

Examining Pre-Service Engineering Technology Teacher Perceptions of Manufacturing

Lisa Bosman, PhD
Assistant Professor, Transdisciplinary Studies in Technology
Department of Technology Leadership and Innovation
Purdue University
West Lafayette, IN, USA
lbosman@purdue.edu

Greg Strimel, PhD
Assistant Professor, Engineering Technology Teacher Education
Department of Technology Leadership and Innovation
Purdue University
West Lafayette, IN, USA
gstrimel@purdue.edu

Abstract—As the 4th industrial revolution permeates its way into the U.S. economy, so does an increase in demand for skilled workers in the manufacturing sector. However, Deloitte’s 2017 report titled “Manufacturing matters: The public’s view of US manufacturing” suggests that although Americans value manufacturing as a strong economic sector, many Americans are reluctant to pursue manufacturing careers; specifically, one-third of the U.S. population would not encourage children to pursue a career in manufacturing. In addition, the literature suggests that very few high schools are using manufacturing curricula, for reasons commonly related to lack of money and resources. Furthermore, a review of university programs suggests that college-level teacher education students are not being exposed to the high demand for manufacturing workers, especially as a career choice for high school graduates. Considering K-12 teachers have a lot of potential for influencing students towards manufacturing [or away from manufacturing], there is a gap in addressing manufacturing awareness for pre-service teachers. This paper provides preliminary results from a qualitative study deploying participatory action research, with a focus on photo-voice and photo-elicitation. This study investigates pre-service engineering technology teacher perceptions of manufacturing and makes recommendations for increasing manufacturing awareness in K-12.

Keywords—participatory action research; pre-service teachers; teacher educators; manufacturing; career perceptions

I. INTRODUCTION AND BACKGROUND

In 2016, there were 343,000 manufacturing jobs available, yet close to 400,000 manufacturing workers were unemployed, along with another 6,461,000 workers in the general population in May 2017 [1]. Despite the abundance of available workers, manufacturing companies continually struggle to hire qualified

employees [2]. The limited pool of qualified workers, including hourly and salary workers, creates a challenging environment for manufacturing organizations who vie for the short supply of experienced and capable workers [2]. This misalignment costs individual companies millions of dollars, unemployed workers stable jobs, and the US economy a global manufacturing advantage.

Deloitte’s 2017 report titled “Manufacturing matters: The public’s view of US manufacturing” suggests that although Americans value manufacturing as a strong economic sector, many are reluctant to pursue manufacturing careers. Specifically, one-third of the U.S. population would not encourage children to pursue a career in manufacturing because (a) 77% are worried about security and stability, (b) 70% don’t believe manufacturing is a strong career path and (c) 64% believe manufacturing does not pay enough. However, on the bright side, those Americans that are familiar with manufacturing are almost two times as likely to encourage children to pursue a career in manufacturing [3].

In summary, the researchers proposed that a major problem with the limited pool of qualified workers seeking manufacturing jobs is the misperception and lack of awareness around the opportunities manufacturing has to offer both high school and higher education graduates [4].

At the college level (including technical colleges and larger universities), students can enroll in skilled trades apprenticeship programs (e.g. electrician, pipefitting, etc...), complete a certificate (e.g. CNC machining, welding, etc...), complete an associate’s degree in professional manufacturing areas (e.g. supply chain management, manufacturing technology, automotive performance technology, etc...),

complete a bachelor's degree in professional manufacturing areas (e.g. manufacturing engineering technology, advanced manufacturing, etc...), and even do graduate level work with a thesis and/or dissertation focus related to manufacturing. Unfortunately, the literature suggests that very few high schools are using manufacturing curricula, and for good reasons. Manufacturing curriculum can require more advanced facilities, thus making the instruction unaffordable to many schools. Furthermore, a review of university programs suggests that college-level teacher education students are not being exposed to the high demand for manufacturing workers, especially high school graduates. The Deloitte 2017 report suggests that people familiar with manufacturing are twice as likely to encourage children to pursue a career in manufacturing [3]. Considering K-12 teachers have a lot of potential for influencing students [5] either towards manufacturing or away from manufacturing, there is a gap in addressing manufacturing awareness for pre-service teachers (pre-service teachers are students, typically undergraduates, enrolled in a teacher preparation program and working towards a teaching certification). Therefore, the purpose of this study was to learn about manufacturing perceptions/misperceptions from the perspective of pre-service teachers, and how it potentially impacts students in K-12 classrooms. The research question that guided this study was:

Research Question: How can we better inform students, parents, teachers, and society on education and career paths within manufacturing?

Manufacturing is an economic driver of entrepreneurship, innovation and prosperity through job creation and life improvements including food, pharmaceuticals, and technology. As a result, this paper addresses societal/community wellbeing, sustainability, and entrepreneurship, to name a few, through better understanding the role teachers play in influencing children's perceptions of manufacturing careers. This paper will (1) summarize perceptions and misperceptions of manufacturing through the lens of pre-service teachers, and (2) provide ideas for how K-12 system can better inform students, parents, teachers, and society on education and career paths within manufacturing.

II. METHODS

The qualitative approach of participatory action research (PAR) with a specific focus on photo-voice and photo-elicitation was employed to gather data regarding pre-service teacher perceptions of manufacturing. This approach required participation from pre-service teachers studying to become secondary engineering technology teachers. The results this research methodology can provide valuable information for informing future development of K-12 STEM curriculum and teacher preparation programs.

A. Participants

Following approval from the university's Institutional Review Board (IRB), the qualitative approach of PAR was initiated by recruiting pre-service teachers studying engineering technology education. In total, 12 participants, all of whom were planning to become a secondary engineering

technology teacher, were enrolled in the study—four female and eight male with ages ranging from 19 to 22 years.

B. Data Collection

Participants were required to attend an initial individual interview to gain an understanding of participation expectations and sign IRB paperwork. Each of the participants were then required to submit 8 photos related to perceptions of manufacturing. Since the demand for manufacturing jobs is a national, and even global, issue, the researchers intentionally took a holistic focus and approach to how perceptions are formed, requesting student participants to consider perceptions of manufacturing from a variety of viewpoints. The photograph prompts were as follows:

Take a picture representing what you think...

1. *of careers in manufacturing.*
2. *society perceives of careers in manufacturing.*
3. *parents perceives of careers in manufacturing.*
4. *K-12 students perceive of careers in manufacturing.*
5. *K-12 teachers perceive of careers in manufacturing.*
6. *K-12 STEM teachers perceive of careers in manufacturing.*
7. *pre-service teachers perceive of careers in manufacturing.*
8. *manufacturing engineering technology students perceive of careers in manufacturing.*

Each picture required a three to five sentence narrative explaining the photograph choice. Individual participants then submitted a document, containing the eight photographs and eight narratives. Once all the submissions were received, the researchers created a slide show using the photographs submitted by the students. The slide show was anonymous. The purpose of the slide show was to further elicit comments within a focus group setting. The following questions were used as a guide for the focus group.

- *What perceptions do you see here?*
- *What one word or phrase would best describe what you see and hear?*
- *Where does this information come from? How are these perceptions made?*
- *How might we better educate K-12 students on manufacturing careers?*

C. Analysis

The NVivo 11 qualitative analysis software was used to analyze the photographs and the focus group transcript. All data were imported into NVivo and the researchers coded and highlighted the documents with the purpose of identifying themes related to the research question and picture taking prompts. Upon completion of the independent analysis, the researchers compared their results, read through the

documents again, and came to a consensus for developing themes and a coding framework.

III. PRELIMINARY FINDINGS AND DISCUSSIONS

Analysis of the photographs, narratives, and focus group discussion led the researchers to identify five themes related to perceptions of manufacturing education and career paths: (1) manufacturing with a hidden veil, (2) media sources of perceptions, (3) education sources of perceptions, (4) manufacturing environments as less desirable, and (5) taking action.

A. *Theme 1: Hidden Veil / Closed Doors – Things Magically Get Produced*

Participants were quick to recognize that society views manufacturing as important, however, little is known about the actual process occurring within the facility. Many participants provided pictures of the outside of manufacturing facilities, noting limited information for what happens inside. The photograph narratives provided by participants that align with this theme include:

“A majority of society doesn’t understand the processes that go into manufacturing but rather only understand the outcome.” [Picture taken of a building.]

“Society perceives that everything being manufactured is overseas. After all it is understandable to think that when so many of our products say ‘Made in China’. So they will think that there are little to no jobs in the industry in America.” [Picture taken of tag stating “Made in China”.]

“Most are probably going to think of the large smoke stacks and hard labor or factories.” [Picture taken of manufacturing facility with smoke stacks.]

“I think that students think that technology and robots do the work of manufacturing now and that people don’t do all that much.” [Picture taken of an old abandoned factory that hasn’t been in operation since 1992.]

In summary, pre-service engineering technology teachers believe that little is shared in the general media about what happens behind the closed doors of a manufacturing facility. And quite often, many manufacturing facilities have a preference to keeping buildings closed to the general public due to intellectual property, patents, trademarks, copyrights and/or trade secrets. For the small percentage of manufacturing companies that do offer tours, the viewing is typically limited to viewing end products (such as the BMW Experience in Munich, Germany) or seeing an assembly line (such as the Subaru plant in Lafayette, IN). In either case, more often than not, taking pictures is not allowed. As a result, consumers naturally focus more on the product and features rather than the process for making the product. Similar to the “endless” availability of electricity in the wall outlets, consumers are more interested in having access to electricity and less concerned with how the electricity is produced. As a

result, little is known around what actually takes place behind the closed doors of a manufacturing facility.

B. *Theme 2: Peoples’ Perceptions Are Based on Movies, TV, and Books*

Per the previous theme, since little is known about what actually takes place behind the closed doors of a manufacturing facility, people’s perceptions seem to be highly dependent upon movies, TV, and books. The photograph narratives provided by participants that align with this theme include:

“If I was asked to give off of the top of my head what an average manufacturing worker looks like I would picture bob the builder.” [Picture taken from children’s TV show, “Bob the Builder”]

“Through my schooling whenever manufacturing was brought up the miracle of the assembly line soon followed. I think that they think that factories still only use this method to create their products.” [Picture taken from textbook, black and white photo of Industrial Revolution]

“Everyone’s view of careers in manufacturing is outdated and think that everything is still just workers on the assembly line. Even the oompa loompas don’t know.” [Picture taken from TV movie, Oompa Loompas from “Willy Wonka and the Chocolate Factory”]

“Many often focus on a small aspect of manufacturing, specifically the recorded history of the field. This is great for students to see, but they aren’t exposed to the real life information regarding what the job requires and who is capable of participating in it.” [Picture taken of a banner showcasing the history of an individual manufacturing company.]

“Students tend to see manufacturing as the old-fashioned large mechanical items that have been portrayed in movies. Often times there is a lot of dirt and grime involved.” [Picture taken of the outside of a manufacturing facility.]

In summary, pre-service engineering technology teachers believe that the media has a great potential to influence people’s perceptions of manufacturing careers and manufacturing environments. However, they realize that convincing people to stop watching the classics is far from plausible. Therefore the pre-service teachers recommend taking updating K-12 social studies standards and textbooks to help address the highlighted concerns.

C. *Theme 3: Peoples’ Perceptions Are Based on Previous K-12 Educational Experiences*

Another theme that emerged based on the photo-voice and photo-elicitation process centered around the influence of K-12 education on a person’s career perceptions. Taking into

consideration Theme 1 and 2, since little is known about what happens behind the closed doors of manufacturing, the classroom can provide another way for people to gain perceptions of what manufacturing is like. The photograph narratives provided by participants that align with this theme include:

“I believe students will think manufacturing is what they experience in high school. They will believe these careers involve machining tools, similar projects, and similar overall experiences.” [Picture taken of machining lab at a university.]

“I liked this picture because it showed manufacturing education tools – (a robotics platform) – and a lab in the background.” [Picture taken of a robotics platform set up in a production line format.]

“Besides the Project Lead the Way classes, at my high school, the only classes that dealt with manufacturing was the one that was tasked with building a home throughout the school year. [Picture taken of a house being built.]

“STEM teachers use all sorts of technologies such as robots, PLCs, coding, legos, etc. to hit on all sorts of careers in manufacturing you could possibly investigate later in life.” [Picture taken of students programming a robot.]

Through the focus group discussion, the pre-service engineering technology teachers recommended that we need to be careful of limiting manufacturing education to STEM, hands-on, and technology-focused contexts. All sorts of careers, from accountants to graphic designers to human resources to managers, are required in manufacturing. Thus, if courses are limited to a technical and experiential context, the pre-service teachers believe it has the potential to turn people away from the field.

D. Theme 4: Manufacturing Environments are Perceived as Less than Desirable

Participants were quick to recognize that society views the manufacturing working environment as less than desirable. In alignment with theme 2, the participants believe that people often still perceive the manufacturing environment as a grey and dirty place housing a more traditional-style assembly line. Many of the participants provided pictures of dark and dirty manufacturing facilities and traditional manual assembly lines. The photograph narratives provided by participants that align with this theme include:

“I choose this picture because it is messy, filled with scraps and tools, and dark.” [Picture taken of machine shop in university basement]

“This picture is just a part of a very large manufacturing assembly line. Most parents probably don’t see a future in manufacturing for today’s students. They probably only

think of workers on the line and it being an unimportant, underpaid job.” [Picture of manufacturing assembly line.]

“I took this picture of a local steel mill that is scrutinized by our community for pollution. I do not believe that it is frowned upon to have a manufacturing career, but they are not seen as the most glamorous careers to pursue and can be seen as “dirty” and “polluting”. [Picture of smoking coming from a mill’s smoke stacks.]

“Most entry level jobs in manufacturing do not require a college degree to apply for.” [Picture taken of a dirty factory.]

In summary, despite K-12 STEM-based manufacturing coursework, such as offerings through Project Lead the Way, pre-service engineering technology teachers believe that manufacturing environments and careers continue to be perceived as less than desirable.

E. Theme 5: Taking Action to Increase Awareness on Manufacturing Careers

After talking about perceptions related to manufacturing, participants were encouraged to brainstorm how might we better educate pre-service teachers on manufacturing careers. Many participants were encouraging about the importance of manufacturing internships/externships for pre-service teachers. Notable conversation quotes were as follows:

“I really like what [my professor] is doing. He's actually sending some of the pre-service teachers here to factories and having them report back and do different things.”

“Yeah, so just require authentic research; just something every student has to do.”

“Manufacturing jobs are very diverse and there's a way to connect basically any type of job that you have in mind to it.”

“You could literally connect all education fields and what not into a manufacturing type career.”

In summary, the participants believe there is great potential to reach K-12 students by providing manufacturing learning experiences all pre-service teachers within their undergraduate teacher education programs. They also believe this will benefit both manufacturing and the economy.

IV. CONCLUSIONS

As with any research, this investigation has limitations. First, the exploratory nature of qualitative research and the small sample size provides limited generalizability. Second, due to limited resources, participation targeted engineering technology pre-service teachers. As such, participation did not include pre-service primary teachers or other STEM teacher education students. Lastly, the participation was limited to pre-

service teachers enrolled in one land-grant university located in the Midwest. Although the location for this study was within a very manufacturing-centric state, our participant group could be more biased than participants located in other states or regions.

While there are certainly limitations in this preliminary analysis and the PAR methodology, the resulting themes from this study can provide some valuable information for informing future development of K-12 STEM curriculum and teacher preparation programs. For example, despite the increasing number of K-12 STEM curriculum programs, pre-service engineering technology teachers believe that manufacturing environments and careers continue to be perceived as less than desirable. As such, they believe that more authentic and locally connected STEM coursework should be offered in schools. In addition, while society may view manufacturing as important, the participants posit that little is known about the actual processes happening within the facility. Therefore, pre-service teachers recommend that more opportunities for exposure to such facilities are provided throughout primary and secondary school. The pre-service teachers also seem to welcome opportunities for manufacturing learning experiences during their undergraduate degree programs specifically through manufacturing internships/externships. They believe these experiences will help share teachers' perceptions of manufacturing and provide them with a better foundation for informing K-12 students about potential career options. Lastly, the pre-service teachers recognize that television and movies are some of the main sources for a person's perceptions of manufacturing careers and manufacturing environments. Therefore, they recommend establishing better methods for integrating social studies with STEM coursework to provide students with a more current view of the social technological integration of manufacturing and the future of the workplace/workforce.

Furthermore, these preliminary findings can serve as a foundation for future research considering the "voice" of other pre-service teachers (e.g. primary, science, mathematics, etc...) in an effort to see how the perceptions and brainstorming ideas

compare to this group. Future researchers should also consider the "voice" of other pre-service teachers located in different regions. The state in which this study took place has the highest percentage of citizens employed in manufacturing; therefore, it would be interesting to compare the perceptions and brainstorming to states where manufacturing is less of an economic driver. Finally, future research should put the brainstorming into action and make an attempt to measure the impacts, direct and indirect (longitudinally).

ACKNOWLEDGMENT

The authors would like to acknowledge internal funding from Purdue University's Big Idea Challenge: Realizing Next-Generation Smart Manufacturing (PI, Dr. Nathan Hartman).

REFERENCES

- [1] Bureau of Labor Statistics Occupational Employment Statistics. (2017). *Employment and Unemployment Data by State*. Available: <https://www.bls.gov/>
- [2] Society for Human Resource Management. (2015). *Hiring Challenges and Trends in Manufacturing: SHRM Annual Conference Workshop*. Available: <https://www.shrm.org>
- [3] Deloitte & Touche LLP. (2017). *Manufacturing matters: The public's view of US manufacturing*. Author. Retrieved from <https://www2.deloitte.com/us/en/pages/manufacturing/articles/public-perception-of-the-manufacturing-industry.html>
- [4] Walls, W. H., & Strimel, G. J. (2017). Improving regional manufacturing ecosystems: Developing authentic, industry-driven design projects. *Technology and Engineering Teacher*, 77(4), 36–41.
- [5] Love, T. S., Love, Z. J., & Love, K. S. (2016). Better Practices for Recruiting T&E Teachers. *Technology & Engineering Teacher*, 76 (1), 10–15.