Board 76: Bridging the Workforce Skills Gap in High Value Manufacturing through Continuing Education

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Abstract
Research shows that there is a growing need for skilled workers in the area of advanced manufacturing; this refers to making use of new technologies and advanced processes to produce products that have high value. More importantly, U.S. government employment data reveals that there is lack of supply of skilled workers in the manufacturing sector. Furthermore, it has also been widely cited in industrial literature that there is a concern regarding the job readiness of fresh college graduates and the gaps in skills sets needed to be successful in an industrial setting, especially in the engineering or manufacturing fields. One approach to bridge the skills gap is to provide customized continuing education to current the workforce as per the industry need. This paper presents a case study of such customized continuing education offered by Texas A&M University for oil and gas industry in Houston, Texas. Specifically, as a part of National Science Foundation Advanced Technological Education project, two professional development sessions were organized in the summer of 2018 in Houston targeting the energy industry. Both programs were two-days long and focused on two key aspects of high value manufacturing: manufacturing operations excellence and manufacturing quality excellence. The professional development sessions were focused on materials and inventory planning, production economics, manufacturing quality, non-destructive evaluation, statistical process control, and lean/ six-sigma. The continuing education programs and course materials were developed based on the feedback from the industry advisory board for the Manufacturing Center of Excellence at Houston Community College, which is a collaborating partner on the ATE Grant. As a part of assessment of the programs, industry participants in the both sessions were given comprehensive surveys asking for their feedback on the applicability of the educational sessions. Overall, the participants rated the sessions very highly on the organization and the relevancy of the program topics and learning materials. The participants also felt that they learned new information through these programs.

1. Introduction

Manufacturing has been a key pillar to economic growth and job creation for the United States (US) economy for a long time. Although a sizeable contraction was seen in US manufacturing for the past two decades, it is strongly believed that there is a projected revitalization thanks to increased demands, the dawn of cutting-edge technologies, and changing dynamics of global value chains (Ramaswamy, Manyinka et al. 2017). This revitalization of manufacturing sector is complemented by innovations that can be brought about by workforce comprising of highly skilled engineers and scientists. On the contrary, US recently dropped out of top 10 ranks from the list of innovation rankings, adversely affecting the prospects of revitalization in manufacturing industry (Jamrisko and Lu 2018). Furthermore, prior researchers point to fact that industries are increasingly finding it difficult to recruit workers with top skills (Giffi, McNelly et al. 2015). With the rapid advancement in manufacturing technologies, companies are also seeing

the gap in existing workforce. Meyer, Brünig et al. (2015) present their survey results of several top executives of European manufacturing companies regarding the competency gap in existing workforce. According to their study, the top four desired competencies in the current and future manufacturing workforce included: flawless execution, quality awareness, analytical ability, and adaptability (or openness to change) ((Meyer, Brünig et al. 2015), pp. 1009).

Unlike other industries, manufacturing still has an image problem among younger potential workers. For example, one survey by the Manufacturing Foundation finds that young people perceive manufacturing as dirty and poorly paid jobs (Garrison, 2014). According to a survey report published by Industry Week, only 45% of Americans think that manufacturing can be a viable career for young workers (Barr, 2018). In order to minimize such challenges in future, several large companies are also working with junior colleges and k-12 schools to prepare the next generation of manufacturing workforce. Such actions are very crucial given the lack of interest in manufacturing jobs among the general public including teenagers and Gen Y (Giffi et al., 2017). The aircraft manufacturing giant, Boeing, has been partnering with local high schools and community colleges in the state of Washington to introduce manufacturing into their academic curricula (Rosendin and Gielczyk, 2018). Likewise, the Northeast Wisconsin Manufacturing Alliance has partnered with the area high schools, colleges, and universities to create a future talent pipeline in manufacturing (Bushmaker and Franz, 2017).

Several prior publications have pointed out a widening gap between what is needed in the present day manufacturing industry and what is available in the existing workforce. Based on a study done by Tooling U-SME, ThomasNet News published a report in which it mentioned the manufacturing companies are far behind in addressing the training need of current workforce to prepare them for future. For example, according to a SME survey, nearly half of the respondents had not even started measuring the skills needed for the future. Likewise, an overwhelming 76% of respondents described that their current workforce skills set as not “adequate” to meet the future need (Tooling U-SME, 2016). According to Nagl (2018), a shortage of manufacturing talent can result into a huge setback for growth in manufacturing sector. For example, the author estimates that as many as 2.5 million manufacturing jobs will go “unfilled” in by year 2028 costing the nation $2.5 billion in GDP. The article also describes the various actions taken by the companies to mitigate the impact of workforce skills gap. Those actions included internal training provided by the senior employees to new hires, hiring decision based on competencies rather than experience, and employing automation where applicable to improve productivity. Another approach to bridge the skills gap is to provide customized continuing education to current the workforce as per the industry need.

The objective of this paper is to present a case study of an ATE grant that involved development of a customized continuing education sessions on high value manufacturing targeting energy industry. As mentioned earlier, the goal of the program was to bridge the skills gap of the existing workforce in energy industry. The remaining sections of the paper are organized as follows. Section 2 provide an overview of the ATE grant and its objectives along with the current state of the grant. Section 3 describes the course development process for the continuing education program and sample content. Section 4 presents a summary of evaluation of the program. Finally, section 5 wraps up the paper with some concluding remarks.

2. Overview of ATE Grant

This work refers to an Advanced Technological Grant from the National Science Foundation awarded to Texas A&M University and Houston Community College (HCC). The title of the project is "Providing an Adaptive Learning Environment for the Acquisition of High Value Manufacturing (HVM) Skills". The key objectives of the project were: 1) increase the number of technicians with the skills necessary for an immediate contribution to the HVM industry; 2) improve student engagement and participation in HVM topics; 3) provide students with a more personalized and adaptive educational experience; 4) promote student success in completing a HVM certificate program; 5) expand high school student and teacher knowledge of HVM skills and jobs; 6) enhance practicing professionals' knowledge of HVM topics; and 7) increase the number of certificate program students receiving credit towards a four year degree. The project thus far has already completed developing the certificate program and its courses. The program has already been approved by the Texas Higher Education Coordination Board. Currently, the program is being offered at Houston Community College. The program courses were developed in collaboration between PIs from Texas A&M University and the faculty members from Houston Community College. However, this paper specifically addresses objective number 6 which was focused on developing short courses on high value manufacturing topics for returning industry professionals. The short courses were offered in summer 2018. The following sections describe the course development and sample content along with the evaluation results.

3. Course Development Process and Sample Content

As mentioned earlier, there were two short courses offered as a part of the ATE grant. The course development process involved multiple steps as outlined below. First, an initial outline for a two and half day course was prepared and presented at the industry advisory board (IAB) meeting of Manufacturing Center of Excellence at HCC. While IAB members liked the overall content, it was suggested that the course be reduced to two-day from two and half-day. Further IAB members also suggested to prepare more focused courses on a specific topic rather than a general topic. In the next step, the initial general manufacturing topics were divided into two short courses focused on: a) manufacturing quality and b) manufacturing operations excellence. Both courses were two-day long. Lastly, the content was developed and offered over the summer of 2018. Furthermore, course learning objectives were determined by considering the need of returning industry professionals.

Table 1: Course learning objectives

Manufacturing Operations Excellence Program	Manufacturing Quality Excellence Program
Understand and implement effective inventory management techniques	Define appropriate quality metrics for your business/products/services
Utilize key inventory control concepts like EOQ, safety stock and re-order point	Inspect and identify manufacturing defects using Non-destructive evaluation techniques
Understand the cost drivers and maximize the economic return from a manufacturing operation	Compare product measurements to specifications using Process Capability Analysis
Improve the production process by reducing cost and minimizing non-value added time	Maintain/Improve the quality of a manufacturing process by utilizing Statistical Process Control (SPC)
Apply quality management techniques to reduce manufacturing and supply chain costs	

Table 1 shows the course learning objectives for both 'manufacturing operations excellence' and 'manufacturing quality excellence' continuing education programs. Similarly, Tables 2 and 3 illustrate the sample topics covered in quality and operations courses respectively. The operations excellence program has three modules focusing on operations management aspect of manufacturing such as inventory management, material planning, production economics, and supplier quality assessment.

Table 2: List of key topics covered in the short course on Manufacturing Operations Excellence

Modules	Contents
Inventory Management Best Practices	Inventory classification Inventory costs and economic order quantity Re-order point and safety stock
Manufacturing Operations Management	Production cost-assessment and management Materials requirements planning Minimizing manufacturing waste and non-value added time
Quality Management Best Practices	Assessing supplier quality, assessing the cost of poor quality.

On the other hand, manufacturing quality courses covered topics related to product quality such as quality management framework, non-destructive evaluation, statistical process control, and lean-six sigma. Both courses were equipped with several hands-on exercise and best practices that industry participants could implement in their work setting.

Table 3: List of key topics covered in the short course on Manufacturing Quality

Modules	Contents
Defining and Measuring Quality	Basics of Quality Cost of poor quality during measurement and analysis
Non-Destructive Evaluation	Identifications of manufacturing defects Types and selection of appropriate NDE methods Analysis and interpretation of data
Statistical Process Control	Statistical Process Control Process Capability Analysis

4. Evaluation

As noted previously, the two continuing education programs were offered in the summer of 2018. At the conclusion of the course, the attendees were asked to complete a course evaluation that consisted of both Likert-scale questions and open ended questions. The Likert-scale questions were tabulated using a five-point scale (1 - Strongly Disagree, 2 - Disagree, 3 - Neither Agree nor Disagree, 4 – Agree, and 5 - Strongly Agree). These questions are shown below.

- Likert-scale Course Evaluation Questions

- Course materials are very well designed and organized
- The course materials are very hands-on and relevant to my job
- I feel like I learned a lot about "module name" best practices through this session
- I would like to attend more "module name" educational sessions to enhance my knowledge

- Open Ended Questions
  - What did you like about this session?
  - What area can be improved to make this session more effective?
  - Based on what we discussed, what are the two things you will commit to changing in your organization?

The first course, Manufacturing Operations Excellence had 18 attendees; of these 11 filled out the end of course assessment. In addition to survey answers respondents, were asked to provide their gender, age, highest education attained, employment status, job designation and race/ethnicity. Of the respondents, 4 were female and 7 were male. The average age was 39.3 years. For educational attainment, 1 participant had a doctoral degree, 2 had master's degrees, 4 had bachelor's degrees, and the other 4 high school diplomas and/or some college. The responses to the course evaluation questions are shown in Table 4. Representative responses for the open ended questions are shown in Table 5.

Table 4: Course Evaluation Responses for Manufacturing Operations Excellence Course (out of 5)

	Inventory Management	Operations Management	Quality Management
Course design and Organization	4.36	4.45	4.36
Hands on and Relevant	4.18	4.27	4.18
Learned a lot	3.91	4.00	3.91
Interest in future sessions	4.18	4.36	4.00

Table 5: Open Ended Responses for Manufacturing Operations Excellence Course

Open Ended Question	Representative Response
What did you like about this session?	I liked that everything was well explained and let me be more aware and what is needed in inventory management point of view
What area can be improved to make this session more effective?	Have set examples for the break-out discussions. For someone who has no knowledge it's hard to continue without experience
Based on what we discussed, what are the two things you will commit to changing in your organization?	Learn more about my companies inventory management process

The second course, Manufacturing Quality had 28 attendees; of these 20 filled out the end of course assessment and 18 consented to have their data used for research purposes. Again, respondents were asked their demographic information. Of the respondents, 10 were female and 8 were male. The average age was 45.4 years. For educational attainment in this group, 3 participants had master's degrees, 7 had bachelor's degrees, 4 has associates degrees, and the remaining 4 high school diplomas and/or some college. The responses to the course evaluation questions for this session are shown in Table 6. Representative responses for the open ended questions are shown in Table 7.

Table 6: Course Evaluation Responses for Manufacturing Quality Course (out of 5)

	Defining and Measuring Quality	**Non-destructive Evaluation**	**Statistical Process Control**
Course design and Organization	4.45	4.3	4.33
Hands on and Relevant	4.00	3.13	3.94
Learned a lot	4.15	4.05	4.06
Interest in future sessions	4.30	3.5	4.17

Table 7: Open Ended Responses for Manufacturing Quality Course

Open Ended Question	Representative Response
What did you like about this session?	For me thinking through how to implement quality and carry out changes in my business had the most information that made an impact to me
What area can be improved to make this session more effective?	I believe that the only way to make this class even better would be to physically see some of this in a lab setting
Based on what we discussed, what are the two things you will commit to changing in your organization?	Implementing a way to track cost of quality in order to track rework and waste, Use value streaming for processes that have high wait times in order to improve and reduce that wait time

5. Summary and Conclusions

The extant research and employment data reveals that there is shortage of skilled workforce in manufacturing. Our research also revealed that even the existing manufacturing workforce needed to be trained to upgrade their skills to match the requirements of 21st century high value manufacturing. In order to mitigate the lack of interest in manufacturing job among younger generation and the existing skills gap in the current workforce, manufacturing companies are partnering with high schools and universities to develop the appropriate curriculum and conduct necessary training programs in the forms of continuing education and certificate programs. This paper presented a case of an ATE funded project in high value manufacturing. As a part of project, two continuing education sessions were offered in manufacturing operations and quality

focusing on energy industry. The programs were offered in Houston, Texas in summer of 2018. There were in total 46 participants between the two programs. The course evaluation survey conducted at the end of the both programs showed that the industry participants rated all aspects of courses highly with an average score of four or higher (out of five). The course evaluation was focused on four aspects of the programs: course design and organization, hands on and relevant, how much they learned, and interest in similar sessions in future. As mentioned earlier, for both programs, the participants rating was close to four or higher except for "non-destructive evaluation(NDE)" module. The main reason for slightly lower score for NDE module could be due to two reasons: first, the participants background, and the nature of content (highly technical). On the other hand, from the program design perspective, it was a very important feedback for design of future professional development sessions. Lastly, the numerical evaluation scores were also supported by the positive open ended comments which suggested that the both continuing education programs were well received by the industry participants.

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