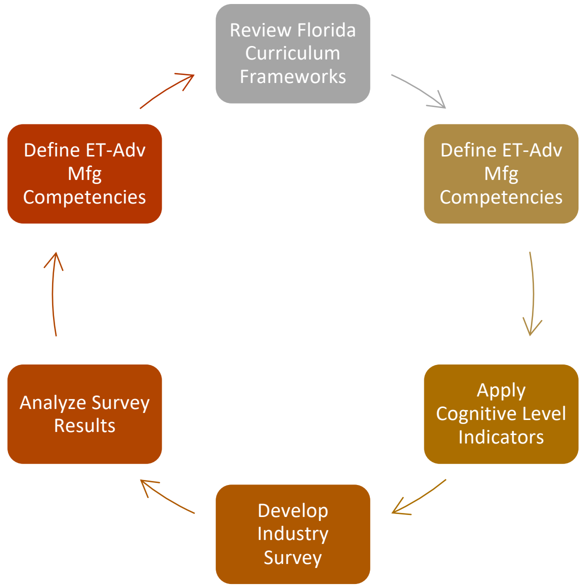

Figure 1. A.S. Engineering Technology Competency Review Cycle

Both industry and educators understand competencies as what a learner/student is able to "do," Additionally, competencies can be defined at different levels. They can also be applied in various contexts and are often considered to support equity in education for historically underserved populations, credential transparency, comparability of credentials, and portability across institutions and between education and industry. These characteristics have promoted industry-valued and validated credentials for a number of years including endorsement from the National Association of Manufacturers, which defined an industry-validated stackable credential system approximately a decade ago.

Implementing the Credential Framework

In Lumina Foundation Beta Credential Framework, the identified competencies are defined as either knowledge-based or skills-based. Additionally, there are three categories of skills: specialized, personal, and social. Specialized skills are those related to the occupation that is being addressed by a particular credential framework. The personal skills are those relating to being responsible, acting independently, using critical thinking and making judgements. Social skills include working together and communicating with diverse peoples, and being respectful of all viewpoints. The cognitive level indicators that were applied to each competency and were selected from the Lumina Foundation Beta Credential Framework Levels. (See Appendix 1 for the level descriptions of each of four different skills categories.) [1]

Polk State College, part of the Florida College System, was established in 1964 and is a multi-campus institution serving over 20,000 students with Bachelor of Applied Science, Bachelor of Science, Associate in Arts, and Associate in Science degrees. PSC offers a variety of certificate and workforce training programs and operates three charter high schools. PSC participated in the Lumina Foundation project that supported the work of defining the program competencies found in the current Curriculum Frameworks for the A.S. Engineering Technology's Advanced Manufacturing (ET-AM) specialization as well as degree programs in other areas.[3]

The Engineering Technology program director led the effort for defining the ET-AM competencies. Three hundred fifty competencies were defined in A.S. ET-AM degree program. Once that was completed, PSC engaged FLATE and the colleges participating in the Florida Forum for Engineering Technology to identify the cognitive indicator levels for each of competency. Five subject matter experts undertook this task individually and the Polk State College team aggregated and averaged the results. A final review by the five subject matter experts and the college representatives attending the 38th ET Forum at Chipola College in the spring of 2017 accepted those results.

The Industry Survey

With the competencies defined and cognitive indicator levels assigned, the team from PSC, the ET Form and FLATE worked together to combine related competencies that would be used in the industry survey. The goal was to minimize the length of the survey distributed to industry partners. After considerable review and refinement, the final survey was divided into two parts. Section 1 consisted of 20 items and addressed competencies from the knowledge and specialized skills items. Section 2 also used 20 items which addressed competencies from the personal and professional skills category. Section 1 requested two responses for each of the twenty items: the importance of the item and the frequency performed. For each question on the importance of the item, respondents were asked to rank the responses using the Likert scale (from 1 to 5) with 5 being "Most Valuable" and 1 being "Least Important." Respondents could also select "N/A" (Not Applicable) if appropriate. For frequency performed, respondents were asked to select one of three choices: "Never", "Sometimes" or "Always". If N/A was selected for the importance response, respondents were asked to select "Never" for the frequency response. Each of the personal and professional skills in Section 2 required only a single response for the level of importance for each item. The same 1-5 Likert Scale that was used in Section 1 was applied to the twenty items in this section. No previously assigned cognitive indicator levels were included/visible in the survey for industry.

In summary, the survey had a total of forty items and was estimated to require 12-15 minutes. It was distributed to manufacturers across Florida via the project partners: FloridaMakes (FloridaMakes is the NIST Manufacturing Extension Partnership (MEP) in Florida; Florida Regional Manufactures Associations (RMA's), and State and Community college offering the A.S. ET Degrees by email with a unified message and postings on organizational websites. The survey was open for a two-week window in November 2017. Eighty-eight respondents from seventeen counties in Florida completed the survey during that time period.

The Industry Survey Results

Industry responses showed a high level of endorsement of the A.S. ET-AM competencies in both sections of the survey. In Section 1, all 20 competencies were ranked as 3 or higher on the 5-

point scale of importance. 70% of these competencies were assigned rank of 4 or 5 (Important or Very Important). These results confirmed that most of the respondents endorsed the 20 technical competencies. Half of the items that ranked 5 (Very Important) on the survey had been previously assigned as a 7 or 8 cognitive indicator level for specialized skills very important to employers. The frequency of use results revealed that 18 of the 20 competencies were used “sometimes” or “always”. These results showed strong alignment of the twenty specialized skills (technical) competencies in the A.S. Engineering Technology Advanced Manufacturing program with industry needs.

The summary results for the twenty items in Section 2 also revealed a strong alignment of the competencies in the A.S. ET-AM degree with industry needs. All twenty items had a weighted average of 3.8 or greater on the 5-point scale, with an overall average of 4.32. There was no correlation of the level of importance to the cognitive level indicators assigned to each of these social and personal competencies, and it is clear that industry highly values these personal and social skills. The tabulated summary results of the industry survey are presented in Appendix 2.

Closing Remarks

In conclusion, the medium to high level of survey response alignment is a strong indication that the A.S. ET-AM degree program in Florida is meeting industry needs for its technician workforce. This statement is amplified by the diversity of Florida manufacturer surveyed as related to products and facilities. For example, a small machining company might not have a need for some of the specific skills in some of the items in Section 1. Other small companies that provide contract manufacturing services might need computer aided design skills. Alternatively, a large facility that is one location of a large corporate entity may produce a single component for the whole company’s product design work is performed at another facility. Thus, even though the immediate needs of manufacturers are their primary concern and those needs are governed by the reality of their production “life style,” all of the surveyed companies identified the importance of the skills in question as being significant if not necessary in their operations.

The standards and benchmarks that are included in each Florida Curriculum Framework for the A.S. ET-AM are reviewed by a panel of industry and educators every three years. This review process is coordinated by the Florida Department of Education Division of Career and Technical Education, which must approve and post the final document. All colleges offer a particular program must prepare students to meet these benchmarks. In Florida, this review process is legislatively mandated. The A.S. ET Curriculum Frameworks are scheduled for review in 2019. The results of the industry survey will be taken into consideration during the review process and could initiate changes to the frameworks that will become effective in the 2020-2021 academic year in Florida.

References

[1] Florida Department of Education A.S. Engineering Technology Curriculum Frameworks, 2019. [Online]. (http://fldoe.org/academics/career-adult-edu/career-tech-edu/curriculum-frameworks/2019-20-frameworks) [Accessed March 1, 2019].

[2] Lumina Foundation, "Connecting Credentials: A Beta Credentials Framework" 2015. [Online]. (www.connectingcredentials.org) [Accessed March 1, 2019].
[3] NAM's Stackable Credential System website [Online]. (http://www.themanufacturinginstitute.org/Skills-Certification/Skills-Certification.aspx) [Accessed March 1, 2019].

Appendix 1. Lumina Foundation Beta Credential Framework Levels

Levels for Knowledge Competencies

1. Demonstrates General Knowledge.
2. Demonstrates and uses basic knowledge.
3. Demonstrates and applies extended knowledge for predictable problems.
4. Demonstrates comprehensive theoretical and technical knowledge.
5. Demonstrates integrated and special professional knowledge.
6. Demonstrates broad integrated knowledge regarding scientific principles and practical application of scientific subject.
7. Demonstrates specialized knowledge in subject and can involve in professional activities.
8. Demonstrates specialized knowledge in adjoining disciplines including knowledge in a new discipline or profession.

Levels for Specialized Skills

1. Demonstrates basic cognitive and practical skills to perform tasks within stipulated rules.
2. Demonstrates skills needed to establish correlations among functions and tasks.
3. Demonstrates cognitive and practical skills for perform tasks and problem solve.
4. Demonstrates ability to select alternative actions based on reciprocal effects on other functional areas.
5. Plans and evaluates processes while considering alternatives and impacts.
6. Develops and evaluates new solutions and considers the effect on various criteria.
7. Demonstrates technical and conceptual skills to analyze, consolidate, and synthesize knowledge toward strategic activities.
8. Demonstrates comprehensive skills in R&D or innovations in profession

Levels for Personal Skills

1. Takes responsibility for learnings.
2. Uses stipulated learning guides and seeks guidance if needed
3. Sets one's own learning and work objectives
4. Initiates planning and designing technical learning objectives.
5. Takes responsibility for overall actions and outcomes.
6. Exercises autonomy and responsibility for planning and development of processes that support substantial changes.
7. Defines objectives for new applications reflecting on societal, economic, and cultural implications.
8. Selects appropriate means and develops new ideas and processes.

Levels for Social Skills (Associates)

1. Respects others' actions and accepts critique and feedback.
2. Listens effectively and uses comprehension skills to receive direction and information
3. Helps shape the work within a heterogeneous, working /learning group.
4. Communicate solutions to moderately complex, controversial, sensitive matters.
5. Demonstrates advanced interpersonal abilities to convey complex facts to cross-disciplinary audiences.
6. Demonstrates ability to work with and lead expert groups.
7. Demonstrates ability to lead expert debates, build consensus, and promote professional development of others.
8. Leads groups in complex or interdisciplinary tasks, promotes organizational goals.

Appendix 2. Section 1 Industry Survey Results

Industry Survey Section 1 Summary Results

Competencies/Learning Objectives Descriptions Competency Descriptions (1-20)	**Frequency of Use**			**Knowledge Levels**	**Specialized Skills Levels**
Technical Skills: A highly skilled employee at this plant is expected to have in-depth technical knowledge, critical thinking and judgement abilities, and systems thinking abilities in order to:	Never	Sometimes	Always	1-8 Level of credentials Ranked highest at 1-5 of importance	1-8 Level of credentials Ranked highest at 1-5 of importance
1. Implement all related safety codes and regulations in industrial working environments	2%	24%	74%	L 3 Rank 5 @ 70%	L 3
2. Perform tasks in a specialized technical area.	1%	41%	58%	L 4 Rank 5 @ 46%	L 3
3. Work with computer aided drafting and create geometric part files.	21%	52%	27%	L 3 Rank 3 @ 25%	L 3
4. Work at the entry level with traditional materials removal machines (milling, lathe, drill press, cut-off-saws).	22%	55%	24%	L 1 Rank 4 @ 26%	L 1
5. Understand mechanical and process characteristics of common materials.	6%	58%	37%	L 4 Rank 4 @ 58%	L 2
6. Operate materials testing tools and equipment.	8%	67%	25%	L 4	L 5 Rank 4 @ 31%
7. Operate, maintain, and repair mechanical, hydraulic and pneumatic systems.	18%	58%	24%	L 3	L 3 Rank 4 @ 27%
8. Operate AC electric-powered tools, and equipment	8%	47%	45%	L 2	L 2 Rank 5 @ 31%
9. Operate DC electric-powered tools and equipment.	18%	52%	30%	L 2	L 2 Rank 3 @ 30%
10. Operate electronic sensors, switches, and controls.	9%	50%	41%	L 2	L 2 Rank 4 @ 29%
11. Operate programmable logic controllers and use systems schematics.	14%	59%	27%	L 3	L 3 Rank 4 @ 33%
12. Diagnose causes and troubleshoot systems operations, using schematics and ladder logic diagrams.	17%	61%	21%	L 7	L 5 Rank 3 @ 25%
13. Report total quality improvements of a unit and the entire systems operation.	19%	63%	18%	L 8	L 7 Rank 3 @ 34%
14. Evaluate the results of tasks performed in accordance with standard operating procedures (SOPs).	8%	43%	49%	L 4	L 3 Rank 4 @ 34%
15. Perform root cause analysis and recommend corrective actions.	7%	58%	35%	L 7	L 7 Rank 4 @ 35%
16. Participate in planning and evaluating processes.	5%	70%	25%	L 7	L 7 Rank 3 @ 37%
17. Compare and contrast process alternatives.	14%	66%	20%	L 7	L 7 Rank 3 @ 34%
18. Recommend new solutions and consider effects on various processes even in circumstances where requirements are subject to frequent changes.	7%	62%	31%	L 8	L 8 Rank 5 @ 31%
19. Demonstrate a high level of independent judgment in a range of technical functions and articulate significant challenges involved.	3%	43%	54%	L 7	L 7 Rank 5 @ 42%
20. Participate in the development of an existing and/or new product and/or operation.	11%	56%	33%	L 8	L 8 Rank 5 @ 34%

Rank 3	Rank 4	Rank 5

Industry Survey Section 2 Summary Results

Competencies/Learning Objectives Descriptions Competency Descriptions (1-20)	**Frequency of Use**			**Personal Skills Level**	**Social Skills**
Personal & Team Skills: Index factors for personal and team skills are based on self-sufficiency, responsibility, and self-awareness, and reflectiveness. In addition team skills are measured based on communication, involvement, work ethic, character, adaptability, problem solving, critical observation, teamwork, and leadership. Employees should be able to demonstrate the ability to:	% Ranked @ the most important. WEIGHTED AVERAGE xx/5.0			1-8 Level of credentials Ranked highest at 1-5 of importance	1-8 Level of credentials Ranked highest at 1-5 of importance
1. Use required learning guides and request learning guidance when needed.	53.4%	WA	4.4	L 2	
2. Use initiative to set their own enhanced learning objectives related to daily tasks and performance.	38.7%	WA	4.1	L 3	
3. Evaluate personal strengths and weaknesses of knowledge and performance related activities.	27.3%	WA	3.9	L 4	
4. Define objectives for new simple applications and establish tasks to accomplish the objectives.	25.0%	WA	3.8	L 4	
5. Share with team members alternative ideas and strategies to define the objectives of complex applications.	46.6%	WA	4.2		L 3
6. Express the mission, goals, and objectives of the workplace.	39.8%	WA	4.1	L 3	
7. Take responsibility for work environment.	81.8%	WA	4.8	L 5	
8. Demonstrate interpersonal communication.	60.2%	WA	4.5		L 1
9. Follow rules and regulations in the workplace.	87.5%	WA	4.8	L 2	
10. Execute team assignments competently.	70.5%	WA	4.6		L 3
11. Listen effectively.	80.7%	WA	4.7		L 2
12. Effectively participate in a diverse work environment	63.6%	WA	4.5		L 3
13. Communicate clearly, timely, and relevant information on processes and results at all levels.	62.5%	WA	4.5		L 4
14. Conduct, analyze, interpret, and present complex facts and provide solutions.	27.3%	WA	3.9	L 8	L 6
15. Take appropriate corrective actions based upon provided feedback.	59.1%	WA	4.5	L 5	
16. Build consensus from group discussions.	27.3%	WA	3.9		L 3
17. Demonstrate the ability to transfer information and specialized skills to others.	36.4%	WA	4.1		L 6
18. Set short-term and long-term goals.	33.0%	WA	4.0	L 4	
19. Represent the organization in a professional manner.	71.6%	WA	4.6		L 8
20. Demonstrate appropriate social skills.	59.1%	WA	4.5		L 6

Rank 3	Rank 4	Rank 5