Developing a Curriculum for Marine Mechatronics Technicians

Dr. Vukica M. Jovanovic, Old Dominion University

Dr. Vukica Jovanovic is an Assistant Professor of Engineering Technology in Mechanical Engineering Technology Program. She holds a Ph.D. from Purdue University in Mechanical Engineering Technology, focus on Digital Manufacturing. Her research is focused on mechatronics, digital manufacturing, digital thread, cyber physical systems, broadening participation, and engineering education. She is a Co-Director of Mechatronics and Digital Manufacturing Lab at ODU and a lead of Area of Specialization Mechatronics Systems Design. She worked as a Visiting Researcher at Commonwealth Center for Advanced Manufacturing in Disputanta, VA on projects focusing on digital thread and cyber security of manufacturing systems. She has funded research in broadening participation efforts of underrepresented students in STEM funded by Office of Naval Research, focusing on mechatronic pathways. She is part of the ONR project related to the additive manufacturing training of active military. She is also part of the research team that leads the summer camp to nine graders that focus on broadening participation of underrepresented students into STEM (ODU BLAST).

Dr. Petros J Katsioloudis, Old Dominion University

Petros J. Katsioloudis is an Associate Professor, Department Chair and the Industrial Technology Program Leader, Department of STEM Education and Professional Studies, Old Dominion University, Norfolk, VA. His research focuses on improving teacher and student performance in STEM education, and enhancing the development of a national STEM-educated workforce.

Prof. Ana Djuric P.E., Wayne State University

Dr. Ana Djuric is an Assistant Professor of Engineering Technology in the College of Engineering at Wayne State University, Detroit, Michigan. Dr. Djuric research areas are industrial robots, kinematics, dynamics, control, and advanced manufacturing systems. She supervises multiple undergraduate and graduate students in their research and is a member of Council on Undergraduate Research (CUR). Her Dipl.-Ing. degree is in the area of mechanical engineering from the University of Belgrade, Serbia, focusing in Control Systems. Her M.A.Sc. degree is in Industrial and Manufacturing Systems Engineering from University of Windsor, Canada, area of Industrial Robotics, and a Ph.D. in Mechanical Engineering from University of Windsor, Canada in the area of Reconfigurable Robotics. Prior to her arrival at WSU, Dr. Djuric worked in the industry as a machine and tool designer first and then as a Robotics software Analyst for five years. Prior to joining WSU, Dr. Djuric was an Instructor at the Mechanical, Automotive and Materials Engineering, and Industrial and Manufacturing and Systems Engineering departments at the University of Windsor.

Dr. Mileta Tomovic, Old Dominion University

Dr. Tomovic received BS in Mechanical Engineering from University of Belgrade, MS in Mechanical Engineering from MIT, and PhD in Mechanical Engineering from University of Michigan. Dr. Tomovic is Professor of Engineering Technology, and Mechanical and Aerospace Engineering, F. Batten College of Engineering and Technology, Old Dominion University, Norfolk, VA. Prior to joining ODU Dr. Tomovic had seventeen years of teaching and research experience at Purdue University, with emphasis on development and delivery of manufacturing curriculum, conducting applied research, and engagement with Indiana industry. While at Purdue University, Dr. Tomovic served as W. C. Furnas Professor of Enterprise Excellence, University Faculty Scholar, Director of Digital Enterprise Center, and Special Assistant to Dean for Advanced Manufacturing. He has co-authored three books on hydraulic systems, product lifecycle management, and manufacturing processes. In addition, he has authored or co-authored over 140 papers in journals and conference proceedings, focused on applied research related to design and manufacturability issues, as well as issues related to mechanical engineering technology education. Dr. Tomovic made over 60 invited presentations nationally and internationally on the issues of design optimization and manufacturability. He has co-authored four patents, and over 120 technical reports on practical industrial problems related to product design and manufacturing process improvements.

Prof. Thomas B. Stout, Tidewater Community College

Thomas Stout is the Dean Of Science, Technology, Engineering and Mathematics Tidewater Community College in Chesapeake, Virginia. He was previously an associate professor of Electromechanical Controls Technology at TCC. He has worked in industrial maintenance, mechatronics and safety. He earned his BS degree from Old Dominion University in 2004 and his MS in Electronics Engineering from Norfolk State University in 2007. He served 20 years in the United States Navy working on aircraft and surface ships.

Developing a Curriculum for Marine Mechatronics Technicians

Abstract:

A growing trend within the U.S. Navy is to streamline operations by deploying ships with less sailors, who are more highly skilled technicians that are trained to do a wide array of jobs. Modern ships also include various automated systems that require more highly skilled technicians for maintenance. Outdated warship designs are now being replaced with industrial grade automation equipment. Such equipment is being used in warships that encounter harsher environments than what exists in the civilian industry. Hence, there is a need for training in regards to industrial grade automation equipment for military and civilian ship repair partners. Marine mechatronics technicians will be trained to maintain these modern complex warship systems. For that purpose, the team of marine mechatronics experts participated in a two day long DACUM workshop at a community college (blind review). The workshop's main purpose was to identify all competencies, skills, tools, and behaviors necessary for the specific job of a marine mechatronics technician.

Introduction

Mechatronics, a term coined by Yaskawa Ekectric Corporation's employee Tetsuro Mori in 1969, combines the technical areas of "mechanical" and "electronic" [1-3]. Mechatronics refers to the integration of design, technologies, and work processes [1, 4]. Various community colleges are adding programs focused on this emerging area, mainly driven by industry requirements and technology changes [1]. As identified by the Employment and Training Administration within the United States Department of Labor, the main Mechatronics Technical Competencies are related to four areas: Mechanical Engineering, Electrical and Electronic Engineering, Systems and Process Control Engineering, and Computer Science. There are different critical work functions related to each one of these main areas [5]. Critical work functions of the overall job description include:

- Understand the necessary steps to plan, execute, and control a mechatronic system.
- Program, calibrate, configure, test, start-up, and operate a mechatronic system.
- Understand mechatronics as the integration of multiple disciplines in industrial processes.
- Identify major application areas for mechatronics.

- Apply mechatronics in various manufacturing, scientific, and technical applications.
- Abide by mechatronics industry codes, standards, and regulations.
- Research and apply emerging and future mechatronics technologies [5]

Figure 1 shows occupation specific competencies and industry sector technical competencies. They include various technical areas ranging from Programmable Logical Controllers (PLCs), Hydraulics, Pneumatics, Machining, power transmission, engineering graphics and geometrical dimensioning and tolerances, as well as topics related to electrical domain, such as circuits, schematics, motion control and troubleshooting [6].

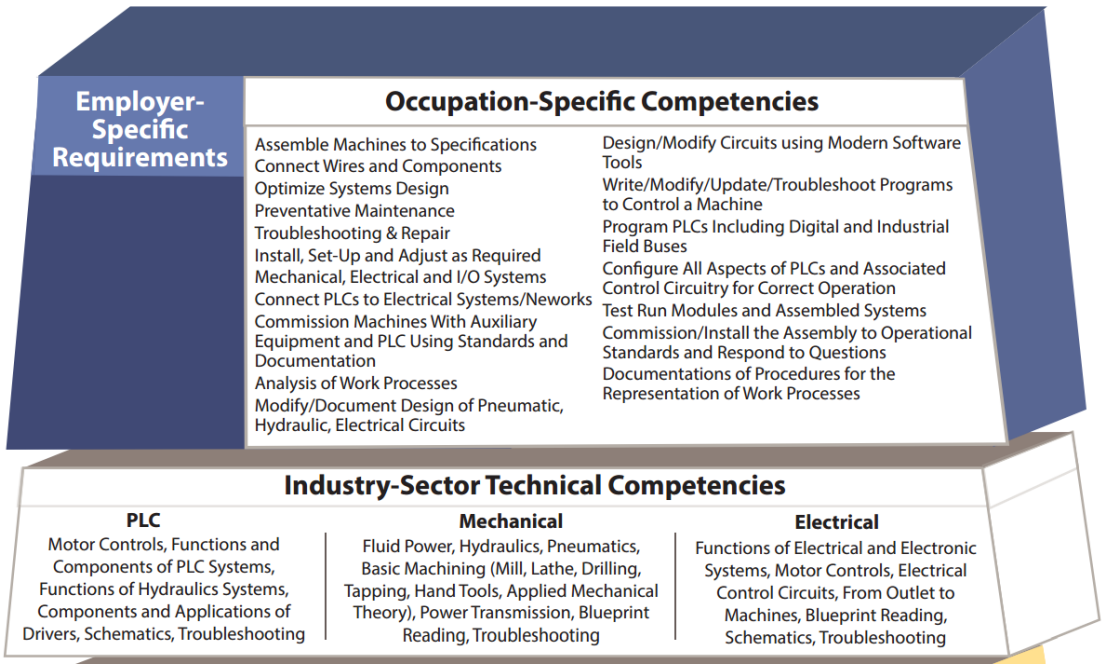

Figure 1: Occupation specific competencies and industry sector technical competencies for Mechatronics [6]

DACUM Process for Marine Mechatronics Technician (MMT)

Developing A curriculUM (DACUM) is a widely used job analysis method of competence based education [7-9]. It is a pedagogical method that involves the use of a trained facilitator and a committee of 5-12 expert workers in a given occupation or area [6]. It is based on an assumption that the people who are working in a specific position can best describe the demands of that position [6, 10]. The DACUM method can be used as a starting point for curriculum development [10].

A DACUM panel was held at the Blind-Review Community College at City, State (blind review) from June 21-22, 2016. The panel included eight participants from various companies and educational institutions with the following job titles: Outside Machinist/Craft Instructor, Apprentice Instructor, Elevator Mechanics, Outside Machinist Apprentice, two Electrical Craft Instructors, a Career and Technical Education Teacher, and a former Navy electrician.

Before the panel began, it was discussed that the technician's position in consideration is not entry level, and will have subordinates, to include mechanics, electricians, laborers, and apprentices. The panelist noted that the main obstacle is to merge all these different skill sets into one person, specifically the marine and electrical skills necessary to be a technician. It is hard to distinguish which of these skills they already have and which they will need to acquire. The MMT job description is geared more towards the position of an engineer. Specifically, someone who will oversee the electrical and mechanical technicians to make sure that both systems are working well together. The MMT position would be a supervisor, as noted by some of the panel members. On the job training should be the main component of this program because the learning has to happen on the job. The technician has to be involved in the production line, such as an apprenticeship program. Many times in apprenticeship programs, apprentices are assigned to work on mechanical, then electrical, and are exposed to different parts of both the mechanical and electrical sides. It is important to consider how much exposure they have to different areas; it can be dangerous if they just get introduction to specific area, but not a higher level understanding of that area.

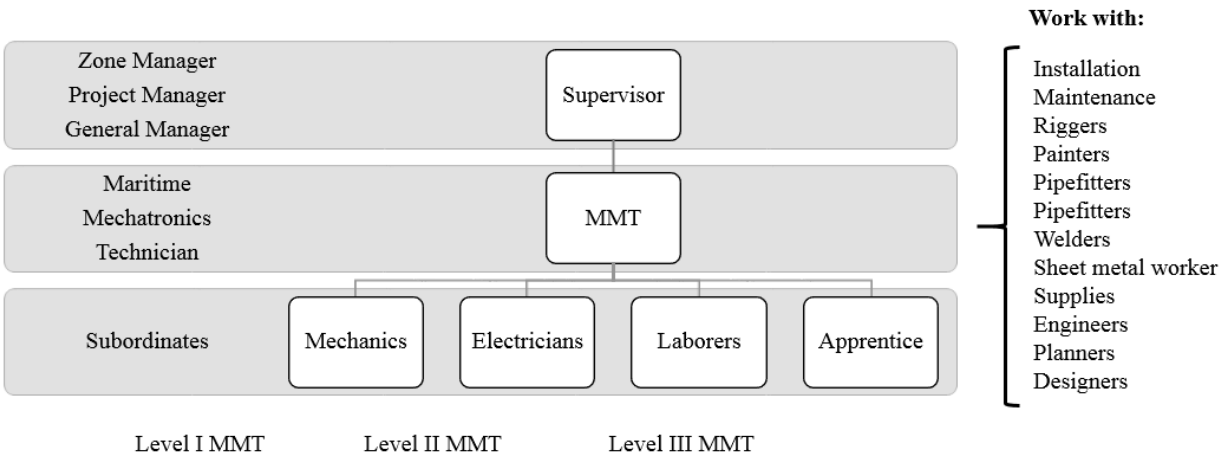

Figure 2: Position of the Marine Mechatronics Technician within the organization

DACUM Research Chart for Maritime Mechatronics Technician (MMT)

The result of the DACUM process is given in Figures 3 and 4. The final result incorporate the concerns expressed by the participants, and it has been validated with all panel members before the finalizing.

Duties	Tasks				
A Research Assigned Shipboard Systems	A-1 Review work instruction	A-2 Establish system stakeholders	A-3 Prioritize work instruction	A-4 Obtain assigned TWD	A-5 Review system history
B Evaluate Shipboard Systems	B-1 Obtain job-specific tools	B-2 Investigate system safety	B-3 Identify system boundaries	B-4 Simulate normal system operations	B-5 Perform system diagnostics
C Troubleshoot Shipboard System	C-1 Identify work Interference	C-2 Address work interference	C-3 Develop system condition report	C-4 Determine system resource needs	C-5 Review assigned TWD
D Perform System Repair	D-1 Review troubleshooting results	D-2 Complete system disassembly	D-3 Complete system inspection	D-4 Identify required resources (e.g. personnel, parts and	D-5 Receive repair parts
E Conduct Operational Testing	E-1 Review system TWD	E-2 Conduct visual inspections	E-3 Establish safety boundaries	E-4 Coordinate system startup	E-5 Determine go/no-go system status
F Certify System Integrity	F-1 Perform certification test	F-2 Document test completion	F-3 Obtain customer acceptance	F-4 Manage surplus material	F-5 Complete pertinent documents
G Pursue Professional Development	G-1 Train on job-specific system	G-2 Obtain system specific certification(s)	G-3 Maintain security clearance	G-4 Participate in leadership development	G-5 Maintain job-specific qualifications

Figure 3: DACUM Research Chart for Maritime Mechatronics Technician part 1

Duties	Tasks				
A Research Assigned Shipboard Systems	A-6 Develop work plan	A-7 Verify job-specific qualifications	A-8 Verify job-specific certification(s)		
B Evaluate Shipboard Systems	B-6 Outline diagnostic results				
C Troubleshoot Shipboard System	C-6 Disseminate troubleshooting results				
D Perform System Repair	D-6 Install repair parts	D-7 Perform safety data sheet (SDS) requirements	D-8 Restore system to operational status		
E Conduct Operational Testing	E-6 Restore system operations	E-7 Monitor system operations	E-8 Confer current job status		
F Certify System Integrity	F-6 Compile lessons learned document	F-7 Distribute lessons learned document			
G Pursue Professional Development	G-6 Participate in required evaluations	G-7 Implement technology changes	G-8 Develop job proficiency	G-9 Develop system knowledge	

Figure 4: DACUM Research Chart for Maritime Mechatronics Technician part 2

Conclusion

As a result of this effort, a curriculum map for the Marine Mechatronic Technician program will be established. Results of the DACUM workshop are presented in this paper. The DACUM workshop will be held at one different community college by the end of the project to verify and modify the research chart presented in this paper. Based on the DACUM research chart, existing courses and new educational modules are developed to match the needs of marine and naval

industries. This educational pathway includes efforts at three educational levels: high school through pre-engineering courses, an associate degree level program, and a bachelor's degree program. In this way, mechatronics related job functions are split into different levels of difficulty. Introduction to Mechatronics modules are embedded into the course Engineering Studies in local Blind-review High School. Articulation agreement is currently being reviewed at the two institutions in this project, one community college, and one engineering technology undergraduate 4-year long program.

Acknowledgement

The authors wish to acknowledge support from the Office of Naval Research for the "Higher Education Pathways for Maritime Mechatronics Technicians (MechTech)" grant, grant number 11910979.

References:

[1] A. Hardcastle, "Mechatronics in Washington State: Manufacturing, Energy and Marine Sectors," 2016.

[2] M. K. Habib, "Mechatronics engineering the evolution, the needs and the challenges," in *IEEE Industrial Electronics, IECON 2006-32nd Annual Conference on*, 2006, pp. 4510-4515.

[3] A. Sergeyev, "Creating Pathways to Stackable Credentials in Robotics: Meeting Industry Needs by Manufacturing a Community College and University Partnership."

[4] M. K. Habib, "Interdisciplinary Mechatronics engineering and science: problem-solving, creative-thinking and concurrent design synergy," *International Journal of Mechatronics and Manufacturing Systems*, vol. 1, pp. 4-22, 2008.

[5] DOL, "Mechatronics Competency Model," United States Department of Labor - Employment and Training Administration, State of Minnesota2017.

[6] DLI. (2017, PIPELINE Project : Competency Model for Advanced Manufacturing, Occupation: Mechatronics. Available: https://www.dli.mn.gov/PDF/pipeline/manufacturing_mechatronics.pdf

[7] J. W. Burke, *Competency based education and training*: Psychology Press, 1989.

[8] R. L. Custer, J. A. Scarcella, and B. R. Stewart, "The Modified Delphi Technique--A Rotational Modification," *Journal of vocational and technical education,* vol. 15, pp. 50-58, 1999.

[9] I. M. Halasz and T. Reid, "Overview of DACUM job analysis Process," *Longmont: NIC Academy Division,* 1994.

[10] R. E. Norton, "DACUM: A Proven and Powerful Approach to Occupational Analysis," 1992.