Curriculum and Specializations Framework to Address Skills Required by Manufacturing Companies

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Dr. Nabeel Yousef is a Professor at the School of Engineering Technology at Daytona State College since 2010. He was a Visiting Assistant Professor in the Engineering Technology Department at the University of Central Florida from 2006 to 2010 and still works there as Adjunct Faculty. In 2014, Dr. Yousef was awarded a Fulbright Scholarship, which is part of the binational program for educational exchange sponsored by the Institute of International Education, the Council for International Exchange Scholars, and Department of State. In 2017, He was awarded the NISOD Excellence Award of Teaching and Leadership. In addition, he was the Chief-in-Editor for the Journal of Management and Engineering Integration from 2008 to 2015. Dr. Yousef has a PhD and MS in Industrial Engineering and management Systems from the University of Central Florida in Orlando. He earned his BS in Physics from Yarmouk University at Jordan in 1986. In 2002 he was appointed as the Director of Information Technology for the International Conference of Industry, Engineering and Management Systems and held that position in addition to other conference duties until 2015. In 2006 he was appointed as the Director of Information Technology and Infrastructure for the NSF Center for e-Design at the University of Central Florida. Dr. Yousef developed a strategic plan for information technology for the center. Dr. Yousef authored several refereed publications including book chapters, journal papers, and conference papers. He was also either the PI or the Co-PI in many research projects related to Cost Engineering, Cost and Quality Effectiveness, Cost Modeling, System of Systems Interoperability, Supply Chain Management, Decision Support Systems, Knowledgebase Systems, and Database Management.

During his career Dr. Yousef earned the award of Excellent Service from the department of Industrial Engineering and Management Systems in 2006, and Faculty Excellence Award for Undergraduate Teaching from the Department of Engineering Technology 2008.

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Abstract

The unfulfilled demand for skilled manufacturing workforce at the technical level is a concern that has been shared by industry leaders across the nation. According to a study published in 2015 by Deloitte and the Manufacturing Institute the U.S. manufacturing industry will add nearly 3.4 million jobs in the next 10 years to meet global consumer demand. The study states that 84% of executives agree that there is a talent shortage in the U.S. manufacturing sector [1]. In 2015 Florida Advanced Technological Education Center (FLATE) reported over 14,000 different companies employ 355,000 individuals in the manufacturing fields in Florida. These manufacturing firms suffer economic loss from the limited pool of the available skilled workers at technical levels [2]. According to the 2015-2016 Florida Statewide Demand Occupation List, the growth in manufacturing jobs continues to climb with a 7% increase in annual growth of available jobs anticipated in manufacturing across the state. With rising concern about an inadequate workforce, the research team is working with industry partners to identify needs and provide educational resources and sustainable programs in advanced technical education. To address the need, the research team enhanced the design and development of the existing Associate Degree in Engineering with adding new specializations and on-site manufacturing experience. This paper will address the model that has been developed through the use of Quality Function Deployment Method and based on industry requirements. Using surveys and interviews with industry leaders, information were collected and summarized in the house of quality. Industry feedback was used in creating the design specification for the new curriculum.

Introduction

Building a strong manufacturing industry will assist in the nation's economic success and advancement. Manufacturing provides better standards of living and creates additional jobs. Based on a report published by Deloitte and the Manufacturing Institute in 2015, investments in manufacturing have a strong multiplier effect for a broader economy. As stated in the report every dollar spent in manufacturing will add $1.37 to the U.S. economy, and every 100 jobs in one manufacturing facility creates an additional 250 jobs in other sectors [1]. The strength of manufacturing and service industry comes from the skilled workforce provided by academic institutions. In 2010 all G20 countries identified skills development as a strategic objective that will provide an industry-based and professional competencies, an objective that will facilitate the transition from education to workforce [5]. This discussion leads to the conclusion that investment in a good quality education and skills development will close the gap with industry needs and increase employability and productivity.

Many tools, methods, and techniques have been used to capture industry needs through the design and development of the proper academic curriculum [6]. One of the common tools is Quality Function deployment (QFD). In 2008 Gonzalez and et al published a paper addressing designing a supply chain management academic curriculum using QFD and benchmarking. The authors used potential employers as a source for data collection. Although the study was specifically concerned with the design of a SCM curriculum, the authors argued that the design methodology could be applied for other academic programs [7]. In 1996 Glenn Mazur wrote a paper that addressed using QFD to design a course in Total Quality management (TQM) at the college of Engineering, University of Michigan. The purpose of the new course was to increase the student to teacher ratio in that course. In his conclusion Mazur stated that QFD can be used to improve all levels of university education activities from degree program design, to curriculum, to specific courses [8]. In 2001 Bier and Cornesky published a paper that addresses the use of QFD to construct a higher education curriculum. In their paper they stated that the use of QFD technique to capture employers' needs into the school curriculum is not new. The tool was implemented at RainStar University to design and develop MS curriculum in the Acupuncture and Oriental Medicine. The implementation was not only successful but exceeded the professional competencies. In addition, the QFD technique ensured that the curriculum is agile and flexible to meet future real-world changes [9] [10].

Based on the literature review and the research in this area our team decided to use QFD technique in the design and development of an existing associate degree in engineering at Daytona State College (DSC) to meet industry workforce needs and professional competencies [11].

Curriculum Design and Development

To identify the gap between industry and academia and to create the best set of educational and professional development materials, interviews and surveys were conducted with 88 industry leaders in Florida. The goal of the survey was to identify the set of skills and competencies academia should produce to meet industry requirements in the area. The identified skills and competencies were used to guide the research team in the development of a new skilled workforce oriented curriculum.

The survey concentrated on two categories or set of skills, the soft skills and the technical skills. Soft skills included: Communications, team work/collaboration, work ethics, innovation/creativity, global competency, financial literacy, and flexibility/adaptability. While the technical skills concentrated on the depth of technical knowledge, critical thinking and judgment abilities, and system thinking abilities. An example of the survey is shown in figure 1 below.

Rank by Importance (1 being least important and 5 being the most valuable)	1	2	3	4	5	N/A	TOTAL
1. Implement all related safety codes and regulations in industrial working environments.	3.41% 3	6.82% 6	10.23% 9	10.23% 9	69.32% 61	0.00% 0	88
2. Perform tasks in a specialized technical area.	2.27% 2	0.00% 0	23.86% 21	28.41% 25	45.45% 40	0.00% 0	88
3. Work with computer aided drafting and create geometric part files.	15.91% 14	6.82% 6	25.00% 22	22.73% 20	21.59% 19	7.95% 7	88
4. Work at the entry level with traditional materials removal machines, (milling, lathe, drill press, cut-off-saws.)	12.50% 11	9.09% 8	21.59% 19	26.14% 23	22.73% 20	7.95% 7	88
5. Understand mechanical and process characteristics of common materials.	2.27% 2	4.55% 4	29.55% 26	35.23% 31	25.00% 22	3.41% 3	88
6. Operate materials testing tools and equipment.	10.23% 9	15.91% 14	26.14% 23	30.68% 27	14.77% 13	2.27% 2	88
7. Operate, maintain, and repair mechanical, hydraulic, and pneumatic systems.	10.23% 9	15.91% 14	21.59% 19	27.27% 24	15.91% 14	9.09% 8	88
8. Operate AC electric-powered tools, and equipment.	4.55% 4	9.09% 8	25.00% 22	25.00% 22	31.82% 28	4.55% 4	88
9. Operate DC electric-powered tools and equipment.	9.09% 8	5.68% 5	29.55% 26	26.14% 23	18.18% 16	11.36% 10	88
10. Operate electronic sensors, switches, and controls.	3.41% 3	12.50% 11	25.00% 22	29.55% 26	23.86% 21	5.68% 5	88
11. Operate programmable logic controllers and use systems schematics.	9.09% 8	6.82% 6	18.18% 16	32.95% 29	23.86% 21	9.09% 8	88
12. Diagnose causes and troubleshoot systems operations, using schematics and ladder logic diagrams.	7.95% 7	15.91% 14	25.00% 22	17.05% 15	22.73% 20	11.36% 10	88

Figure 1: Sample of the industry leaders survey questions related to Technical skills

Those skills were also identified through reports published by the Volusia Manufacturing Association (VMA) and through advisory board meetings. To verify and validate the information, the survey above was created asking specifically about the importance of each skill on a scale of 1 to 5 as industry requirement. The results are shown figure 2 below.

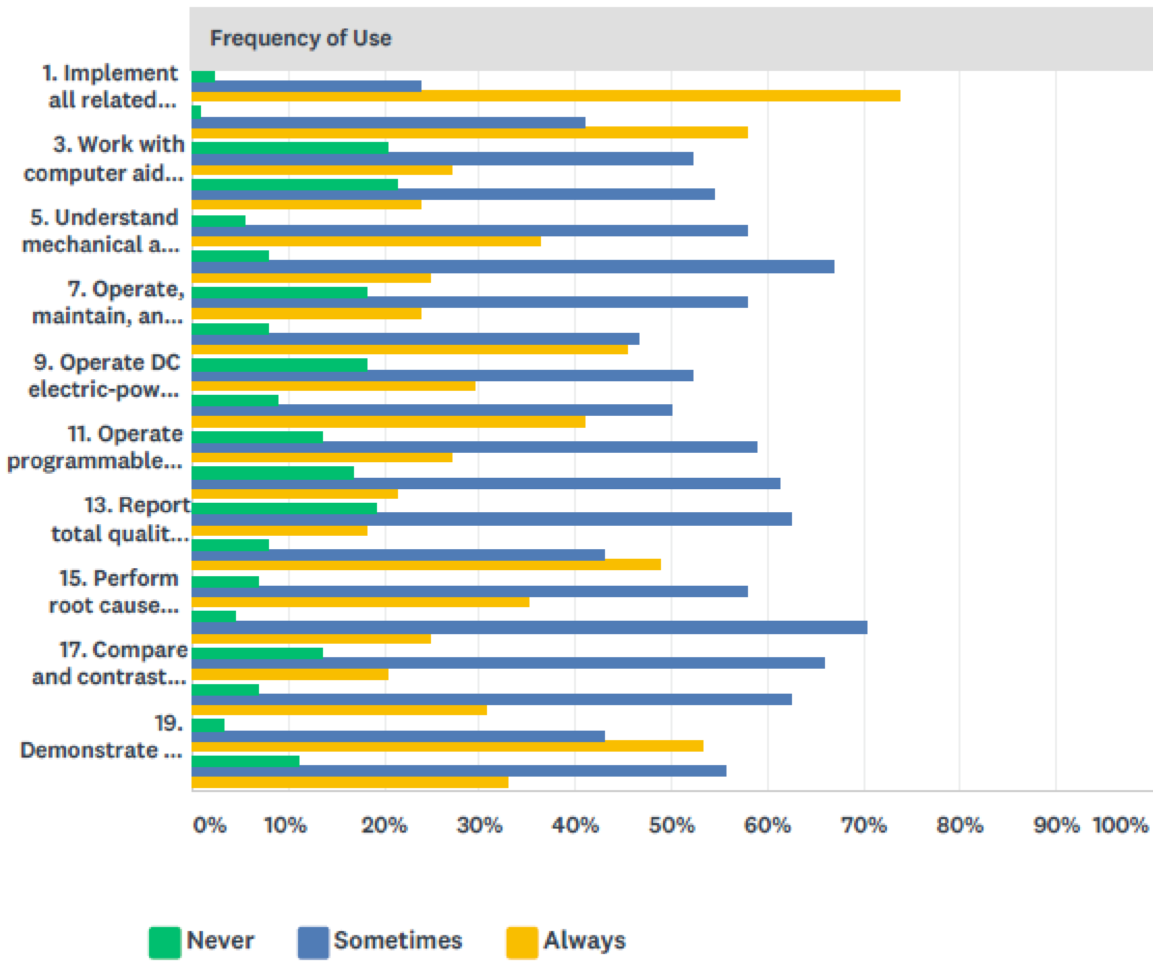

Figure 2: This chart represents the frequency of use for the required skills based on industry feedback

Survey Analysis

Based on the survey analysis the research team ranked the skills according to their importance. The matrix of the collected data and the analyzed results were mapped using the house of quality as shown in the figure below. The house of quality shows industry requirements (skills), their importance for employers, and their weights on the left vertical columns. The industry requirements were translated into design specification of the new curriculum. The specifications are courses, course outcomes, team projects, assignments and case studies, new specializations, strong advising, and internships. The correlation between the specifications was positive in all cases. The developed curriculum was compared to other programs and curriculums in the area to ensure alignment and transferability. Best practices were documented to be part of the continuous improvement plan that has been developed by the research team. See figure 3 for the implementation of the house of quality.

Row #	Required Skills	Weight Chart	Relative Weight	Importance for Industry	Maximum Relationship	Industry Requirements (Explicit and Implicit) \ Acdemic Course Activities and programs	1 Course Outcomes	2 Courses	3 Projects	4 Assignments and Case Studies	5 Strong Advising	6 Internship	7 New Specializations	8	9	10
						Direction of Improvement	◇	◇	◇	◇	▲	◇				
1	Soft Skills		13%	4	5	Safety Codes and regulations	●	●	●	○	●	●	●			
2	Soft Skills		10%	3	5	Work with computer aided drafting	●	●	●			●	●			
3	Soft Skills		10%	3	5	Work at entry level with machines	●	●	●	○	○	○				
4	Soft Skills		10%	3	5	Maintain and repair machines	●	●	●			○				
5	Soft Skills		6%	2	5	Operate AC/DC electrical-powered tools	○	●	●							
6	Soft Skills		13%	4	5	Use required learning guides	●			●						
7	Soft Skills		10%	3	5	Set their own enhanced learning objectives	○	●	●							
8	Soft Skills		10%	3	5	Evaluate personal strength and weeknesses	▽	●	●			○				
9	Technical Skills		6%	2	5	Establish tasks to complete objectives		○	○	○	○		●			
10	Technical Skills		13%	4	5	Work with team members				●	●		●			
11																

Figure 3: A close-up snap shot of the house of quality magnified showing industry needs/requirements mapped to curriculum design specifications

The collected and analyzed data summarized in the house of quality were translated into curriculum model, which shows the major changes of the existing ASET program at Daytona State College. The model is depicted in figure 4 below.

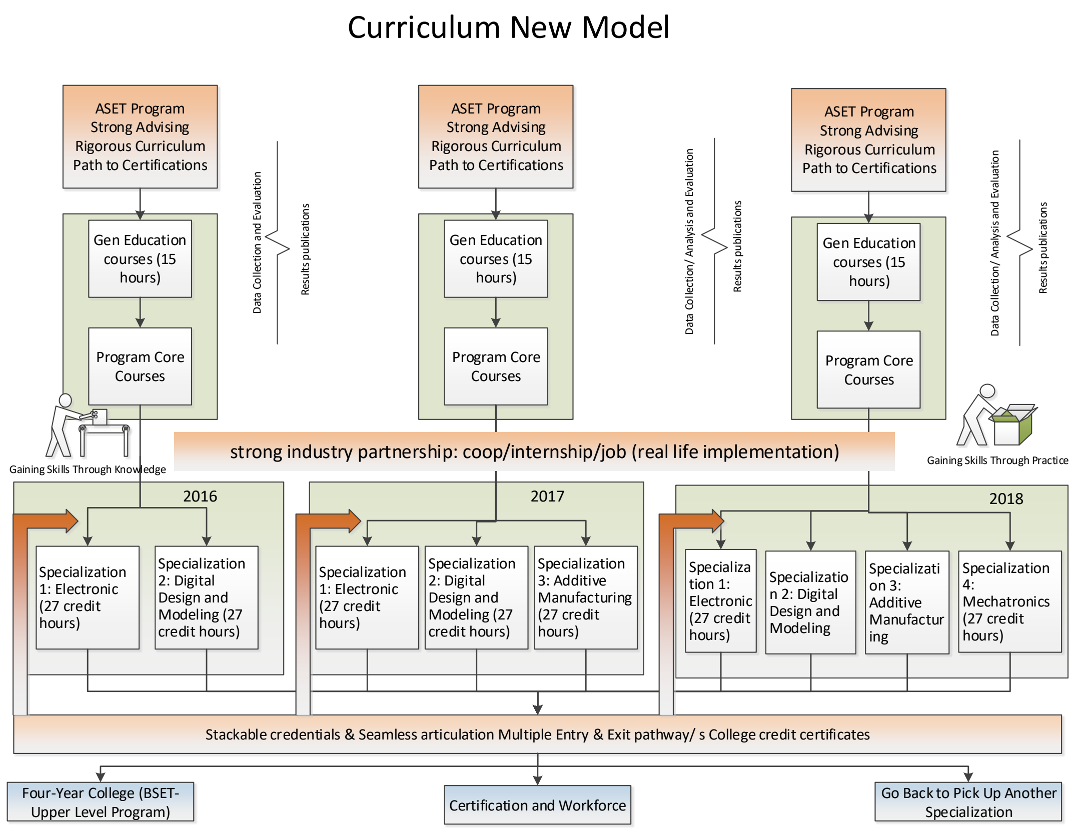

Figure 4: The developed curriculum model

The model includes strategic activities which were used to significantly transform DSC's ability to prepare students for entry- and mid-level jobs in engineering, technology, and manufacturing to meet local business and industry needs. The model includes the paths for students who choose to pursue their education with successful transfer into upper division baccalaureate programs in engineering technology or related fields. Through carefully planned interventions, the new curriculum created continuous educational pathways with targeted specializations. Each activity aligns with the program's aim to enhance the diverse training and education of the workforce by increasing the supply of ASET graduates that pursue jobs in manufacturing. By collaborating with the FLATE consortium, DSC will be able to utilize the services of FLATE and contribute to the state-wide initiative to train and increase skilled workers in manufacturing.

The analyzed data were translated into program outcomes, related courses were identified, and topics required to accomplish objectives were defined. The curriculum is currently preparing students through guided pathways supported with faculty mentors and academic advising. Students will have the option to choose from four industry-recommended specializations in electronics, drafting and design, mechatronics, and additive manufacturing. Each specialization was mapped to an industry certificates and to workforce needs. Creating those specializations enhanced the existing ASET program by providing resources for the current students and increasing the competitiveness of our graduates. The implementation of the new curriculum supports students via intrusive advising, career coaching, transfer assistance and internship scholarships. Through collaborative agreements with industry partners, internships are designed to fit the needs and situations of the local industries involved. The curriculum is implementing well-integrated strategies, rooted in education research, that provide students with what they need to progress to the next educational step or needed credentials.

Measuring the Dimensions of Quality

DSC has identified and begun implementing strategies and activities that directly impact the College's ability to increase enrollment of students in the ASET program. In 2014-2015, DSC enrolled over 27,000 students of who 69% were designated low-income based on federal poverty rates [3] [4]. Like most two-year colleges around the nation, many of DSC's students enroll in academic programs expecting results in upward social mobility, career satisfaction and workforce training for a potential increase in earning. An annual report by the Office of Institutional Research shows that 52% of students who were newly admitted first-time-in-college during fall semester 2013 dropped out before fall semester 2014. Many students drop-out before finishing their degree due to financial concerns and lack of direction. Thus, program efforts will make degrees in engineering technology affordable and provide open-access for community members to pursue advanced technical training regardless of their educational level and workforce experience. The ASET program will provide the shortest pathways to a high-skill, high-wage, and in-demand jobs.

As part of the college continuous improvement plan the team will track students' advancement collect data, analyze it, and adjust the curriculum as needed.

Conclusion

The impact of the skills' gap on the industry is real and the new developed curriculum is assisting in preparing students through guided pathways supported with faculty mentors and academic advising. Students will have the option to choose from four industry-recommended specializations in electronics, drafting and design, mechatronics, and additive manufacturing. The curriculum enhanced the existing ASET program by providing resources for current students, increasing their professional competencies and decreasing the gap between academic programs and industry requirements.

In addition, the curriculum will be affordable and provide open-access for community members to pursue advanced technical training regardless of their educational level and workforce experience. The ASET program will provide the shortest pathways to a high-skill, high-wage, and in-demand jobs. New curriculum implementation results will be collected for additional analysis and continuous improvement.

Acknowledgements

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References

[1] Deloitte and Manufacturing Institute, "The Skill Gap in US Manufacturing 2015 and Beyond". The Manufacturing Institute.

[2] MSSC credential aligned ET Degree Engineering Technology Degree Alignment to Industry Validated Credentials. http://fl-ate.org/programs/stackable-credentials/ [Accessed Jan 29, 2018]

[3] Caspio.com. "Population Estimates for Volusia and Flagler Counties". The Daytona Beach News-Journal. http://www.news-journalonline.com/article/20130523/MULTIMEDIA/130529863 [Accessed Jan 29, 2018]

[4] U.S. DEPARTMENT OF LABOR FY 2011 ANNUAL PERFORMANCE REPORT. http://www.dol.gov/dol/budget/2013/PDF/CBJ-2013-V1-01.pdf [Accessed Jan 29, 2018]

[5] International Labor Office (G20). "A Skilled Workforce for Strong, Sustainable and Balanced Growth", Geneva, 2010. ISBN 978-92-2-124278-9 http://www.oecd.org/g20/topics/employment-and-social-policy/G20-Skills-Strategy.pdf

[6] D. Grant, E. Mergen, & S.M. Widrick. "Quality management applied to higher education. Total Quality Management", ProQuest 11(3), 345-352.

[7] Marvin E. Gonzalez, Gioconda Quesada, Kent Gourdin, Mark Hartley. "Designing a supply chain management academic curriculum using QFD and benchmarking", Quality Assurance in Education, Vol. 16 Iss: 1, pp.36 – 60, 2008

[8] Glenn Mazur, "The Application of Quality Function Deployment to Design a Course in Total Quality management at the University of Michigan College of Engineering", ISQ 96, Yokohama 1996.

[9] I.D. Bier, & R. Cornesky, "Using QFD to construct a higher education curriculum". Quality Progress, 34(4), 64-68. 2001 http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/214765287?accountid=27203

[10] J.W. Denton, F. K. Virginia, & N. Surendra, "Curriculum and course design: A new approach using quality function deployment. Journal of Education for Business, 81(2), 111-117. http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/202822221?accountid=27203

[11] N. Yousef and A. Mehrabian, "Using QFD to Develop a Curriculum that Addresses Skills Gap with Industry, ISERC proceeding, ISERC May 21-24, 2016 Anaheim, CA.