Nocti Business Solutions®
Your Corporate Assessment Provider

Advanced Manufacturing Technical Education Collaborative (AMTEC)

Industry 4.0

DACUM and Delphi Report

Analysis Prepared By
Dr. Tina Koepf
Psychometrician
Nocti Business Solutions

February 2022

Contents

AMTEC Industry 4.0 Project Overview

Advanced Manufacturing Technical Education Collaborative's (AMTEC) mission is to create and sustain an innovative, responsive, and standards-based workforce development system that meets advanced manufacturing industries skill requirements. Furthermore, the vision is to be a recognized collaboration of colleges and companies working to strengthen the competency and global competitiveness of the advanced manufacturing workforce.

The goals include implementing industry-led, advanced curriculum and certificates to increase student exposure to critical-thinking and problem-solving skills; institutionalize the AMTEC Career Pathway model with current AMTEC colleges and their secondary school and industry partners; expand the AMTEC instructional and industry-led collaborative model for the partners to grow, sustain, and replicate within other industry sectors; and drive performance improvement through the use of performance measures that systematically align AMTEC organizational direction and resources.

Because Industry 4.0 standards have not been properly identified for manufacturing, AMTEC's initiative is to define the standards, driven by Business and Industry experts. AMTEC contracted with Nocti Business Solutions to complete a DACUM and Delphi Study in 2021. The results of these two projects will be used to determine the current industry-defined core skill standards for Industry 4.0.

Using the DACUM process, a team of Subject Matter Experts (SMEs) developed Industry 4.0 standards. Then, a larger group of industry and educational experts were asked to rate the standards via a Delphi platform. These standards and their corresponding ratings will be used when building Industry 4.0 curriculum and future assessments.

Part I – DACUM

Scope

The first core function for developing curriculum for an is to develop and validate occupational standards. The development of the occupational standards uses a process called DACUM.

DACUM is an acronym for Develop A CUrriculuM. DACUM is used widely today as a unique, innovative, and effective method of job, and/or occupational analysis. It is equally effective for conducting process and functional analyses. The DACUM analysis workshop involves a DACUM-trained facilitator and a committee of five to ten expert workers from the position, occupation, or other area of analysis identified by the client. The result is the development of a list of precise duty and task statements.

DACUM is based on three logical premises:

1. Expert workers can describe and define their job/occupation more accurately than anyone else. Persons who are working full-time in their positions are the real experts for that specific job. Although supervisors and managers have a significant understanding about their subordinates' work, they usually lack the expertise needed for a high-quality analysis.

2. An effective way to define a job/occupation is to precisely describe the tasks that expert workers perform. A successful worker performs a variety of tasks that either the customer or employer wants performed. Possessing positive attitudes and knowledge alone are not enough. Hence, finding out what the expert workers (top performers) do provides the opportunity to prepare other experts.

3. All tasks, in order to be performed correctly demand the use of certain knowledge, skills, tools, and positive worker behaviors. While the knowledge, skills, tools, and worker behaviors are not tasks, they are enablers which make it possible for the worker to be successful. Because these four enablers are so important, considerable attention is given during the DACUM workshop to identifying lists of each. Because these attributes are different and distinct from the tasks, it is very important to keep them separate if a high-quality analysis of job performance requirements is to be obtained.

DACUM has been used effectively to analyze occupations at the professional, managerial, technical, skilled, and semi-skilled levels. It has also been used effectively to conceptualize future jobs, and to analyze portions (selected duties) of a particular occupation. Recently, with the increasing emphasis on quality brought forth by the TQM (Total Quality Management), ISO 9000, and QS 9000 movements, DACUM also has been used widely as a basis or foundation for analyzing various industrial systems and processes.

The purpose of the systematic DACUM job and task analysis is to accurately establish baseline data to improve both the process and the product or service produced on the job through constant and continuous improvement.

- Group interaction - Committee members freely share ideas and hitchhike on each other's contributions.
- Brainstorming power - The brainstorming process is used several times to maximum advantage to identify all of the duties and tasks.
- Group synergy - Properly facilitated, members of the group motivate and empower each other to produce a high-quality product.
- Group consensus - Members of the committee, with the facilitator's guidance, assess each contribution and refine it until agreement is reached.
- Future oriented - The committee is specifically asked to specify future occupational trends and concerns that are likely to change their job in the future.
- Employee/Learner buy-in - Once the learners know that practicing expert workers identified the duties and tasks, support for the results of the analysis is greatly enhanced.
- Comprehensive outcome - When 5-12 expert workers are motivated and guided for two days by a qualified facilitator, all duties and tasks are usually identified along with the related general knowledge and skills, worker behaviors, tools and equipment, and future trends and concerns.
- Superior quality - It is the combination of the features already mentioned plus the fact that whenever one committee member speaks, the other (4 to 11) members who are well qualified to do so, assess and modify contributions so as to maximize quality.

When the DACUM committee creates a job-specific chart, the substantive involvement of the committee members usually results in very strong support and buy-in that cannot be obtained with any other job analysis methodology.

DACUM and Delphi Processes to Identify Occupational Standards

The occupational standards are identified by convening a representative group of workers in the occupation provided by A&J Training Trust Fund. The scope of the process is represented in the selection of the panel. The two-day Turbo-DACUM process includes the following three phases.

Step 1—The Job Analysis
The panel first brainstorms a list of job duty areas. These are main areas that pertain to Industry 4.0. These duties are added to a spreadsheet online for the participants to continue to add, delete, or edit as the process continues.

Step 2—The Task Analysis
The task analysis portion of the DACUM process is facilitated by entering details of each task as dictated by the panel directly into a computer system. Once the tasks have been verified, clustered, and sequenced by the panel.

The panel members verbally provide the facilitator with the steps necessary to accomplish the task including all rational physical and decision steps. All occupational standards or tasks require enabling content knowledge or skills to be effectively performed. Therefore, the DACUM process uses the SMEs to identify the following work enablers.

> Tools and Equipment: What types of tools and equipment are needed to perform this task and what skills do workers need to operate these tools and equipment?
>
> Calculations: What calculations are required to perform this task, and what math skills are required to perform these calculations?
>
> Communications: How much does the worker communicate with others to perform this task, and what communication skills are required to do so?
>
> Technology: What technology is needed to perform this task, and what technological skills must the worker have in order to do so?
>
> Safety: What safety practices are associated with performing this task and what knowledge of safety practices must the worker know in order to successfully accomplish this task?

Step 3—Duty Weighting and Task Rating
This phase of the DACUM process is used as the basis for developing a content-valid table of test specifications for the standards. After the data has been collected for each task and entered into the computer, the panelists are then asked to weight the duty categories on a 100% scale based on perceived importance of the duty. This information is important when mapping the DACUM into curriculum modules and courses.

DACUM Workshop

DACUM Web-based meetings were held on October 4th, 7th, 11th, 14th, and 28th, 2022 from 9:00 am to 11:00 am (EST). The workshop was facilitated by Dr. Tina Koepf of Nocti Business Solutions and included a panel of subject matter experts (SMEs) provided by AMTEC. These SMEs included: Amy Seymour – Interactive Training Systems, Inc., Eric Yoxtheimer – Boeing, Bob Taylor – Toyota, Maurice Salazar – Toyota, Jason Benadum – Toyotetsu, Bryan Lowery – Boeing, and Dave Brickles – Boeing. Also, Christina Rustik – Boeing, Jason Simon – Kentucky Community Technical College System, Vicki Boyd - Kentucky Community Technical College

System, and Tyler Ashton - Kentucky Community Technical College System supported the SME team.

DACUM Competencies

The full DACUM is located in Appendix A. The abbreviated competencies that were rated for the Delphi study are listed in Table 1.

Table 1

Competencies Rated in Delphi Study

AMTEC Industry 4.0 DACUM – Duty/Task List					
A					**Industry 4.0 Fundamentals**
	1				**Define additive manufacturing as it relates to Industry 4.0**
	2				**Describe how cybersecurity impacts Industry 4.0**
	3				**Identify extended reality's role in Industry 4.0**
	4				**Identify smart systems related to Industry 4.0**
	5				**Define advanced materials used in Industry 4.0**
	6				**Discuss the concept of proactive maintenance**
	7				**Discuss general safety issues related to Industry 4.0**
B					**Internet of Things (IoT) and Industrial Internet of Things (IIoT)**
	8				**Identify interconnectivity of IoT and IIoT**
	9				**Identify IIoT devices**
	10				**Identify IIoT media**
	11				**Discuss cybersecurity related to Industry 4.0**
	12				**Review safety precautions related to IoT and IIoT**
C					**Big Data and Analytics**
	13				**Explain the role of Big Data in Industry 4.0**
	14				**Identify smart system and components used in Industry 4.0**
	15				**Explain the use of Artificial Intelligence (AI)**
	16				**Explain the function of The Cloud**
	17				**Identify monitoring systems used in Industry 4.0**
	18				**Describe the use of digital twins in the production environment**
	19				**Describe and explain the utilization of Big Data**
	20				**Review safety related to Big Data**
D					**System Integration**
	21				**Discuss application of robotics in Industry 4.0**
	22				**Describe applications of autonomous and collaborative robots**

	23				**Review safety related to robot integration**
	24				**Discuss the usage of advanced HMI's**
	25				**Identify advanced PLCs**
	26				**Describe electrical control theory and circuits**
	27				**Describe the integration of process controls**
	28				**Discuss the application of Variable Frequency Drives (VFDs)**
	29				**Describe advanced fluid power systems**
	30				**Identify basic network concepts**
	31				**Review safety hazards related to networking**
E					**Predictive Maintenance**
	32				**Apply proactive mindset for equipment performance monitoring**
	33				**Review safety hazards related to predictive maintenance**
F					**Tracking Systems**
	34				**Identify the integration of intelligent tracking systems**
	35				**Review safety hazards related to tracking systems**
	35				**Review safety hazards related to tracking systems**

DACUM Competencies rated by SME Team

Four of the DACUM SME team members rated the competencies based on Frequency, Criticality, Learning/Difficulty, and Experience Level. *Note that this group of SMEs are not the same experts that rated the Delphi project*. Results are found in Table 2.

Table 2

DACUM ratings by SME Team

			Key			
			Y=Yearly	*1=Rarely needed*	*1=Easy*	*A=Senior/Expert*
			M=Monthly	*2=Need by department*	*2=Somewhat Difficult*	*B=Intermediate*
			W=Weekly	*3=Need in crew*	*3=Medium Difficulty*	*C=Entry Level*
			D=Daily	*4=Need by most*	*4=Difficult*	
		Rated Competencies for AMTEC Industry 4.0 by DACUM SME Team	*H=Hourly*	*5=Need by everyone*	*5=Very Difficult*	
A		**Industry 4.0 Fundamentals**	**Frequency**	**Criticality**	**Learning Difficulty**	**Level**
	1	Define additive manufacturing as it relates to Industry 4.0	Y	2	2	C
	2	Describe how cybersecurity impacts Industry 4.0	M	3	2	C
	3	Identify extended reality's role in Industry 4.0	Y	2	2	C
	4	Identify smart systems related to Industry 4.0	M	3	3	B
	5	Define advanced materials used in Industry 4.0	M	2	3	B
	6	Discuss the concept of proactive maintenance	M	4	3	B
	7	Discuss general safety issues related to Industry 4.0	W	4	2	B

B		Internet of Things and Industry Internet of Things (IoT and IIoT)	Frequency	Criticality	Learning Difficulty	Level
	8	Identify interconnectivity of IoT and IIoT	M	3	3	B
	9	Identify IIoT devices	M	4	3	B
	10	Identify IIoT media	M	3	3	C
	11	Discuss cybersecurity related to Industry 4.0	M	3	3	C
	12	Review safety precautions related to IoT and IIoT	D	3	2	C
C		**Big Data and Analytics**	**Frequency**	**Criticality**	**Learning Difficulty**	**Level**
	13	Explain the role of Big Data in Industry 4.0	Y	3	3	B
	14	Identify smart systems and components used in Industry 4.0	W	4	3	B
	15	Explain the use of Artificial Intelligence (AI)	Y	2	3	B
	16	Explain the function of The Cloud	M	3	2	B
	17	Identify monitoring systems used in Industry 4.0	W	3	2	B
	18	Describe the use of digital twins in the production environment	Y	2	2	C
	19	Describe and explain the utilization of Big Data	M	3	2	B
	20	Review safety related to Big Data	M	3	2	B

D		System Integration	Frequency	Criticality	Learning Difficulty	Level
	21	Discuss application of robotics in Industry 4.0	M	4	3	B
	22	Describe applications of autonomous and collaborative robots	W	4	3	B
	23	Review safety related to robot integration	H	5	3	B
	24	Discuss the usage of advanced HMI's	Y	4	3	A
	25	Identify advanced PLCs	W	4	3	A
	26	Describe electrical control theory and circuits	W	4	3	B
	27	Describe the integration of process controls	W	4	3	B
	28	Discuss the application of Variable Frequency Drives (VFDs)	W	4	3	B
	29	Describe advanced fluid power systems	W	3	3	B
	30	Identify basic network concepts	M	4	3	B
	31	Review safety hazards related to networking	W	4	3	B
E		**Predictive Maintenance**	**Frequency**	**Criticality**	**Learning Difficulty**	**Level**
	32	Apply proactive mindset for equipment performance monitoring	H	3	3	B
	33	Review safety hazards related to predictive maintenance	D	4	3	B

F		Tracking Systems	Frequency	Criticality	Learning Difficulty	Level
	34	Identify the integration of intelligent tracking systems	Y	3	4	A
	35	Review safety hazards related to tracking systems	W	3	3	B

Part II - Delphi

Scope

Delphi Process

The Delphi method is a systematic, method in which panels of experts respond to a series of electronic questionnaires. Panelists are asked to rate the criticality of the Key Activities (duties) and Performance Indicators (tasks) for their industry sector and/or business. Oftentimes the first questionnaire in the series is designed to collect individual response ratings and then subsequent questionnaires enable the Delphi experts to refine their initial rates as they view the ratings of the other Delphi respondents through one or two additional Delphi rounds. Because no Delphi participants added comments to offer new content/standards to rate for Round 2, a second round of the Delphi was not needed.

The Delphi method overcomes the disadvantages of conventional committee actions as the process requires anonymity of the experts. The advantage of the Delphi method is that panel members can be geographically dispersed and demographically varied and yet responses can be statistically analyzed to identify critical and/or core curriculum. The Delphi method may also include educator's ratings of the duties and tasks in order to provide the comparative analysis of ratings by educators and industry representatives.

Delphi Participants and Schedule

In 2021, AMTEC identified a group of hand-selected experts to complete the Delphi Study. The names, organizations, and field of expertise of the recipients are shown in Table 3. 25 of the Delphi participants responded to the first round Delphi.

Participant Names and Job Titles

Table 3

Delphi Panel Names, Employers, and Job Titles

What is your first and last name?	What is the name of the company or school where you are employed?	What is your job title?
Butch Tincher	Somerset Community College	Assistant Professor
Chris Rustik	Boeing	Senior Skill Leader
Derek Albertson	ATC Automation	Machine Builder
Eric W. Haynes	Toyota Mfg Texas	Skilled Team Leader
Eugene Grant	BMW Manufacturing Co., LLC	Operational Lead
Gerald Sexton	Retired	Retired
J Craig McAtee	National Coalition of Advanced Technology Centers (NCATC)	CEO & Executive Director
James Berry	Central New Mexico Community C	Instructor
Jason	Benadum	Assistant Manager Training and Development
Jason Simon	AMTEC	Director
Jeff Hunt	Spartanburg Community College	Dean of Technologies
Jeff Schmitz	Whirlpool	Maintenance Engineer
John Bishop	Ford, KTP	Maintenance Electrician
John Davis	Boeing	Manager
John Huthcinson	Toyota	Specialist
Nick Brunney	Boeing	Maintenance Manager
Nick Tomlinson	Somerset Community College - KCTCS	Professor, Program Coordinator of Industrial Maintenance Technology
Phil Baughman	DCC	Apprentice Coordinator
Richard Ozuna	St, Philip's College	F/T Faculty
Robert White	Everett community college	Instructor
Sidney Mosley	Lansing Community College	Professor
Steve Kidd	Cimtech	CEO retired
Tim White	Boeing	Facilities Manager
Tyler Ashton	OCTC	Dir. External Education
Wayne Ellington	Nissan	Maintenance Supervisor

SME Comments

The Delphi panel had the opportunity to add standards or make comments on the competency list. The comments are shown in Table 4.

Table 4
Delphi Panel Comments

Name	Duty Sequence ID	Duty Name	Comment
John Bishop	1	Industry 4.0 Fundamentals	I'm not familiar with the standard
Eric Haynes	1	Industry 4.0 Fundamentals	Vision systems are critical in today's industry
Butch Tincher	3	Big Data and Analytics	The level of importance of most of these topics will depend on if we are talking technician, engineer, or planner. Also, much will be specific to a certain sector or equipment, also much will be proprietary and learned on the job.

Demographic Questions and Profile

What is your gender?

A. **4%(N=1)** Female
B. **96% (N=24)** Male
C. Non-binary
D. Another gender
E. Prefer not to respond

Which ethnic category best describes you?

A. **92% (N=23)** White
B. **4%(N=1)** Hispanic or Latino
C. **4%(N=1)** Black or African American
D. Native Hawaiian or Other Pacific Islander
E. Asian
F. American Indian or Alaska Native
G. Two or more races

Which age group best describes you?

A. 18 or under
B. **8%(N=2)** 19-30 years old
C. 31-40 years old
D. **24% (N=6)** 41-50 years old
E. **36% (N=9)** 51-60 years old
F. **32% (N=8)** 61 years old or more

Which best describes your highest level of education?

A. High school diploma
B. **16% (N=4)** High school diploma plus several years of college or specialized training
C. **28% (N=7)** Associate degree
D. **20% (N=5)** Bachelor's degree
E. **36% (N=9)** Master's degree
F. Doctorate

How many years have you spent working for pay performing Manufacturing responsibilities?

A. Less than 1 year
B. **4%(N=1)** 1 to 4 years
C. **16%(N=4)** 5 to 9 years
D. **8% (N=2)** 10 to 14 years
E. **12%(N=3)** 15 to 20 years
F. **60%(N=15)** 21 or more years

How many years have you spent working for pay performing Industry 4.0 responsibilities?

A. **28%(N=7)** Less than 1 year
B. **12%(N=3)** 1 to 4 years
C. **20%(N=5)** 5 to 9 years
D. **12%(N=3)** 10 to 14 years
E. **4%(N=1)** 15 to 20 years
F. **24%(N=6)** 21 or more years

Did you receive any of your training related to Industry 4.0 at (choose all that apply)?

A. A trade school/career technical center?
B. A comprehensive high school?
C. Through Military (MOS) training?
D. An apprenticeship/on-the-job training?
E. An external/specialized training program(s)?
F. A community/junior/technical college?
G. A 4-year college/university?

(N=1) 4-year college/university
(N=1) 4-year college/university, Apprenticeship/on-the-job training
(N=1) 4-year college/university, Apprenticeship/on-the-job training, Community/junior/technical college, Military (MOS) training
(N=1) 4-year college/university, Apprenticeship/on-the-job training, External/specialized training program(s)
(N=2) 4-year college/university, Community/junior/technical college, External/specialized training program(s)
(N=1) Apprenticeship/on-the-job training, Community/junior/technical college
(N=1) Apprenticeship/on-the-job training, Community/junior/technical college, External/specialized training program(s), Military (MOS) training, Trade school/career technical center
(N=1) Apprenticeship/on-the-job training, Community/junior/technical college, External/specialized training program(s), Trade school/career technical center
(N=1) Apprenticeship/on-the-job training, Community/junior/technical college, Trade school/career technical center
(N=1) Apprenticeship/on-the-job training, Trade school/career technical center
(N=4) Community/junior/technical college
(N=1) Community/junior/technical college, External/specialized training program(s)
(N=5) External/specialized training program(s)
(N=1) Military (MOS) training

Are you employed in Education or Business and Industry?

A. **40%(N=10)** Education

B. **56%(N=14)** Business and Industry

Competencies Rated by Panel

Table 5 contains the competencies that were rated by the Delphi Panel.

Table 5
Industry 4.0 Competencies Rated by Delphi Panel

A		**Industry 4.0 Fundamentals**
	1	**Define additive manufacturing as it relates to Industry 4.0**
	2	**Describe how cybersecurity impacts Industry 4.0**
	3	**Identify extended reality's role in Industry 4.0**
	4	**Identify smart systems related to Industry 4.0**
	5	**Define advanced materials used in Industry 4.0**
	6	**Discuss the concept of proactive maintenance**
	7	**Discuss general safety issues related to Industry 4.0**
B		**Internet of Things and Industry Internet of Things (IoT and IIoT)**
	8	**Identify interconnectivity of IoT and IIoT**
	9	**Identify IIoT devices**
	10	**Identify IIoT media**
	11	**Discuss cybersecurity related to Industry 4.0**
	12	**Review safety precautions related to IoT and IIoT**
C		**Big Data and Analytics**
	13	**Explain the role of Big Data in Industry 4.0**
	14	**Identify smart systems and components used in Industry 4.0**
	15	**Explain the use of Artificial Intelligence (AI)**
	16	**Explain the function of The Cloud**
	17	**Identify monitoring systems used in Industry 4.0**
	18	**Describe the use of digital twins in the production environment**
	19	**Describe and explain the utilization of Big Data**
	20	**Review safety related to Big Data**
D		**System Integration**
	21	**Discuss application of robotics in Industry 4.0**
	22	**Describe applications of autonomous and collaborative robots**
	23	**Review safety related to robot integration**
	24	**Discuss the usage of advanced HMI's**
	25	**Identify advanced PLCs**
	26	**Describe electrical control theory and circuits**
	27	**Describe the integration of process controls**

	28	Discuss the application of Variable Frequency Drives (VFDs)
	29	Describe advanced fluid power systems
	30	Identify basic network concepts
	31	Review safety hazards related to networking
E		Predictive Maintenance
	32	Apply proactive mindset for equipment performance monitoring
	33	Review safety hazards related to predictive maintenance
F		Tracking Systems
	34	Identify the integration of intelligent tracking systems
	35	Review safety hazards related to tracking systems

Delphi Rating Scale

Panelists were asked to rate the criticality of the duties and tasks for their industry sector and/or business using the rating scale shown in Table 6.

Table 6
Delphi Rating Scale

5	Essential	not having skill knowledge in this area will keep you from gaining employment in this occupation
4	Very Important	skill knowledge in this area WILL enhance employability in this occupation
3	Important	skill knowledge in this duty area MAY enhance employability in this occupation
2	General Importance	skill knowledge in this duty area will be learned on-the-job and would NOT affect employment in this occupation
1	Not Important	skill knowledge in this duty area is NOT important for employment in this occupation at all
0	No opinion/Not applicable	I have no opinion or do not wish to rate this task

Delphi Rating Summary

Appendix B contains results of the Delphi ratings for each Duty and Task area, as well as sorted by demographic categories. Table 6 contains the average rating summaries for each Duty area for the overall group as well as various demographic categories.

Table 6

Delphi Duty Rating Summary

Delphi Demographic Questions -- Rated Competencies for AMTEC Industry 4.0		A Industry 4.0 Fundamentals	B Internet of Things	C Big Data and Analytics	D System Integration	E Predictive Maintenance	F Tracking Systems
Overall Group Average	N=25	3.81	4.14	3.61	4.35	4.42	3.96
What is your gender?							
Female	N=1	3.00		3.57	5.00	5.00	3.00
Male	N=24	3.84	4.14	3.61	4.32	4.40	4.00
Which ethnic category best describes you?							
Black or African American	N=1	3.43	3.00	3.50	3.55	4.00	3.50
Hispanic or Latino	N=1	4.57	4.80	4.13	4.91	5.00	4.50
White	N=23	3.80	4.16	3.59	4.35	4.41	3.96
Which age group best describes you?							
19-30 years old	N=2	3.43	4.70	3.25	4.64	4.25	4.00
41-50 years old	N=6	3.60	3.57	2.94	3.95	4.17	3.33

51-60 years old	N=9	3.89	4.18	3.87	4.50	4.61	4.11
61 years old or more	N=8	4.04	4.43	3.98	4.39	4.44	4.25
Which best describes your highest level of education?							
High school diploma plus several years of college or specialized training	N=4	3.95	3.75	3.63	4.15	4.13	3.25
Associate degree	N=7	3.70	4.37	3.67	4.42	4.43	4.00
Bachelor's degree	N=5	3.80	4.44	3.71	4.54	4.60	4.40
Master's degree	N=9	3.86	3.98	3.52	4.26	4.44	4.00
How many years have you spent working for pay performing Manufacturing responsibilities?							
1 to 4 years	N=1	3.43	3.60	3.50	4.18	4.50	4.00
5 to 9 years	N=4	3.31	4.33	3.08	4.64	4.63	3.88
10 to 14 years	N=2	4.00	4.60	4.19	4.32	4.75	4.50
15 to 20 years	N=3	3.86	4.47	3.69	4.27	4.33	3.83
21 or more years	N=15	3.93	4.00	3.67	4.29	4.33	3.93
How many years have you spent working for pay performing Industry 4.0 responsibilities?							
Less than 1 year	N=7	3.74	3.77	3.62	4.31	4.57	3.93
1 to 4 years	N=3	3.33	3.87	3.00	4.12	4.17	3.33
5 to 9 years	N=5	3.97	4.48	3.89	4.40	4.40	4.30
10 to 14 years	N=3	4.24	4.53	4.04	4.61	4.67	4.50
15 to 20 years	N=1	3.86	4.00	3.75	5.00	5.00	5.00
21 or more years	N=6	3.78	4.20	3.38	4.20	4.17	3.58
Are you employed in Education or Business/Industry?							
Education	N=10	3.78	4.08	3.51	4.26	4.40	4.00
Business and Industry	N=14	3.84	4.20	3.71	4.41	4.39	3.93

Appendix A

Sorted DACUM (Duty, Duty/Task, Duty/Task/Sub Task)

AMTEC Industry 4.0 DACUM – Duty List

A					**Industry 4.0 Fundamentals**
B					**Internet of Things (IoT) and Industrial Internet of Things (IIoT)**
C					**Big Data and Analytics**
D					**System Integration**
E					**Predictive Maintenance**
F					**Tracking Systems**

AMTEC Industry 4.0 DACUM – Duty/Task List

A					**Industry 4.0 Fundamentals**
	1				**Define additive manufacturing as it relates to Industry 4.0**
	2				**Describe how cybersecurity impacts Industry 4.0**
	3				**Identify extended reality's role in Industry 4.0**
	4				**Identify smart systems related to Industry 4.0**
	5				**Define advanced materials used in Industry 4.0**
	6				**Discuss the concept of proactive maintenance**
	7				**Discuss general safety issues related to Industry 4.0**
B					**Internet of Things (IoT) and Industrial Internet of Things (IIoT)**
	8				**Identify interconnectivity of IoT and IIoT**
	9				**Identify IIoT devices**

	10				Identify IIoT media
	11				Discuss cybersecurity related to Industry 4.0
	12				Review safety precautions related to IoT and IIoT
C					Big Data and Analytics
	13				Explain the role of Big Data in Industry 4.0
	14				Identify smart system and components used in Industry 4.0
	15				Explain the use of Artificial Intelligence (AI)
	16				Explain the function of The Cloud
	17				Identify monitoring systems used in Industry 4.0
	18				Describe the use of digital twins in the production environment
	19				Describe and explain the utilization of Big Data
	20				Review safety related to Big Data
D					System Integration
	21				Discuss application of robotics in Industry 4.0
	22				Describe applications of autonomous and collaborative robots
	23				Review safety related to robot integration
	24				Discuss the usage of advanced HMI's
	25				Identify advanced PLCs
	26				Describe electrical control theory and circuits
	27				Describe the integration of process controls
	28				Discuss the application of Variable Frequency Drives (VFDs)
	29				Describe advanced fluid power systems
	30				Identify basic network concepts
	31				Review safety hazards related to networking
E					Predictive Maintenance
	32				Apply proactive mindset for equipment performance monitoring
	33				Review safety hazards related to predictive maintenance

F					**Tracking Systems**
	34				**Identify the integration of intelligent tracking systems**
	35				**Review safety hazards related to tracking systems**
	35				**Review safety hazards related to tracking systems**

AMTEC Industry 4.0 DACUM – Duty/Task/Sub-Task

A					**Industry 4.0 Fundamentals**
	1				**Define additive manufacturing as it relates to Industry 4.0**
		a			Discuss 3-D printing
		b			Identify examples of additive manufacturing
	2				**Describe how cybersecurity impacts Industry 4.0**
		a			Describe secure and unsecure networks
	3				**Identify extended reality's role in Industry 4.0**
		a			Describe the overview of extended reality (XR)
		b			Identify applications of extended reality
	4				**Identify smart systems related to Industry 4.0**
		a			Describe the integrated manufacturing system view
		b			Describe top floor to shop floor communications
	5				**Define advanced materials used in Industry 4.0**
		a			Discuss advanced material awareness
	6				**Discuss the concept of proactive maintenance**
		a			Describe the difference between preventative and reactive maintenance
	7				**Discuss general safety issues related to Industry 4.0**
		a			Identify a proactive mindset regarding safety with Industry 4.0

		b			Conduct job hazard/safety analysis
B					**Internet of Things (IoT) and Industrial Internet of Things (IIoT)**
	8				**Identify interconnectivity of IoT and IIoT**
		a			Discuss communications between integrated systems
	9				**Identify IIoT devices**
		a			Identify sensors
	10				**Identify IIoT media**
		a			Describe fiber
		b			Discuss ethernet
		c			WiFi
		d			Bluetooth
	11				**Discuss cybersecurity related to Industry 4.0**
		a			Describe cybersecurity fundamentals
		b			Describe cybersecurity applications
		c			Identify tools (software)
	12				**Review safety precautions related to IoT and IIoT**
		a			Identify hazards
C					**Big Data and Analytics**
	13				**Explain the role of Big Data in Industry 4.0**
	14				**Identify smart system and components used in Industry 4.0**
	15				**Explain the use of Artificial Intelligence (AI)**
	16				**Explain the function of The Cloud**
		a			Discuss storage
		b			Identify safety protocols
		c			Addressing
	17				**Identify monitoring systems used in Industry 4.0**

		a			Describe PLCs
		b			Data displays from smart data from central control room
	18				**Describe the use of digital twins in the production environment**
	19				**Describe and explain the utilization of Big Data**
		a			Predictive analytics and modeling
		b			Introduction to Key Performance Indicator (KPIs)
		c			Describe improving KPIs with Big Data
	20				**Review safety related to Big Data**
		a			Identify hazards
D					**System Integration**
	21				**Discuss application of robotics in Industry 4.0**
	22				**Describe applications of autonomous and collaborative robots**
		a			Describe system interconnectivity
		b			Discuss robotic programming
		c			Integrate equipment
		d			Robot elements (tooling or end effectors)
	23				**Review safety related to robot integration**
		a			Machine envelop awareness
		b			Describe photo eyes
		c			Describe light curtain function and components
	24				**Discuss the usage of advanced HMI's**
		a			Explain full interoperability
		b			Describe the application of HMI programming
		c			Identify HMI connectivity
		d			Describe the application of graphical editing
	25				**Identify advanced PLCs**
		a			Describe the setting configuration of PLCs

		b			Identify hardware platform
		c			Discuss advanced programming
	26				**Describe electrical control theory and circuits**
		a			Identify common control circuits and their applications
		b			Safely recognize high voltage circuits
		c			Identify feedback loop circuits
		d			Review electrical safety hazards
	27				**Describe the integration of process controls**
		a			Describe process control flow
		b			Discuss controllers
		c			Identify inputs
			--		*examples of sensors*
		d			Identify outputs
	28				**Discuss the application of Variable Frequency Drives (VFDs)**
		a			VFD application
	29				**Describe advanced fluid power systems**
		a			Read circuit diagrams and understand function of components in fluid power systems
		b			Determine function of fluid power integrated devices
		c			Specify and size components for fluid power systems
		d			Explain system functionality
		e			Describe various source function
		f			Review safety hazards related to fluid power
	30				**Identify basic network concepts**
		a			Layout network topology
		b			Describe protocols
			--		*device levels*

		c			Describe platform configuration
	31				**Review safety hazards related to networking**
		a			Identify hazards
E					**Predictive Maintenance**
	32				**Apply proactive mindset for equipment performance monitoring**
		a			Describe reactive vs. predictive maintenance
		b			Describe relevance of data and parameters to equipment reliability
	33				**Review safety hazards related to predictive maintenance**
		a			Identify hazards
F					**Tracking Systems**
	34				**Identify the integration of intelligent tracking systems**
		a			Identify tracking system components
		b			Digital Twins for Production system
	35				**Review safety hazards related to tracking systems**
		a			Identify hazards

Final DACUM Including Tools/Equipment, Calculations, Communications, Technology, and Safety

AMTEC Industry 4.0 DACUM

A					Industry 4.0 Fundamentals	Tools and Equipment	Calculations / Knowledge	Communications	Technology	Safety
	1				**Define additive manufacturing as it relates to Industry 4.0**					
		a			Discuss 3-D printing	3-D printers			CAD software	
			--		*regulations and process for prototyping*	computer				
		b			Identify examples of additive manufacturing					
			--		*deposit*					
			--		*material extrusion*					
			--		*material jetting*					
			--		*powder bed fusion*					
			--		*sheet lamination*					
			--		*vat polymerization*					
	2				**Describe how cybersecurity impacts Industry 4.0**					

		a			Describe secure and unsecure networks			cybersecurity training and compliance		cybersecurity precautions
	3				**Identify extended reality's role in Industry 4.0**					
		a			Describe the overview of extended reality (XR)	virtual reality (VR) glasses			digital library	cybersecurity precautions
			--		*virtual reality*					secure passwords
			--		*augmented reality*					
			--		*integrated reality*					
		b			Identify applications of extended reality					
			--		*location detection technology*					
			--		*video procedures/maintenance library*					
			--		*digital factory tour*					
			--		*product/process simulation*					
			--		*troubleshooting tool*					
	4				**Identify smart systems related to Industry 4.0**					

		a			Describe the integrated manufacturing system view		analyze production data	system integration communication	smart devices	
		b			Describe top floor to shop floor communications					
			--		*electrical mechanical devices*					
			--		*predictive to smart*					
			--		*data analysis*					
			--		*PLC for IIoT*					
			--		*I/O condition monitoring*					
			--		*advanced networking and connectivity*					
	5				**Define advanced materials used in Industry 4.0**					
		a			Discuss advanced material awareness					
	6				**Discuss the concept of proactive maintenance**					
		a			Describe the difference between preventative and reactive maintenance		analyze machine and performance data		instruments	
			--		*smart instruments*					

			--		*data analysis*					
	7				**Discuss general safety issues related to Industry 4.0**					
		a			Identify a proactive mindset regarding safety with Industry 4.0					common safety practices
		b			Conduct job hazard/safety analysis					
			--		*hazards for connected machines and systems*					
			--		*hazards which cause loss of production and damage of machinery*					
			--		*hazards for human robot cooperation*					
			--		*security and security risks with Industry 4.0*					
			--		*security and privacy risks in artificial intelligence (AI)*					
			--		*energy Isolation*					
B					**Internet of Things (IoT) and Industrial Internet of Things (IIoT)**	**Tools and Equipment**	**Calculations/ Knowledge**	**Communications**	**Technology**	**Safety**
	8				**Identify interconnectivity of IoT and IIoT**					

		a			Discuss communications between integrated systems	PC		product documentation	network concepts	common safety practices
	9				**Identify IIoT devices**					
		a			Identify sensors	handheld scanner		product documentation		common safety practices
	10				**Identify IIoT media**					
		a			Describe fiber	special hand tools	basic math	product documentation	network concepts	common safety practices
		b			Discuss ethernet	crimpers				
		c			Wi-Fi					
		d			Bluetooth					
	11				**Discuss cybersecurity related to Industry 4.0**					
		a			Describe cybersecurity fundamentals	virus software	online searchability	product documentation	operating system knowledge	common safety practices
			--		*external components (flash drive)*	flash drive	computer aptitude		command line prompts	identify hazards with change point management

			--		*security*	computer	looking up resources			job hazard analysis process
		b			Describe cybersecurity applications					cybersecurity precautions
			--		*routing and firewall*					
			--		*address assignments in production networks*					
		c			Identify tools (software)					
			--		*IP Config*					
			--		*troubleshooting*					
	12				**Review safety precautions related to IoT and IIoT**					
		a			Identify hazards	virus software		product documentation	backup programs	common safety practices
						malware			cloud storage	
						backup software				

C					Big Data and Analytics	Tools and Equipment	Calculations/ Knowledge	Communications	Technology	Safety
	13				**Explain the role of Big Data in Industry 4.0**					
								visual tracking and updated KPIs and settings		
	14				**Identify smart system and components used in Industry 4.0**					
						smart plugs	Bluetooth	phone		identify hazards with change point management
						basic installation tools	Wi-Fi	computer		job hazard analysis process
						wiring tools				
						ethernet, Wi-Fi33, Bluetooth				
	15				**Explain the use of Artificial Intelligence (AI)**					

							basic programming		cybersecurity fundamentals	identify hazards with change point management
							system integration		networking	job hazard analysis process
							software			
							data analysis			
							intelligent processes			
							process control			
							autonomous decision making			
	16				**Explain the function of The Cloud**					
		a			Discuss storage		security issues	constraints of using proprietary cloud storage	cybersecurity fundamentals	safety process
		b			Identify safety protocols					identify hazards with change point management
		c			Addressing					job hazard analysis process

	17				**Identify monitoring systems used in Industry 4.0**					
		a			Describe PLCs					identify hazards with change point management
		b			Data displays from smart data from central control room					job hazard analysis process
	18				**Describe the use of digital twins in the production environment**					
						PLC/processor	basic math calculation	visual tracking and updated KPIs and settings	programming processor PLC, addressing, & basic networking	safety and security protocols
						network connections	digital thread			
						ethernet	digital model, design, virtual model			
							digital numbering systems			

	19				**Describe and explain the utilization of Big Data**					
		a			Predictive analytics and modeling	basic tools for installation of processor and sensing devices and alignment	Pull data	visual tracking and updated KPIs and settings	Excel software	identify hazards with change point management
			--		*preventative maintenance*	fault/data tracking equipment	spreadsheet skills		programming skills and parameter settings	job hazard analysis process
			--		*reactive maintenance*		basic math calculation		monitoring systems with storage capability	
		b			Introduction to Key Performance Indicator (KPIs)		proactive to reactive concepts			
			--		*KPI safety*		systems that capture the fault recording system			
			--		*quality*		tracking system downtime			
			--		*productivity*		OEE			
			--		*HRD*					
		c			Describe improving KPIs with Big Data					
	20				**Review safety related to Big Data**					

		a			Identify hazards					
D					**System Integration**	**Tools and Equipment**	**Calculations/ Knowledge**	**Communications**	**Technology**	**Safety**
	21				**Discuss application of robotics in Industry 4.0**					
								verbal communication with co-workers	understand integration points	identify hazards with change point management
										job hazard analysis process
	22				**Describe applications of autonomous and collaborative robots**					
		a			Describe system interconnectivity	common hand tools	mechanical knowledge	verbal communication with co-workers	network concepts	common safety practices
		b			Discuss robotic programming	computer	machine geometry	written documentation	understand language	electrical safety practices
			--		*inputs*	programming software		product documentation	device functionality	identify hazards with change point management

			--		*outputs*					job hazard analysis process
			--		*machine geometry*					
				---	*define axis*					
				---	*axis movement*					
		c			Integrate equipment					
		d			Robot elements (tooling or end effectors)					
			--		*camera vision systems*					
			--		*smart systems*					
	23				**Review safety related to robot integration**					
		a			Machines envelop awareness	common hand tools		written documentation	axis movement	common safety practices
		b			Describe photo eyes			product documentation	device alignment	identify hazards with change point management
		c			Describe light curtain function and components					job hazard analysis process

	24				**Discuss the usage of advanced HMI's**					
		a			Explain full interoperability	computer	symbology	written documentation	network concepts	identify hazards with change point management
			--		*customization of key factors (fault, number, condition)*	programming software		product documentation	available software	job hazard analysis process
			--		*types of programs and software*	editing software				common safety practices
		b			Describe the application of HMI programming					
			--		*functionability of how it is used*					
			--		*HMI as a troubleshooting tool*					
			--		*proper program to edit or create image for HMI*					
		c			Identify HMI connectivity					
			--		*various ways the controllers are connected to HMIs*					
			--		*capabilities of external monitoring*					

		d			Describe the application of graphical editing					
			--		*different graphical representations*					
	25				**Identify advanced PLCs**					
		a			Describe the setting configuration of PLCs	computer		network hub	PLC backups, restoration	identify hazards with change point management
			--		*Identify different configurations of integration*	computer programs		system communication		job hazard analysis process
		b			Identify hardware platform	installation tools		communicate how the systems fit together into the whole system		
			--		*system compatibility and restrictions*	cabling/wiring				
			--		*importance of module configuration of hardware*	meters (multi-meter)				
			--		*different types of networking*	ethernet				
			--		*proper wiring diagrams*	refer to network section				
				---	*wiring protocols*					
			--		*numbering systems*					

				---	*decimal, hexadecimal, binary*					
				---	*numbering system applications*					
		c			Discuss advanced programming					
			--		*types of data to transfer*					
				---	*sub-routine functions*					
			--		*storage areas for data*					
			--		*data manipulation*					
			--		*advanced data structures and their usage*					
	26				**Describe electrical control theory and circuits**					
		a			Identify common control circuits and their applications	multi-meter	Ohm's law	standard verbal communication with team		identify hazards with change point management
			--		*2-wire control*	megger Ohm Meter	basic math	written documentation		job hazard analysis process
			--		*3-wire control*	basic hand tools				electrical safety practices
		b			Safely recognize high voltage circuits					

			--		*configurations*					
		c			Identify feedback loop circuits					
			--		*inputs*					
				---	*positioning*					
				----	*encoders*					
				----	*scales*					
				----	*lasers*					
				---	*speed detection*					
				---	*environmental feedback*					
				----	*resistance temperature detector (RTD)*					
				----	*pressure*					
				----	*thermocouple*					
			--		*outputs*					
				---	*drive a motor*					
				---	*open a valve*					
				----	*solenoid*					
		d			Review electrical safety hazards					

			--		*stored energy*					
			--		*mechanical energy*					
			--		*gravity*					
					Identify appropriate PPE					
	27				**Describe the integration of process controls**					
		a			Describe process control flow	basic hand tools	programming PLCs, into larger system	communicate how systems work together		identify hazards with change point management
			--		*processes control concepts*	megger Ohm Meter				job hazard analysis process
				---	*steps used in the specific application*					electrical safety practices
				---	*workable tasks/set parameters*					
			--		*feedback system*					
			--		*proper adjustments*					
				---	*feedback from advanced controllers*					
				----	*temperature set points*					

				----	*fluid flow*					
				----	*current*					
			--		*how components work together*					
				---	*integration methods to control the process*					
		b			Discuss controllers					
			--		*PLC*					
				---	*addressing*					
				---	*logic - (advanced programming)*					
			--		*PID (Proportional Integral Derivative)*					
				---	*scaling*					
				---	*dip switches or programmable settings*					
				---	*wiring*					
		c			Identify inputs					
			--		*PID Controls*					
				---	*time*					
				---	*unit based*					
				---	*takt time*					

			--		*examples of sensors*					
				---	*humidity controls*					
				---	*laser sensors*					
				---	*position sensors*					
				---	*pressure sensors*					
				---	*thermocouples*					
				---	*tachometer*					
				---	*proximity switches*					
				---	*limit switches*					
				---	*torque sensors*					
			--		*vision systems*					
		d			Identify outputs					
			--		*examples of outputs*					
				---	*valves*					
				---	*heating elements*					
				---	*motors*					
				---	*indicator lights*					

	28				**Discuss the application of Variable Frequency Drives (VFDs)**					
		a			VFD application	basic hand tools	data input, output		AC	identify hazards with change point management
			--		*VFD integration with the system*	wires			Frequency	job hazard analysis process
				---	*VFD communication to control system*	connectors			VFD Parameters	electrical safety practices
			--		*load the VFD is driving*	multi-meter			braking	high voltage safety
				---	*how they relate to the motor they are controlling*	controllers			load	
			--		*inputs coming into the VFD*				electrical	
			--		*drive configuration*				feedback	
									wiring	
									input cards	

	29				**Describe advanced fluid power systems**					
		a			Read circuit diagrams and understand function of components in fluid power systems	crimper	basic math	make systems communicate		identify hazards with change point management
		b			Determine function of fluid power integrated devices	hoses	algebra	crimping		job hazard analysis process
			--		*device integration with the system*	precision measuring tools	torque, speed, power	troubleshooting pumps		electrical safety practices
				---	*PLCs*	pumps	calculate loads and systems	application of fluid power systems		promote safe working conditions with pressurized systems
				---	*HMIs*	valves	calculate pressure	Communicate troubleshooting problems with fluid power systems		fluid injection hazards
				---	*VFDs*	cylinders	geometry	wiring		stored energy
		c			Specify and size components for fluid power systems	filters	reference tables and charts			pressure control
			--		*valves*	reservoirs	interpret industry specifications			

			--		*advanced fluid power components*	accumulators				
			--		*manifolds*					
				---	*intelligent manifolds*					
			--		*accumulators*					
		d			Explain system functionality					
			--		*load*					
			--		*test point readings*					
			--		*system parameters*					
		e			Describe various source function					
			--		*pump*					
					compressors					
		f			Review safety hazards related to fluid power					
			--		*stored energy*					
			--		*mechanical energy*					
			--		*gravity*					
			--		*safety circuit*					

	30				**Identify basic network concepts**					
		a			Layout network topology	network analysis tools	basic math	verbal with co-workers	basic electrical knowledge, computer knowledge (hardware/software)	identify hazards with change point management
			--		*network design*	punch tools, RJ45 related tools	ControlNet standards and parameters	written documentation	computer skills knowledge with networking hardware	job hazard analysis process
				---	*examples of network design*	software tools	DeviceNet standards and parameters			electrical safety practices
				--	*ring*	installation and cable-making tools	ProfiNet standards and parameters			ergonomic lifting concerns, electro-static discharge prevention
				--	*star*	specialized termination tools	ProfiBus standards and parameters			
				--	*token*	specialized ControlNet termination tools	Wi-Fi design constraints			
			--		*addressing scheme*	RJ45/M12 connection tools	organizational security concerns and mitigation			

		b			Describe protocols	specialized ProfiBus termination tools				
			--		*device levels*	common tools				
				---	*ethernet IP*					
				---	*Control Net*					
				---	*Device Net*					
				---	*ProfiNet*					
				---	*ProfiBus*					
				---	*Wi-Fi Ethernet IP*					
		c			Describe platform configuration					
			--		*hardware*					
			--		*wiring protocols*					
	31				**Review safety hazards related to networking**					
		a			Identify hazards					ergonomic lifting concerns
										electro-static discharge prevention

E					Predictive Maintenance	Tools and Equipment	Calculations/ Knowledge	Communications	Technology	Safety
	32				**Apply proactive mindset for equipment performance monitoring**					
		a			Describe reactive vs. predictive maintenance	Fault tracking equip and data bases.	Basic math calculation	visual tracking and updated KPIs and settings	monitoring systems with storage capabilities	identify hazards with change point management
			--		*cycle-based maintenance*	processors/PLC logic to track cycle time, cycles completed. Tracking MTBF historical data		visual tracking and updated targets and results		job hazard analysis process
		b			Describe relevance of data and parameters to equipment reliability	tracking systems for environmental conditions, cycle times, machine run time.				
			--		*conditioned-based monitoring*	basic tools for installation. Vibration analyzer and sensing devices.				
			--		*data collection*	basic tools for retrieving oil samples				

				---	*vibration analysis*	basic tools for installation current sensors or devices.				
				---	*thermography*					
				---	*oil collection/analysis*					
				---	*current readings*					
	33				**Review safety hazards related to predictive maintenance**					
		a			Identify hazards					
F					**Tracking Systems**	**Tools and Equipment**	**Calculations/ Knowledge**	**Communications**	**Technology**	**Safety**
	34				**Identify the integration of intelligent tracking systems**					
		a			Identify tracking system components	basic tools for installation of processor and devices	basic math calculation	updated KPIs and settings	Monitoring systems with storage capabilities	identify hazards with change point management
			--		*examples of tracking system components*	PLC/Processor ethernet	addressing	visual tracking	programming processor PLC	job hazard analysis process

				---	*processor/PLC*		parameter settings			safety and security protocols
				---	*RFID tags*		basic networking			
				---	*Bar Code Scanner*		digital numbering systems (binary, hexadecimal)			
				---	*QR Codes*					
		b			Digital Twins for Production system					
	35				**Review safety hazards related to tracking systems**					
		a			Identify hazards					

Appendix B

Delphi Ratings by Demographic Group

Gender

		What is your gender?		Female	Male
		Rated Competencies for AMTEC Industry 4.0	Group Average Rating (N=25)	N=1	N=24
A		**Industry 4.0 Fundamentals**			
	1	Define additive manufacturing as it relates to Industry 4.0	3.39	2.00	3.45
	2	Describe how cybersecurity impacts Industry 4.0	4.04		4.04
	3	Identify extended reality's role in Industry 4.0	3.00		3.00
	4	Identify smart systems related to Industry 4.0	3.91		3.91
	5	Define advanced materials used in Industry 4.0	3.36	1.00	3.48
	6	Discuss the concept of proactive maintenance	4.46	4.00	4.48
	7	Discuss general safety issues related to Industry 4.0	4.54	5.00	4.52
		Domain Average Mean	3.81	3.00	3.84
B		**Internet of Things and Industry Internet of Things (IoT and IIoT)**			
	8	Identify interconnectivity of IoT and IIoT	4.04		4.04
	9	Identify IIoT devices	4.13		4.13
	10	Identify IIoT media	3.83		3.83
	11	Discuss cybersecurity related to Industry 4.0	4.39		4.39
	12	Review safety precautions related to IoT and IIoT	4.30		4.30
		Domain Average Mean	4.14		4.14
C		**Big Data and Analytics**			
	13	Explain the role of Big Data in Industry 4.0	3.43	3.00	3.45
	14	Identify smart systems and components used in Industry 4.0	3.96	3.00	4.00

	15	Explain the use of Artificial Intelligence (AI)	3.39	3.00	3.41
	16	Explain the function of The Cloud	3.50		3.50
	17	Identify monitoring systems used in Industry 4.0	4.13	5.00	4.09
	18	Describe the use of digital twins in the production environment	3.14	3.00	3.14
	19	Describe and explain the utilization of Big Data	3.57	3.00	3.59
	20	Review safety related to Big Data	3.78	5.00	3.73
		Domain Average Mean	3.61	3.57	3.61
D		**System Integration**			
	21	Discuss application of robotics in Industry 4.0	4.44	5.00	4.42
	22	Describe applications of autonomous and collaborative robots	4.36	5.00	4.33
	23	Review safety related to robot integration	4.52	5.00	4.50
	24	Discuss the usage of advanced HMI's	4.17	5.00	4.13
	25	Identify advanced PLCs	4.32	5.00	4.29
	26	Describe electrical control theory and circuits	4.36	5.00	4.33
	27	Describe the integration of process controls	4.40	5.00	4.38
	28	Discuss the application of Variable Frequency Drives (VFDs)	4.40	5.00	4.35
	29	Describe advanced fluid power systems	4.20	5.00	4.17
	30	Identify basic network concepts	4.24	5.00	4.21
	31	Review safety hazards related to networking	4.40	5.00	4.38
		Domain Average Mean	4.35	5.00	4.32
E		**Predictive Maintenance**			
	32	Apply proactive mindset for equipment performance monitoring	4.36	5.00	4.33
	33	Review safety hazards related to predictive maintenance	4.48	5.00	4.46
		Domain Average Mean	4.42	5.00	4.40
F		**Tracking Systems**			
	34	Identify the integration of intelligent tracking systems	3.88	3.00	3.92
	35	Review safety hazards related to tracking systems	4.04	3.00	4.08

		Domain Average Mean	3.96	3.00	4.00

Ethnicity

		Which ethnic category best describes you?		Black or African American	Hispanic or Latino	White
		Rated Competencies for AMTEC Industry 4.0	Group Average Rating (N=25)	N=1	N=1	N=23
A		**Industry 4.0 Fundamentals**				
	1	Define additive manufacturing as it relates to Industry 4.0	3.39	3.00	5.00	3.33
	2	Describe how cybersecurity impacts Industry 4.0	4.04	4.00	4.00	4.05
	3	Identify extended reality's role in Industry 4.0	3.00	2.00	4.00	3.00
	4	Identify smart systems related to Industry 4.0	3.91	4.00	5.00	3.85
	5	Define advanced materials used in Industry 4.0	3.36	2.00	4.00	3.40
	6	Discuss the concept of proactive maintenance	4.46	5.00	5.00	4.41
	7	Discuss general safety issues related to Industry 4.0	4.54	4.00	5.00	4.55
		Domain Average Mean	3.81	3.43	4.57	3.80
B		**Internet of Things and Industry Internet of Things (IoT and IIoT)**				
	8	Identify interconnectivity of IoT and IIoT	4.04	3.00	4.00	4.10
	9	Identify IIoT devices	4.13	3.00	5.00	4.14
	10	Identify IIoT media	3.83	3.00	5.00	3.81
	11	Discuss cybersecurity related to Industry 4.0	4.39	3.00	5.00	4.43
	12	Review safety precautions related to IoT and IIoT	4.30	3.00	5.00	4.33
		Domain Average Mean	4.14	3.00	4.80	4.16
C		**Big Data and Analytics**				

	13	Explain the role of Big Data in Industry 4.0	3.43	3.00	4.00	3.43
	14	Identify smart systems and components used in Industry 4.0	3.96	4.00	4.00	3.95
	15	Explain the use of Artificial Intelligence (AI)	3.39	4.00	5.00	3.29
	16	Explain the function of The Cloud	3.50	4.00	4.00	3.45
	17	Identify monitoring systems used in Industry 4.0	4.13	4.00	4.00	4.14
	18	Describe the use of digital twins in the production environment	3.14	3.00	4.00	3.10
	19	Describe and explain the utilization of Big Data	3.57	3.00	4.00	3.57
	20	Review safety related to Big Data	3.78	3.00	4.00	3.81
		Domain Average Mean	3.61	3.50	4.13	3.59
D		**System Integration**				
	21	Discuss application of robotics in Industry 4.0	4.44	4.00	5.00	4.43
	22	Describe applications of autonomous and collaborative robots	4.36	4.00	4.00	4.39
	23	Review safety related to robot integration	4.52	4.00	5.00	4.52
	24	Discuss the usage of advanced HMI's	4.17	4.00	5.00	4.14
	25	Identify advanced PLCs	4.32	4.00	5.00	4.30
	26	Describe electrical control theory and circuits	4.36	3.00	5.00	4.39
	27	Describe the integration of process controls	4.40	3.00	5.00	4.43
	28	Discuss the application of Variable Frequency Drives (VFDs)	4.40	3.00	5.00	4.41
	29	Describe advanced fluid power systems	4.20	3.00	5.00	4.22
	30	Identify basic network concepts	4.24	3.00	5.00	4.26
	31	Review safety hazards related to networking	4.40	4.00	5.00	4.39
		Domain Average Mean	4.35	3.55	4.91	4.35
E		**Predictive Maintenance**				
	32	Apply proactive mindset for equipment performance monitoring	4.36	4.00	5.00	4.35
	33	Review safety hazards related to predictive maintenance	4.48	4.00	5.00	4.48
		Domain Average Mean	4.42	4.00	5.00	4.41

F		**Tracking Systems**				
	34	Identify the integration of intelligent tracking systems	3.88	3.00	4.00	3.91
	35	Review safety hazards related to tracking systems	4.04	4.00	5.00	4.00
		Domain Average Mean	3.96	3.50	4.50	3.96

Age

		Which age group best describes you?		19-30 years old	41-50 years old	51-60 years old	61 +years old
		Rated Competencies for AMTEC Industry 4.0	Group Average Rating (N=25)	N=2	N=6	N=9	N=8
A		**Industry 4.0 Fundamentals**					
	1	Define additive manufacturing as it relates to Industry 4.0	3.39	2.50	3.00	3.50	3.86
	2	Describe how cybersecurity impacts Industry 4.0	4.04	4.00	3.67	4.13	4.29
	3	Identify extended reality's role in Industry 4.0	3.00	1.50	2.50	3.57	3.29
	4	Identify smart systems related to Industry 4.0	3.91	3.00	3.83	4.14	4.00
	5	Define advanced materials used in Industry 4.0	3.36	3.50	3.20	3.13	3.71
	6	Discuss the concept of proactive maintenance	4.46	5.00	4.17	4.33	4.71
	7	Discuss general safety issues related to Industry 4.0	4.54	4.50	4.83	4.44	4.43
		Domain Average Mean	3.81	3.43	3.60	3.89	4.04
B		**Internet of Things and Industry Internet of Things (IoT and IIoT)**					
	8	Identify interconnectivity of IoT and IIoT	4.04	5.00	3.33	4.00	4.43
	9	Identify IIoT devices	4.13	5.00	3.33	4.13	4.57
	10	Identify IIoT media	3.83	4.00	3.17	4.00	4.14
	11	Discuss cybersecurity related to Industry 4.0	4.39	5.00	4.00	4.50	4.43

	12	Review safety precautions related to IoT and IIoT	4.30	4.50	4.00	4.25	4.57
		Domain Average Mean	4.14	4.70	3.57	4.18	4.43
C		**Big Data and Analytics**					
	13	Explain the role of Big Data in Industry 4.0	3.43	3.50	3.00	3.38	3.86
	14	Identify smart systems and components used in Industry 4.0	3.96	4.50	3.50	4.13	4.00
	15	Explain the use of Artificial Intelligence (AI)	3.39	3.00	2.33	3.88	3.86
	16	Explain the function of The Cloud	3.50	3.00	2.67	3.86	4.00
	17	Identify monitoring systems used in Industry 4.0	4.13	4.50	3.50	4.38	4.29
	18	Describe the use of digital twins in the production environment	3.14	2.00	2.20	3.50	3.71
	19	Describe and explain the utilization of Big Data	3.57	2.50	3.00	3.88	4.00
	20	Review safety related to Big Data	3.78	3.00	3.33	4.00	4.14
		Domain Average Mean	3.61	3.25	2.94	3.87	3.98
D		**System Integration**					
	21	Discuss application of robotics in Industry 4.0	4.44	5.00	4.00	4.44	4.63
	22	Describe applications of autonomous and collaborative robots	4.36	5.00	4.00	4.44	4.38
	23	Review safety related to robot integration	4.52	4.50	4.50	4.44	4.63
	24	Discuss the usage of advanced HMI's	4.17	4.00	3.33	4.50	4.50
	25	Identify advanced PLCs	4.32	5.00	4.00	4.33	4.38
	26	Describe electrical control theory and circuits	4.36	5.00	4.00	4.56	4.25
	27	Describe the integration of process controls	4.40	4.50	4.00	4.67	4.38
	28	Discuss the application of Variable Frequency Drives (VFDs)	4.40	4.50	4.17	4.67	4.14
	29	Describe advanced fluid power systems	4.20	4.00	4.00	4.56	4.00
	30	Identify basic network concepts	4.24	4.50	3.67	4.44	4.38
	31	Review safety hazards related to networking	4.40	5.00	3.83	4.44	4.63
		Domain Average Mean	4.35	4.64	3.95	4.50	4.39
E		**Predictive Maintenance**					
	32	Apply proactive mindset for equipment performance monitoring	4.36	4.00	4.17	4.56	4.38

	33	Review safety hazards related to predictive maintenance	4.48	4.50	4.17	4.67	4.50
		Domain Average Mean	4.42	4.25	4.17	4.61	4.44
F		**Tracking Systems**					
	34	Identify the integration of intelligent tracking systems	3.88	4.00	3.33	4.11	4.00
	35	Review safety hazards related to tracking systems	4.04	4.00	3.33	4.11	4.50
		Domain Average Mean	3.96	4.00	3.33	4.11	4.25

Education Level

		Which best describes your highest level of education?		HS + training	AAS degree	BS degree	MS degree
		Rated Competencies for AMTEC Industry 4.0	Group Average Rating (N=25)	N=4	N=7	N=5	N=9
A		**Industry 4.0 Fundamentals**					
	1	Define additive manufacturing as it relates to Industry 4.0	3.39	4.00	3.33	3.20	3.33
	2	Describe how cybersecurity impacts Industry 4.0	4.04	4.00	3.83	4.40	4.00
	3	Identify extended reality's role in Industry 4.0	3.00	3.00	2.67	2.80	3.38
	4	Identify smart systems related to Industry 4.0	3.91	4.00	3.67	3.60	4.25
	5	Define advanced materials used in Industry 4.0	3.36	3.67	3.33	3.40	3.25
	6	Discuss the concept of proactive maintenance	4.46	4.50	4.83	4.60	4.11
	7	Discuss general safety issues related to Industry 4.0	4.54	4.50	4.20	4.60	4.70
		Domain Average Mean	3.81	3.95	3.70	3.80	3.86
B		**Internet of Things and Industry Internet of Things (IoT and IIoT)**					
	8	Identify interconnectivity of IoT and IIoT	4.04	3.50	4.33	4.60	3.75

	9	Identify IIoT devices	4.13	3.50	4.50	4.40	4.00
	10	Identify IIoT media	3.83	3.50	4.00	4.20	3.63
	11	Discuss cybersecurity related to Industry 4.0	4.39	4.50	4.50	4.40	4.25
	12	Review safety precautions related to IoT and IIoT	4.30	3.75	4.50	4.60	4.25
		Domain Average Mean	4.14	3.75	4.37	4.44	3.98
C		**Big Data and Analytics**					
	13	Explain the role of Big Data in Industry 4.0	3.43	3.33	3.50	3.60	3.33
	14	Identify smart systems and components used in Industry 4.0	3.96	4.00	4.17	3.80	3.89
	15	Explain the use of Artificial Intelligence (AI)	3.39	3.67	3.67	3.00	3.33
	16	Explain the function of The Cloud	3.50	3.67	3.67	3.40	3.38
	17	Identify monitoring systems used in Industry 4.0	4.13	4.33	4.33	4.60	3.67
	18	Describe the use of digital twins in the production environment	3.14	2.67	3.00	3.50	3.22
	19	Describe and explain the utilization of Big Data	3.57	3.67	3.33	3.80	3.56
	20	Review safety related to Big Data	3.78	3.67	3.67	4.00	3.78
		Domain Average Mean	3.61	3.63	3.67	3.71	3.52
D		**System Integration**					
	21	Discuss application of robotics in Industry 4.0	4.44	4.25	4.57	4.60	4.33
	22	Describe applications of autonomous and collaborative robots	4.36	4.25	4.29	4.60	4.33
	23	Review safety related to robot integration	4.52	4.75	4.43	4.80	4.33
	24	Discuss the usage of advanced HMI’s	4.17	3.67	4.14	4.40	4.22
	25	Identify advanced PLCs	4.32	4.25	4.43	4.40	4.22
	26	Describe electrical control theory and circuits	4.36	4.00	4.57	4.60	4.22
	27	Describe the integration of process controls	4.40	4.00	4.43	4.60	4.44
	28	Discuss the application of Variable Frequency Drives (VFDs)	4.40	4.50	4.43	4.50	4.22
	29	Describe advanced fluid power systems	4.20	4.25	4.14	4.00	4.33
	30	Identify basic network concepts	4.24	4.00	4.43	4.80	3.89
	31	Review safety hazards related to networking	4.40	3.75	4.71	4.60	4.33

		Domain Average Mean	4.35	4.15	4.42	4.54	4.26
E		**Predictive Maintenance**					
	32	Apply proactive mindset for equipment performance monitoring	4.36	4.25	4.29	4.60	4.33
	33	Review safety hazards related to predictive maintenance	4.48	4.00	4.57	4.60	4.56
		Domain Average Mean	4.42	4.13	4.43	4.60	4.44
F		**Tracking Systems**					
	34	Identify the integration of intelligent tracking systems	3.88	3.25	3.71	4.40	4.00
	35	Review safety hazards related to tracking systems	4.04	3.25	4.29	4.40	4.00
		Domain Average Mean	3.96	3.25	4.00	4.40	4.00

Years Worked in Manufacturing

		How many years have you spent working for pay performing Manufacturing responsibilities?		1 - 4 years	5 -9 years	10 - 14 years	15 - 20 years	21 + years
		Rated Competencies for AMTEC Industry 4.0	Group Average Rating (N=25)	N=1	N=4	N=2	N=3	N=15
A		**Industry 4.0 Fundamentals**						
	1	Define additive manufacturing as it relates to Industry 4.0	3.39	4.00	2.25	4.00	3.00	3.69
	2	Describe how cybersecurity impacts Industry 4.0	4.04	3.00	4.00	4.00	4.33	4.07
	3	Identify extended reality's role in Industry 4.0	3.00	3.00	1.33	4.50	3.33	3.08
	4	Identify smart systems related to Industry 4.0	3.91	3.00	3.67	4.50	4.00	3.92
	5	Define advanced materials used in Industry 4.0	3.36	3.00	2.67	3.50	3.33	3.54
	6	Discuss the concept of proactive maintenance	4.46	3.00	4.50	4.00	4.33	4.64
	7	Discuss general safety issues related to Industry 4.0	4.54	5.00	4.75	3.50	4.67	4.57
		Domain Average Mean	3.81	3.43	3.31	4.00	3.86	3.93

B		**Internet of Things and Industry Internet of Things (IoT and IIoT)**						
	8	Identify interconnectivity of IoT and IIoT	4.04	3.00	4.33	4.50	4.67	3.86
	9	Identify IIoT devices	4.13	3.00	4.67	4.50	4.33	4.00
	10	Identify IIoT media	3.83	3.00	3.67	4.50	3.67	3.86
	11	Discuss cybersecurity related to Industry 4.0	4.39	4.00	4.67	5.00	4.67	4.21
	12	Review safety precautions related to IoT and IIoT	4.30	5.00	4.33	4.50	5.00	4.07
		Domain Average Mean	4.14	3.60	4.33	4.60	4.47	4.00
C		**Big Data and Analytics**						
	13	Explain the role of Big Data in Industry 4.0	3.43	3.00	3.25	3.50	3.67	3.46
	14	Identify smart systems and components used in Industry 4.0	3.96	4.00	4.00	4.00	4.00	3.92
	15	Explain the use of Artificial Intelligence (AI)	3.39	3.00	2.50	4.00	3.33	3.62
	16	Explain the function of The Cloud	3.50	4.00	2.67	3.50	3.67	3.62
	17	Identify monitoring systems used in Industry 4.0	4.13	4.00	4.00	4.50	4.33	4.08
	18	Describe the use of digital twins in the production environment	3.14	3.00	2.00	4.50	3.50	3.23
	19	Describe and explain the utilization of Big Data	3.57	3.00	2.75	5.00	3.33	3.69
	20	Review safety related to Big Data	3.78	4.00	3.50	4.50	3.67	3.77
		Domain Average Mean	3.61	3.50	3.08	4.19	3.69	3.67
D		**System Integration**						
	21	Discuss application of robotics in Industry 4.0	4.44	4.00	5.00	4.50	4.33	4.33
	22	Describe applications of autonomous and collaborative robots	4.36	4.00	4.75	5.00	4.33	4.20
	23	Review safety related to robot integration	4.52	4.00	4.75	4.00	4.67	4.53
	24	Discuss the usage of advanced HMI's	4.17	4.00	4.25	4.50	3.33	4.29
	25	Identify advanced PLCs	4.32	4.00	4.75	4.50	3.67	4.33
	26	Describe electrical control theory and circuits	4.36	5.00	4.75	4.00	4.33	4.27
	27	Describe the integration of process controls	4.40	4.00	4.75	4.50	4.67	4.27
	28	Discuss the application of Variable Frequency Drives (VFDs)	4.40	4.00	4.50	4.50	4.33	4.36
	29	Describe advanced fluid power systems	4.20	5.00	4.25	4.00	4.00	4.20

	30	Identify basic network concepts	4.24	4.00	4.25	4.00	4.67	4.20
	31	Review safety hazards related to networking	4.40	4.00	5.00	4.00	4.67	4.27
		Domain Average Mean	4.35	4.18	4.64	4.32	4.27	4.29
E		**Predictive Maintenance**						
	32	Apply proactive mindset for equipment performance monitoring	4.36	4.00	4.50	5.00	4.33	4.27
	33	Review safety hazards related to predictive maintenance	4.48	5.00	4.75	4.50	4.33	4.40
		Domain Average Mean	4.42	4.50	4.63	4.75	4.33	4.33
F		**Tracking Systems**						
	34	Identify the integration of intelligent tracking systems	3.88	4.00	3.75	4.50	4.00	3.80
	35	Review safety hazards related to tracking systems	4.04	4.00	4.00	4.50	3.67	4.07
		Domain Average Mean	3.96	4.00	3.88	4.50	3.83	3.93

Years Worked in Industry 4.0

		How many years have you spent working for pay performing Industry 4.0 responsibilities?		> 1 year	1 to 4 yrs	5 to 9 yrs	10 - 14 yrs	15 - 20 yrs	21 + yrs
		Rated Competencies for AMTEC Industry 4.0	Group Avg Rating (N=25)	N=7	N=3	N=5	N=3	N=1	N=6
A		**Industry 4.0 Fundamentals**							
	1	Define additive manufacturing as it relates to Industry 4.0	3.39	3.29	2.33	3.60	3.67	4.00	3.75
	2	Describe how cybersecurity impacts Industry 4.0	4.04	4.00	3.33	4.20	4.67	4.00	4.00
	3	Identify extended reality's role in Industry 4.0	3.00	3.00	2.33	3.40	3.67	2.00	2.75
	4	Identify smart systems related to Industry 4.0	3.91	4.33	3.33	4.20	4.33	3.00	3.25
	5	Define advanced materials used in Industry 4.0	3.36	2.83	3.00	3.80	3.67	4.00	3.50
	6	Discuss the concept of proactive maintenance	4.46	4.14	4.67	4.40	4.67	5.00	4.60

	7	Discuss general safety issues related to Industry 4.0	4.54	4.57	4.33	4.20	5.00	5.00	4.60
		Domain Average Mean	3.81	3.74	3.33	3.97	4.24	3.86	3.78
B		**Internet of Things and Industry Internet of Things (IoT and IIoT)**							
	8	Identify interconnectivity of IoT and IIoT	4.04	3.50	4.00	4.40	4.67	4.00	4.00
	9	Identify IIoT devices	4.13	3.67	4.00	4.40	4.67	4.00	4.20
	10	Identify IIoT media	3.83	3.33	3.33	4.40	4.00	4.00	4.00
	11	Discuss cybersecurity related to Industry 4.0	4.39	4.17	4.00	4.60	4.67	4.00	4.60
	12	Review safety precautions related to IoT and IIoT	4.30	4.17	4.00	4.60	4.67	4.00	4.20
		Domain Average Mean	4.14	3.77	3.87	4.48	4.53	4.00	4.20
C		**Big Data and Analytics**							
	13	Explain the role of Big Data in Industry 4.0	3.43	3.29	3.33	3.80	3.67	3.00	3.25
	14	Identify smart systems and components used in Industry 4.0	3.96	4.00	3.33	4.40	4.67	4.00	3.25
	15	Explain the use of Artificial Intelligence (AI)	3.39	3.43	2.33	3.60	4.33	3.00	3.25
	16	Explain the function of The Cloud	3.50	3.67	2.33	4.00	4.33	3.00	3.00
	17	Identify monitoring systems used in Industry 4.0	4.13	4.00	3.67	4.40	4.33	5.00	4.00
	18	Describe the use of digital twins in the production environment	3.14	3.14	2.33	3.50	3.67	4.00	2.75
	19	Describe and explain the utilization of Big Data	3.57	3.57	3.00	3.60	3.67	4.00	3.75
	20	Review safety related to Big Data	3.78	3.86	3.67	3.80	3.67	4.00	3.75
		Domain Average Mean	3.61	3.62	3.00	3.89	4.04	3.75	3.38
D		**System Integration**							
	21	Discuss application of robotics in Industry 4.0	4.44	4.57	4.00	4.40	4.67	5.00	4.33
	22	Describe applications of autonomous and collaborative robots	4.36	4.57	4.00	4.60	4.33	5.00	4.00
	23	Review safety related to robot integration	4.52	4.43	4.00	4.60	4.67	5.00	4.67
	24	Discuss the usage of advanced HMI's	4.17	4.29	3.67	4.20	4.33	5.00	4.00
	25	Identify advanced PLCs	4.32	4.29	4.33	4.20	4.33	5.00	4.33
	26	Describe electrical control theory and circuits	4.36	4.14	4.67	4.40	4.67	5.00	4.17

	27	Describe the integration of process controls	4.40	4.43	4.33	4.40	4.67	5.00	4.17
	28	Discuss the application of Variable Frequency Drives (VFDs)	4.40	4.14	4.33	4.40	4.67	5.00	4.40
	29	Describe advanced fluid power systems	4.20	4.29	3.67	4.20	4.67	5.00	4.00
	30	Identify basic network concepts	4.24	3.86	3.67	4.60	5.00	5.00	4.17
	31	Review safety hazards related to networking	4.40	4.43	4.67	4.40	4.67	5.00	4.00
		Domain Average Mean	4.35	4.31	4.12	4.40	4.61	5.00	4.20
E		**Predictive Maintenance**							
	32	Apply proactive mindset for equipment performance monitoring	4.36	4.57	4.00	4.40	4.33	5.00	4.17
	33	Review safety hazards related to predictive maintenance	4.48	4.57	4.33	4.40	5.00	5.00	4.17
		Domain Average Mean	4.42	4.57	4.17	4.40	4.67	5.00	4.17
F		**Tracking Systems**							
	34	Identify the integration of intelligent tracking systems	3.88	3.86	3.00	4.40	4.67	5.00	3.33
	35	Review safety hazards related to tracking systems	4.04	4.00	3.67	4.20	4.33	5.00	3.83
		Domain Average Mean	3.96	3.93	3.33	4.30	4.50	5.00	3.58

Education or Business/Industry

		Do you work in Education or Business/Industry?		Education	Business/Industry
		Rated Competencies for AMTEC Industry 4.0	Group Average Rating (N=25)	N=10	N=14
A		**Industry 4.0 Fundamentals**			
	1	Define additive manufacturing as it relates to Industry 4.0	3.39	3.50	3.33
	2	Describe how cybersecurity impacts Industry 4.0	4.04	4.00	4.08

	3	Identify extended reality's role in Industry 4.0	3.00	2.90	3.09
	4	Identify smart systems related to Industry 4.0	3.91	3.90	4.00
	5	Define advanced materials used in Industry 4.0	3.36	3.44	3.25
	6	Discuss the concept of proactive maintenance	4.46	4.30	4.54
	7	Discuss general safety issues related to Industry 4.0	4.54	4.40	4.62
		Domain Average Mean	3.81	3.78	3.84
B		**Internet of Things and Industry Internet of Things (IoT and IIoT)**			
	8	Identify interconnectivity of IoT and IIoT	4.04	3.90	4.17
	9	Identify IIoT devices	4.13	4.10	4.17
	10	Identify IIoT media	3.83	3.70	4.00
	11	Discuss cybersecurity related to Industry 4.0	4.39	4.40	4.42
	12	Review safety precautions related to IoT and IIoT	4.30	4.30	4.25
		Domain Average Mean	4.14	4.08	4.20
C		**Big Data and Analytics**			
	13	Explain the role of Big Data in Industry 4.0	3.43	3.40	3.50
	14	Identify smart systems and components used in Industry 4.0	3.96	3.90	4.00
	15	Explain the use of Artificial Intelligence (AI)	3.39	3.20	3.58
	16	Explain the function of The Cloud	3.50	3.20	3.73
	17	Identify monitoring systems used in Industry 4.0	4.13	4.00	4.25
	18	Describe the use of digital twins in the production environment	3.14	3.10	3.18
	19	Describe and explain the utilization of Big Data	3.57	3.60	3.58
	20	Review safety related to Big Data	3.78	3.70	3.83
		Domain Average Mean	3.61	3.51	3.71
D		**System Integration**			
	21	Discuss application of robotics in Industry 4.0	4.44	4.60	4.36
	22	Describe applications of autonomous and collaborative robots	4.36	4.50	4.36

	23	Review safety related to robot integration	4.52	4.50	4.57
	24	Discuss the usage of advanced HMI's	4.17	4.10	4.31
	25	Identify advanced PLCs	4.32	4.40	4.36
	26	Describe electrical control theory and circuits	4.36	4.10	4.50
	27	Describe the integration of process controls	4.40	4.20	4.50
	28	Discuss the application of Variable Frequency Drives (VFDs)	4.40	4.20	4.46
	29	Describe advanced fluid power systems	4.20	4.10	4.21
	30	Identify basic network concepts	4.24	3.90	4.43
	31	Review safety hazards related to networking	4.40	4.30	4.43
		Domain Average Mean	4.35	4.26	4.41
E		**Predictive Maintenance**			
	32	Apply proactive mindset for equipment performance monitoring	4.36	4.40	4.29
	33	Review safety hazards related to predictive maintenance	4.48	4.40	4.50
		Domain Average Mean	4.42	4.40	4.39
F		**Tracking Systems**			
	34	Identify the integration of intelligent tracking systems	3.88	3.90	3.86
	35	Review safety hazards related to tracking systems	4.04	4.10	4.00
		Domain Average Mean	3.96	4.00	3.93