Facilitating Advanced Manufacturing Technicians' Readiness in the Rural Economy: A Competency-based Deductive Approach

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Abstract

While rural manufacturing job availability is growing throughout the country, rural communities often lack skilled workers. Thus, it is imperative for employers to validate needed new professional competencies by understanding which skills can be taught on-the-job as well as the knowledge and abilities best gained through classroom learning and experiential learning opportunities. This enhanced understanding not only benefits employers' hiring practices, but also it can help Career and Technical Education (CTE) programs improve curricula and expand learning opportunities to best meet students' and employers' needs. In this study, we triangulated industry competency model content with rural employer perspectives on new advanced manufacturing (AM) professionals' desired competencies (i.e., the level of skill sophistication in a particular AM work area). To extract competencies for entry-level AM rural jobs, we used a deductive approach with multiple methods. First, we used Natural Language Processing (NLP) to extract, analyze, and compare the U.S. Department of Labor's AM 2010 and 2020 Competency Models because they reflect the levels and topics AM industry professionals nationally reported as technician needs. Then, we interviewed 10 rural AM employers in North Florida to capture their perceptions of the most important competencies for new middle-skill technicians. Interview transcripts were also processed using NLP to extract competency levels and topics; we compared this output to the AM Competency Model analysis results. We deduced that the most critical competencies identified by rural AM employers required direct classroom instruction, but there was a subset of skills obtainable through on-the-job training or other experiential learning. This study, with the goal of addressing employee shortages and increasing the number of technicians ready for the workforce, has implications for rural community colleges' AM programs curricula and the role of experiential learning.

1.0. Introduction

Manufacturing represents a greater share of private rural jobs and earnings compared to urban areas, making manufacturing essential to rural economies. Some researcher also suggest that rural manufacturing is more resilient to economic downturns and associated with higher survival rates than urban plants, likely because rural plants are often independent and not connected with multi-unit firms. For these reasons, along with benefits of lower property taxes, wages, and land prices, companies are attracted to locating manufacturing plants in rural areas. Unfortunately, while rural manufacturing jobs markets are strong, rural markets are often limited in skilled workers. Thus, it is imperative that employers can identify competencies that are needed prior to entry, those that can be taught on-the-job, and even opportunities that can be taught through experiential learning. Equipped with this knowledge, CTE programs can improve curricula to best meet the needs of students and employers, alike.

In this study, we compare the competencies that AM industry professionals believe are important to entry-level technicians through document text-mining analysis of the Department of Labor's AM competency Model (henceforth the DOL AM Competency Model) and employer interviews. We further identify the topics (i.e., nouns) and competency levels (or nouns according to Bloom's taxonomy) that highlight low- to high-level competencies. We then use this hierarchy scheme to answer the following 2-part research question concerning AM employers in Northwest Florida:

RQ 1) How do national AM competencies levels in the DOL AM Competency Model compare to competency levels expressed by Northwest Florida employers?

RQ 2) What competencies most critical to rural AM employers can benefit entry-level technicians through classroom learning and experiential learning?

2.0. Literature Review

2.1. Industry Demands in DOL AM Competencies

AM Competencies are developed by the Employment and Training Administration (ETA) of the U.S. Department of Labor. Industry subject matter and technical experts provide feedback on the model and the model is validated with input from industry associations, labor organizations, educators, and other subject matter experts [1]. The ETA and partners recently updated the 2010 DOL AM Competencies [2] with the 2020 AM Competencies [3] to represent competencies across a wide range of AM industries and is mean to provide allow new AM technicians, educators, and employers to align competencies (or knowledge, skills, and abilities) to facilitate recruitment, retention, training, and developing in AM. The *Summary of Changes* [4] from the 2010 and 2020 models does not appear significantly different within the 10 year span, and the major topic themes or tiers are as follows:

1) Tier 1 includes Personal Effectiveness Competencies (or soft skills) which focus on interpersonal skills, integrity, professionalism, initiative, dependability and reliability, adaptability and flexibility, and lifelong learning.
2) Tier 2 includes Academic Competencies which focus on reading, writing, math, science, communication, critical and analytical thinking, and basic computer skills.
3) Tier 3 includes Workplace Competencies such as business fundamentals, teamwork, customer focus, scheduling and coordinating, creative thinking and problem solving, recording or examining information, working with tools and technology, personal health and safety, and sustainable practices that meet the needs of future generations.
4) Tier 4 are Industry-Wide Technical Competencies and include manufacturing process design and development, operations management, maintenance, installation, and repair, production in the supply chain or supply chain logistics, quality assurance, process and equipment health, safety, and environment.

These Tiers are essentially building blocks of related competencies to successfully perform broad skills needed for the entire industry and not just an industry sector or occupation, also referred to as industry-wide competencies.

2.2. Experiential learning in CTE and AM

Integration of experiential learning is now a requirement for funding in Florida of all programs that use Perkins V funds, a program that strengthens Career and Technical Education (CTE) in secondary and postsecondary levels in the U.S. [5, 6]. With the passing of Executive Order 19-

31, Florida Governor Ron DeSantis committed that Florida would chart a course for students to be prepared for Jobs of the Future and the State to rank first nationally in Workforce Education by 2030[7]. Florida's Perkins V State Plan, in alignment with Executive Order 19-31, necessitates alignment of the secondary and postsecondary programs with the future of work and specifically "emphasizes experiential learning, a tighter and more intentional alignment to industry demand, increased access for special populations and a more innovative approach to how workforce education is structured and delivered [5]."

Florida's Experiential Learning Framework for Perkins Size, Scope, and Quality [6] defines experiential learning as providing students with opportunities for 1) work-based learning, 2) career and technical student organizations (CTSOs), or capstone experiences that engage students through formal or informal learning. Florida's Experiential Learning Framework provides examples of work-based learning as career experiences (e.g., practicum, internships, registered apprenticeships or pre-apprenticeships, and on-the-job training), and career engagement (e.g., directed student or other capstone courses, school enterprise, service learning, simulated work environments, or participation in CTSOs. Experiential learning also includes preparation for work-based learning, which includes career exposure (e.g., job shadowing, mentoring, company tours, and informational interviews) and career exploration (e.g., career fairs, interest inventories, mock interviews, and guest speakers).

Across the nation, AM and Engineering Technology (ET) programs, which fall under the prevue of CTE, have or are aligning core curricula and programs with industry needs to better prepare students to meet the demands of the AM workforce [8-10], recognizing the benefits that college-industry partnerships have on student learning. Some researchers [11, 12] have even developed experiential models for AM in areas of additive manufacturing and lean-thinking-learning space. While there is general enthusiasm about the integration of experiential learning in CTE programs, the process for including such activities have existed for some time [13, 14] and require a reflective learning process for students to learn [15, 16], which signifies caution for program administrators or courses instructors that integrate learning opportunities without heeding to the theoretical concepts or approaches that lead to student learning outcomes.

3.0. Method

In this study, we compare competencies that AM industry professionals believe entry-level manufacturing employees should possess and compare them to national AM competencies. Competencies refers to both the level of competence in a particular topic and the topic itself. To extract competencies for entry-level AM rural jobs, we use a deductive approach and multiple methods.

3.1. Data Collection

We use Natural Language Processing to review DOL's AM Competency Model (2020) [3] and extracted the competency levels and topics that AM industry professionals nationally believe are needed by entry-level employees. Next, we interview 10 AM industry employers in rural manufacturing plants in Northwest Florida and ask them to identify the most essential competencies entry level workers should possess.

3.2. Data Analysis.

Interviews are transcribed and also processed using NLP to extract competency levels (verbs) and topics (nouns), and then compared with industry-based national competencies to understand the extent to which competency levels and topics are similar between national and regional competencies. We compare AM competencies in the national DOL AM Competency Model to regional employer needs in Northwest Florida by using frequency percentages.

Competencies are sorted into two main categories based on Bloom's Taxonomy verbs to understand which competencies might be:

1) Taught in classrooms – referring to competencies that utilize Bloom's Taxonomy verbs in levels 1 through 3; and
2) Supplemented by experiential learning – referring to Bloom's Taxonomy levels 4 through 6. Category 2 is not meant to supplant the teaching of these competencies in the classrooms, but provides an opportunity to explore how students and the curriculum might benefit from industry collaboration and inclusion for competencies that require higher levels of learning, according to employers.

The verbs were categorized into Bloom's *Revised Taxonomy of Educational Objectives* six cognitive levels [17, 18], whereby Bloom's six cognitive levels are defined, from low to high, as:

1) Remember – Retrieve relevant knowledge from long-term memory.
2) Understand – Construct meaning from instructional messages, including oral, written and graphic communication.
3) Apply – Carry out or use a procedure through executing or implementing.
4) Analyze – Breaking material or concepts into parts, determining how the parts relate or interrelate to one another or to an overall structure or purpose.
5) Evaluate – Make judgements based on criteria and standards through checking or critiquing.
6) Create – Put elements together to form a coherent whole; reorganize into a new pattern or structure.

Then the percentage of verbs belonging to each level was calculated as:

$$\% \text{ of verbs in each of Bloom's Level} = \frac{\boldsymbol{V_i}}{\sum_{\boldsymbol{i=1}}^{\boldsymbol{6}} \boldsymbol{V_i}} * 100$$

Where $\boldsymbol{i}$ = Bloom's *Revised Taxonomy* level & $\boldsymbol{V_i}$= Total # of verbs in the i^{th} level.

To compare the ranges of categorized verbs within the AM Competency Model, we also visualized the data with pie and radar charts to emphasize aspects of the analysis.

3.3. Limitations.

This study is based the 2020 AM Competency Model with input from a national group of AM industry representatives, and thus reflective of competencies that AM employers believe are needed by AM entry-level employees; however, the employers interviewed as part of this study were from rural Northwest Florida. Although the findings cannot be generalized to other area, the method does lend itself to replicability to other rural areas.

4.0. Results

4.1. Comparing National to Northwest FL Regional employer needs

As shown in Figure 1, a comparison of the DOL AM Competency Model with rural employers' stated needs for entry-level employees revealed several differences between verb levels.

DOL AM Competencies showed the greatest percentage of action verbs in the Applying category (37.01%) followed by Understanding (20.19%), Remembering (16.45%), Creating (13.08), Analyzing (6.73%), and Evaluating (6.54%). The two verbs categories with the highest variance (or different verbs) were Remembering and Applying.

Rural Employers identified Remembering verbs the most (38.91%), following by Applying (27.60%), Understanding (17.44%), Creating (11.02%), Evaluating (2.68%), and Analyzing (2.35%). The greatest variances were seen in the Remembering and Understanding categories.

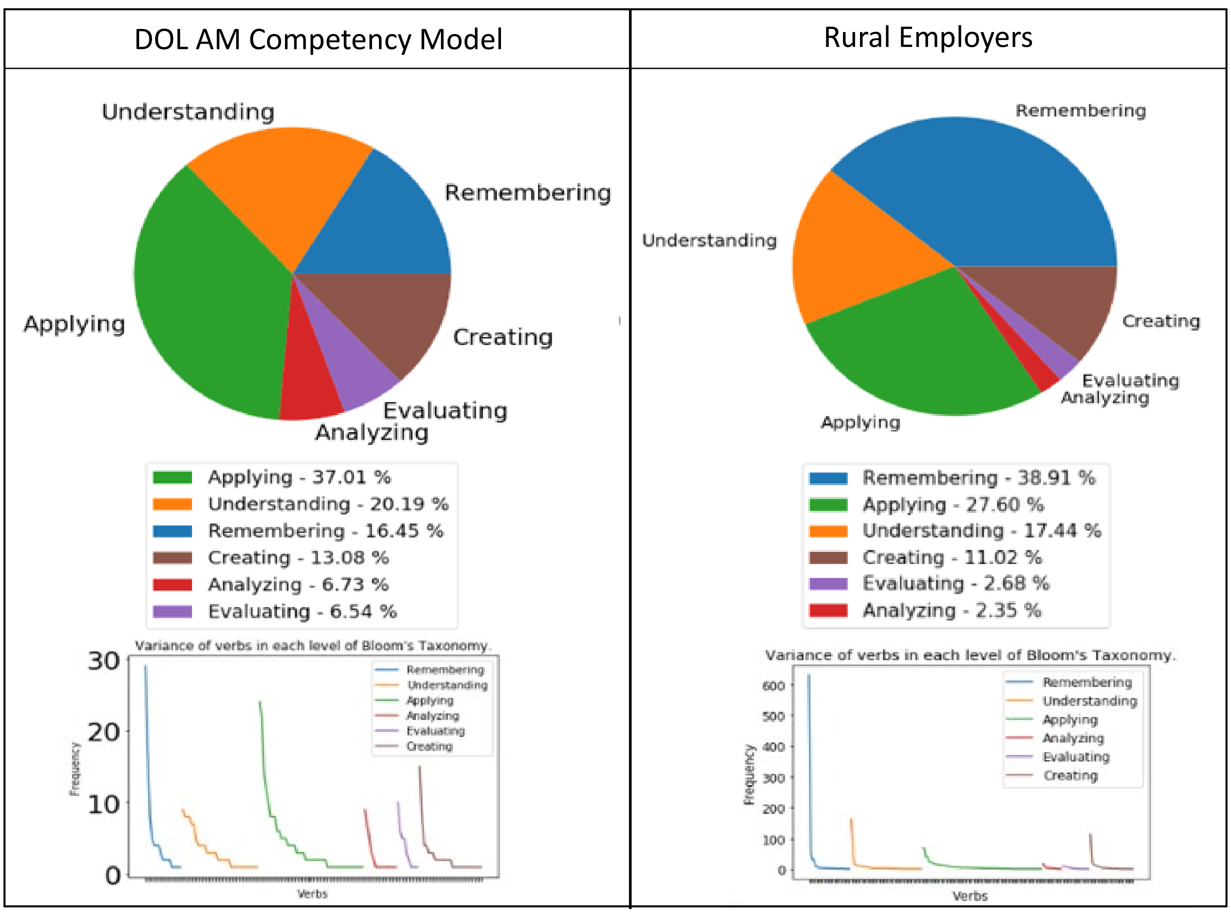

Figure 1. Comparison of AM Competency Model and Employers, by Verb Level

4.2. Competencies with Verbs in Blooms Levels 4-6.

4.2.1. The AM Competency Model Higher Level Competencies.

With Natural Language Processing revealing that 26.25% of verbs in the DOL Competency Model competencies were higher level verbs, a subsequent review was conducted to identify the specific competencies (verb and topic) in the document. Competencies with high level verbs in the DOL AM Competency Model were classified as follows:

Table 1. AM Competency Model, Verb Levels by Tier

Tier	Level 4 Analyze	Level 5 Evaluate	Level 6 Create	Verb Issue	Not scored	Total
1	1	1	4	8	0	14
2	12	8	5	19	0	44
3	10	9	11	12	0	42
4	1	3	10	11	284	25/309
Total	24	21	30	50	284	409

The review of the competencies identified Create verbs as most frequently mentioned, followed by Analyze and Evaluate verbs. The Appendix shows the competencies with verbs that were assigned to a higher-level category. Tiers that were not assigned to a category were either verbs in Levels 1-3, had problematic verbs that could not be classified, or not scored because they did not have a verb to classify (e.g., poor sentence structure). Verb issues included words such as "use" or "have," which are not action verbs that can be applied with Bloom's Taxonomy. Examples of competencies not scored because they were not properly structured were "hot and cold forming process," whereby there was no verb to classify the statement (i.e., a topic without a verb). It should be noted that only in Tier 4, or Industry-wide Technical Competencies, were there many topical lists without appropriate action verbs for proper classification into a Bloom's level category.

4.2.2. Employers' Higher Level Competencies.

After review of the AM Competency Model, we reviewed employer transcripts for evidence of the 16.05% of higher-level verbs identified by the Natural Language processing, but there were a few surprising findings. Although we knew that employers used few higher level verbs, we did not know that most were based in Tier 4 and particularly in areas that the AM Competency Model could not be scored in. For example, one employer said that *"a power train specialist is going to build transmissions and torque converters,"* whereas as "Mechanical power transmission systems maintenance, installation and repair" was listed in the AM Competency Model (competency 4.3.9) as a topic without a verb that could not be scored. There was also an abundance of the word "use" within the Create category, which were removed from the study for the AM Competency Model, and thus removed from the employer analysis. With the challenges identified, we decided to further analyze the higher-level competencies found in the AM Competency Model (see Appendix) as a starting point for supplementing instruction in AM rural programs through experiential learning.

4.2.3. Limitations.
Competency analysis is only as valuable as the relevance and the competencies themselves. There were over 284 statements in Tier 4 (Industry-wide Technical Competencies) that could not be properly categorized. There were issues with the overuse of verbs, such as "use," which were found to have multiple meanings and hard to categorize according to Bloom's Taxonomy.

5.0. Discussion

5.1. How do national AM competencies levels in the DOL AM Competency Model compare to competency levels expressed by Northwest Florida employers?

The DOL AM Competency Model contained 73.65% of verbs in lower category levels 1-3 (Remember, Understand, and Apply) of the Bloom's Taxonomy and 26.35% of verbs in higher levels 4-6 (Analyze, Evaluate, and Create). In the Remembering category, employers (38.91%) had over double the AM Competency Model verbs (16.45%) in that category; however, the DOL AM Competency Model had a greater percentages in all other verb categories.

Employers' verbs were skewed towards lower level verbs (83.95%) then the higher level (16.05%), although all of the differences could be attributed to Remembering category verbs. This suggests that developers of the AM Competency Model and rural employers who participated in this study either believe that lower level competencies are most needed by entry level technicians, or higher level competencies were not given as much consideration during the development process. It can also mean that rural employers are not as experienced in articulating verb levels for competency development, perhaps on specific employers (at certain levels should be asked competency-related questions, or that HR or curriculum development specialists should be involved in processes that involve competency development.

The most frequently used verbs in the DOL AM Competency Model were in the Applying (37.01%) and Understanding (20.19%) categories, while Remembering (38.91%) and Applying (27.60%) were highest among employers, suggesting that Applying verbs were among the most frequently mentioned verbs in both the AM Competency Model and by rural employers. With this study focusing on competencies that might complement formal learning through an experiential learning component, an argument can be made that the Applying category should belong to higher level verbs and that lower level verbs should only include levels 1 and 2; however, if this is the case, then it may be that Applying level verbs are being used synonymously with Create verbs or that the higher level verbs are not being used sufficiently in manufacturing which by definition involves the creation of things.

5.2. What competencies most critical to rural AM employers can benefit entry-level technicians through classroom learning and experiential learning?

Additional review of the high-level competencies in the DOL AM Competency Model highlighted opportunities for experiential learning in all Tiers.

Tier 1 covers personal effectiveness competencies and includes four Level 6 competencies, which focus on adapting and modifying behavior based on feedback, self-analysis, or past mistakes. The interpretation of verbal and nonverbal behavior of others (Level 5), and anticipation of changes in work demands (Level 4) are also included in this Tier. The use of "soft skills" can certainly be developed using experiential learning concepts, which may not be highly integrated in curricula, but necessary in the AM profession.

Tier 2 covers academic competencies and contains 12 analyzing verbs (Level 4), 8 evaluating, and 5 creating. Verbs that focus on analysis (e.g., infer, detect, analyze, distinguish, conclude, and compare) are mostly seen in topics such as mathematics, logic and reasoning, and drawing conclusions from information. Evaluate verbs (8) involve topics of time, temperature, distance, evaluation of data, controls, and sources of error. Competencies that involve Create verbs (e.g., compose, solve, and create) often involve composition of documents, creation of presentations, and solving problems or issues. On-the-job training, internships, field experiences, and apprenticeships may be beneficial for development of academic competencies in real workplace settings. Tier 2 also had the highest number of high-level verbs in the AM Competency Model, and the highest number of verbs in the Analyze category, suggesting that there are many opportunities for increasing student learning in Academic Competencies, which are directly taught in the classroom.

Tier 3 focuses on Workplace Competencies and contains the greatest number of Create (Level 6) verbs (11) in the AM Competency model and focus on developing relationships with others, planning work, developing contingency plans, designing systems, compiling information or data, developing alternatives, and improving efficiency. Evaluate verbs (Level 5) in Tier 3 involve prioritizing, estimating, evaluating, and assessing outcomes, and focus on the relative merits of solutions, consequences of actions, the importance or criticality of problems, and resources needed for project completion. Analyzing (Level 4) verbs are also high in Tier 3 target the need to anticipate the future needs of customers, anticipate obstacles to project completion, anticipate problems, and discover new ways to add value to the team and organization, and anticipate and prevent work-related injuries. Workplace Competencies, which had the second highest number of high-level verbs in the AM Competency Model is likely to be conducive to experiential learning, given that these competencies may be difficult to simulate in a classroom environment.

Tier 4 includes Industry-Wide Competencies has the second highest number of Create verbs, but most likely the first [i.e., given the number unscored topics (284) from this category]. Tier 4 competencies focus on the manufacturing process, design, and development, and the continuous improvement of the AM process to ensure products meet customer needs. Verbs used most frequently are design, create, and develop (Create, Level 6) with topics involving production of support systems, developing corrective actions, delivery schedules and supplier networks, and control systems. This was undoubtedly the Tier with the most incomplete competencies, which likely has the greatest applicability to the AM workforce and experiential learning potential for students.

5.3. Next Steps

Competencies are the basis from which curricula are built, and without appropriate classification of topics and levels, assessment of programs and extension to types of learning are difficult. A holistic document, such as a Body of Knowledge, which incorporates the views of the AM educators, practitioners, policymakers, with the assistance of an HR or curriculum specialist, may be valuable. If only the perspective of employers is desired, then creation of a more comprehensive document is an important future undertaking.

Collection of data for AM competency development that is based on employer needs should be done using multiple methods such as interviews, surveys, and sorting exercises, with competencies that are measureable and developed at the appropriate student learning level for entry-level technicians versus advanced technicians. Competency development teams should also use action verbs for the discipline, but exclude words that have multiple meanings such as "use." Instead, verbs like build, develop, and create are more appropriate, since the word "use" also is synonymous with both "apply" and "create," which are level 3 and 6 verbs, respectively.

Despite some of the challenges with these data, alignment of experiential learning opportunities with competencies to produce formalized "contracts" with performance metrics that can be shared and integrated as part of college-industry relationships is an important finding of this study. Additional research on how to formalize industry relationships based on experiential learning programs, and what the formalization of learning in the AM industry might look like for educators, industry representatives, and especially students, is needed. Additional research on assessment and evaluation of student learning outcomes in these programs is also warranted.

Conclusion

In this study, we explored high-level competencies using the Bloom's Taxonomy in the DOL AM Competency Model and employer interviews. We made an assumption that experiential learning could complement or supplement formal classroom instruction when higher-level competence (i.e., to analyze, evaluate, and create) is sought. Employers, in particular, could begin to identify aspects of various technician jobs that would be conducive to apprenticeships, internships, and other experiential learning opportunities. Findings revealed that college-industry partnerships can be best aligned if there is a core document that reflects competencies that are both comprehensive and measurable. Experiential learning, if it is to be part of a formalized process, will only be valuable if students have a clear sense of what they should learn during the experience and how proficient they should be at the conclusion of the experience.

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APPENDIX

Advanced Manufacturing Competency Model

Code	Content	Green	Orange	Yellow
		Level 4	Level 5	Level 6
		Analyze	Evaluate	Create
		24.0	21.0	30.0
1	**Tier 1: Personal Effectiveness Competencies**			
1.1.3.2	Accurately interpret and respond to the verbal and nonverbal behavior of others.		1.0	
1.6	**Adaptability and Flexibility: Displaying the capability to adapt to new, different or changing requirements.**			1.0
1.6.2.2	Adapt plans, goals, actions, or priorities in response to unpredictable or unexpected events, pressures, situations, and job demands.			1.0
1.7.1.2	Seek feedback and modify behavior for improvement.			1.0
1.7.1.3	Modify behavior based on feedback, self-analysis, or past mistakes.			1.0
1.7.3.1	Anticipate changes in work demands and actively search for and participate in assignments or training to support changing demands.	1.0		
2	**Tier 2: Academic Competencies**			
2.1.1.4	Infer or locate meaning of unknown or technical vocabulary.	1.0		
2.1.2.2	Detect inconsistencies.	1.0		
2.1.4.1	Critically evaluate and analyze information in written materials.	1.0	1.0	
2.1.4.3	Distinguish fact from opinion.	1.0		
2.2.1.1	Create documents such as letters, directions, manuals, reports, graphs, and flow charts.			1.0
2.3	**Mathematics: Using principles of mathematics such as algebra, geometry, and trigonometry to solve problems.**			1.0
2.3.2.1	Add, subtract, multiply, and divide with whole numbers, fractions, decimals, and percents.	1.0		
2.3.3	**Measurement and estimation**		1.0	
2.3.3.1	Take measurements of time, temperature, distances, length, width, height, perimeter, area, volume, weight, velocity, and speed.		1.0	
2.3.3.2	Use and report measurements correctly.		1.0	
2.3.3.3	Correctly convert from one measurement to another (e.g., from English to metric to International System of Units [SI], or Fahrenheit to Celsius).		1.0	

2.4.3.3	Evaluate scientific constructs including conclusions, conflicting data, controls, data, inferences, limitations, questions, sources or errors, and variables.	1.0	1.0	
2.6	**Critical and Analytical Thinking: Using logical thought processes to analyze information and draw conclusions.**	2.0		
2.6.1.1	Use logic and reasoning to identify strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.	1.0		
2.6.1.3	Critically review, analyze, synthesize, compare, and interpret information.	2.0	2.0	
2.6.1.4	Draw conclusions from relevant or missing information.	1.0		
2.7.2.1	Use word processing software to compose, organize, edit, and print documents and other business communications.			1.0
2.7.2.3	Use presentation software to create, manipulate, edit and present digital representations of information to an audience.			1.0
2.7.2.5	Create and maintain a well-organized electronic file storage system.			1.0
3	**Tier 3: Workplace Competencies**			
3.1.3.2	Discern who the company's primary competitors are and stay current on organizational strategies to maintain competitiveness.	1.0		
3.2.2.1	Develop constructive and cooperative working relationships with others.			1.0
3.3.1.3	Anticipate the future needs of the customer.	1.0		
3.4	**Scheduling and Coordinating: Planning and prioritizing work to manage time effectively and accomplish assigned tasks as efficiently as possible.**		1.0	1.0
3.4.1.2	Plan and schedule tasks so that work is completed on time.			1.0
3.4.2.1	Prioritize various competing tasks.		1.0	
3.4.2.3	Find new ways of organizing work area or planning work to accomplish work more efficiently.			1.0
3.4.3.1	Estimate resources needed for project completion.		1.0	
3.4.4.1	Anticipate obstacles to project completion.	1.0		
3.4.4.2	Develop contingency plans to address identified obstacles.			1.0
3.5	**Creative Thinking and Problem Solving: Applying creative-thinking skills to solve problems by generating, evaluating, and implementing solutions.**		1.0	1.0
3.5.1.1	Anticipate or detect the existence of a problem.	2.0		
3.5.1.3	Evaluate the importance and criticality of the problem.		1.0	
3.5.1.6	Use the most advanced software and tools available to analyze root cause of the problem.	1.0		
3.5.2.1	Appreciate the pieces of a system as a whole and assess the consequences of actions on other parts of the system.		1.0	
3.5.2.3	Modify or design systems to improve performance.			1.0

3.5.3.4	Discover new ways to add value to the efforts of a team and organization.	1.0		
3.5.4.1	Evaluate the relative merits of each possible solution and decisively choose the best option.		1.0	
3.5.5.5	Observe and evaluate the outcomes of implementing the solution to assess the need for alternative approaches and identify the lessons learned.		1.0	
3.6.1.4	Compile, categorize, and verify information for data.	1.0		1.0
3.6.2.1	Detect and correct errors or inconsistencies, even under time pressure.	1.0		
3.7.3.2	Adapt quickly to changes in process or technology.			1.0
3.7.4.1	Develop alternatives to complete a task if desired tool or technology is not available.			1.0
3.8.1.2	Anticipate and prevent work-related injuries and illnesses.	1.0		
3.9.1.1	Use equipment, processes, and systems that minimize waste, improve efficiency, and reduce resource use (e.g., reuse and recycle).			1.0
3.9.1.4	Suggest and/or implement continuous improvement actions.		1.0	
4	**Tier 4: Industry-Wide Technical Competencies**			
4.1	**Manufacturing Process Design/Development: Research design, implement, and continuously improve the manufacturing process to ensure product meets customer needs.**			1.0
4.1.1.2	Design production and production support systems.			1.0
4.1.1.3	Create and apply technology to control production and process functions.			1.0
4.1.1.4	Develop functional specifications for the design and development of control systems.			1.0
4.1.1.6	Interpret and clarify customer expectations and product specifications.		1.0	
4.1.2.1	Computer-aided design (CAD) drawing			1.0
4.2.1.6	Develop industrial production/process plans and documentation.			1.0
4.2.1.8	Monitor industrial processes and systems.		1.0	
4.3.2.7	Design and document equipment/system/process improvements			1.0
4.4.1.10	Develop and maintain production/delivery schedules and supplier networks.			1.0
4.4.5.4	Evaluating performance of operations		1.0	
4.5.1.7	Apply and analyze concepts associated with measuring quality.	1.0		
4.5.3.1	Statistical process control including run charts, control charts, a focus on continuous improvement, design of experiments, etc.			1.0
4.6.4.1	Developing corrective actions			1.0