Changing the Manufacturing Perception of Millennial and Generation Z Engineering Students

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Abstract

Over five years of work in an industrial engineering manufacturing process course has been carried out to understand engineering undergraduate student perceptions of manufacturing in the United States. This paper discusses a holistic approach being taken in an industrial engineering program to understand Millennial and Generation Z student manufacturing perception while working to get students interested in manufacturing careers through coursework, internships, and co-op experiences. The generation divisions are often argued about, but Millennials are generally thought of as being born from the early 1980s to the mid-1990s with Generation Z following. Millennials can be defined as those born from 1981 to 1996, with Generation Z following from 1997 on. The results of over five years of questionnaire data shows that a well-designed manufacturing processes course equipped with hands-on labs, plant visits, and manufacturing job fairs can be effective in changing student's perception of manufacturing. It is also shown that campus location may play a key part in industrial engineering student knowledge of manufacturing and the percentage of students completing internships and co-ops in manufacturing. Data was collected across two campuses within the same U.S. University where both campuses offer B.S. degrees in Industrial Engineering. The enrollment at the two campuses and manufacturing footprint around the two campuses are significantly different and this is discussed with the results of the survey data.

Introduction

The Society of Manufacturing Engineers reports that a "Silver Tsunami" is occurring in manufacturing as baby boomers continue to retire [1]. It is of utmost importance to attract Millennials and Generation Z to work in the manufacturing sector of the U.S. Economy. The United States has declared the first Friday in October Manufacturing Day. Most of the current talk in the media surrounds the need for skilled workers in manufacturing. The manufacturing sector of the U.S. economy desperately needs a workforce with a blend of both strong hands-on trade skills and the technical problem-solving skills typically learned through the completion of a B.S. Industrial Engineering program. As companies focused on "doing more with less" and sending more profits on to shareholders, they abandoned the manufacturing apprentice programs that kept skilled workers in the pipeline for decades. Today, manufacturers expect students coming out of engineering and technical programs to be able to contribute immediately. As a result, multiple internships and co-op experiences have become crucial for industrial engineering students.

Motivation and Literature Review

Manufacturing in the U.S. represented 19% of private GDP and 17% of total GDP in 2018 [2]. It is also known that for every $1 spent in manufacturing, an additional $1.37 is added to the economy. The highest multiplier effect of any industry [3]. The Bureau of Labor Statistics indicated that manufacturing represented 7.9% of employment in the U.S., employing 12.3 million workers [4]. Of this workforce, over 28% have a Bachelor degree or higher and 26% have some college; with all of these percentages increasing from 2000 to 2012 [5]. In 2013, the average manufacturing worker earned $77,506 in salary and benefits, which is 24% more than

the average worker in all other industries ($62,546) [6]. The manufacturing sector in the U.S. would be the 9th largest economy in the world [7].

Regrettably, many future engineers have developed incorrect assumptions regarding the manufacturing sector. These students have the impression that manufacturing is a struggling industry in the U.S. with limited job and growth potential. Obviously, this is an incorrect conclusion. In addition, there is a skills-gap with the baby boomer generation retiring and a shortage of available skilled workers. In a 2011 survey of 1,123 manufacturing executives 67% reported a moderate to severe shortage of available and qualified workers. Also, 60% stated they were experiencing a moderate to severe shortage of industrial engineers, manufacturing engineers, and/or planners [8].

The manufacturing industry is considering approaches to reduce the skills gap by partnering with universities, community colleges, and certification providers. In a report co-authored by Deloitte and The Manufacturing Institute entitled "Boiling Point? The Skills Gap in U.S. Manufacturing", it was noted that the lacking skills in college graduates to the manufacturing workforce are those that have the most impact on operations and require the most technical training. The manufacturing industry is impacted by students moving away from STEM fields, which will lead companies and manufacturers to be unable to fill technical positions. This issue must be fixed within the classrooms across the U.S. by offering more manufacturing exposure to students in the classroom [9].

Manufacturing engineering education is primarily associated with industrial engineering and mechanical engineering. Manufacturing is the production and processes, as well as the required personnel, machines, and equipment to produce a certain product. Industrial engineers are concerned with the processes of the production line, whereas the mechanical engineers are focused on the components of the systems, such as the machines and lines. Courses are often integrated into these two engineering disciplines to allow for some exposure to the manufacturing industry. A paper by Todd, et al. in the *Journal of Engineering Education* notes that a movement to move to higher course content on manufacturing in both of these disciplines is needed[8]. Many current engineering programs do not emphasize the marriage of design and manufacturing in a modern industrial technical workforce [10].

Many research studies have assessed the quality of exposure to manufacturing through the senior design or capstone course. McMasters and Lang indicate that few people in industry have an understanding of how the current engineering education is undertaken. Through design projects, the inclusion of industry partners in the education process will enhance the education provided to the students and better reflect the expectations of industry [11]. Universities are exposing students to manufacturing through senior capstone design courses to offer students with a realistic perspective of industry needs and economic principles [12].

Government organizations are also a sector where manufacturing skills are needed, including the Department of Defense and the Department of Energy. A report by the National Academies indicated that remanufacturing of weapons systems and nuclear systems, as well as maintaining facilities for the maintenance and production of systems, is a strategic need for the security of the U.S. [13]. The Defense Advanced Research Projects Agency (DARPA) has also supported

research to reduce the cost and increase the speed of delivery of high-quality manufactured goods. This program investigates the capability of supporting advanced manufacturing applications that range from the aerospace, to chemical, to pharmaceutical, to everyday manufactured goods [14].

There are many articles in the engineering education literature that focus on manufacturing education. An article published in 2015 discussed the implications of having a manufacturing internship or co-op experience on industrial engineering students. The perceptions of the students changed significantly with regards to working in the manufacturing sector upon graduation [15]. The "four pillars of manufacturing knowledge" was developed and is maintained by the Society for Manufacturing Engineers [16]. In a 2014 paper, Ermer presented the four pillars of manufacturing knowledge in the education plan for a mechanical engineering concentration of a general engineering program, specifically in the manufacturing processes course. It identified various engineering programs in Michigan with mechanical engineering degrees or concentrations, and then identified similar course outcomes for a manufacturing processes course. It also identified how these various programs are meeting or not meeting the recommendations of the four pillars, with recommendations to align the university program with the four pillars by recommending different course content for addition and subtraction to the manufacturing processes course (e.g., additional lecture for nanotechnology, subtraction of a lecture for costing and finishing) [17].

As much of the current U.S. workforce in manufacturing approaches retirement, it is important that the current generation of college students becomes interested in manufacturing as a career path. The Society of Manufacturing Engineers Strategy recommends promoting the wide availability of jobs that can be found in manufacturing careers. Students can be motivated to pursue a certain career path if they see the value and need for skilled engineers [18-20].

The manufacturing processes course discussed in this specific study introduces industrial engineering students to the theory, principles, mechanisms, and concepts of solidification/additive manufacturing processes for materials, emphasizing process selection and the effects of process capabilities and limitations on design, costs, and quality. The course includes lectures, hands-on laboratories, manufacturing facility visits, demonstrations, videos, and manufacturing extension readings. The course covers material structures, mechanical testing and properties, metalcasting processes, joining processes, polymer processes, solid state deformation processes, advanced/additive manufacturing processes, and manufacturing process cost estimation.

Results and Discussion

Over the span of five school years, data was collected in the same industrial engineering manufacturing process course across two Penn State University campuses regarding millennial and generation Z interest and perception of manufacturing specifically as it relates to:

(1) Student interest/perception of manufacturing before and after taking the manufacturing process course
(2) How students felt about pursuing a career in manufacturing before and after taking the manufacturing process course
(3) Placement of students in manufacturing internships and co-op positions

The survey data from the large main campus at University Park comes from the classes from 2014 and 2015 with a total of 113 survey takers. The survey data from the Behrend campus comes from 2016 through 2018 with a total of 55 survey takers. The gender breakdown for the students answering the survey is displayed in Figure 1 below. The academic classification of the students answering the survey is displayed in Figure 2 below. At University Park in 2014, out of a total of 56, there were 39 male students (69.64%) and 17 female students (30.36%). There were 19 Seniors (33.93%) and 37 Juniors (66.07%). In 2015 at University Park, there were a total of 58 students, with 35 male (60.34%) and 23 female (39.66%). There were 19 Seniors (32.76%) and 39 Juniors (67.24%).

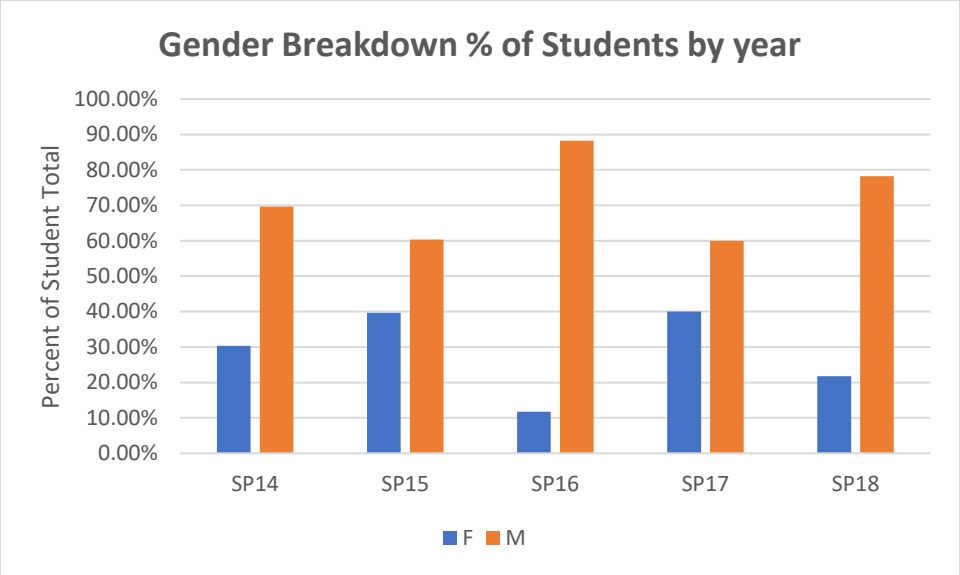

Figure 1: Gender Breakdown of Students Taking the Survey by Year

At the Behrend campus in 2016 there were 17 students, with 15 male (88.24%) and 2 female (11.76%). All 17 students were Juniors. In 2017 at Behrend, there were 15 students, with 9 male (60.00%) and 6 female (40.00%). All 15 students were Juniors. In 2018 at Behrend, out of a total 23 students, 18 students were male (78.26%) and 5 female (21.74%). Of the 23 students, 3 were Seniors (13.04%) and 19 were Juniors (82.61%).

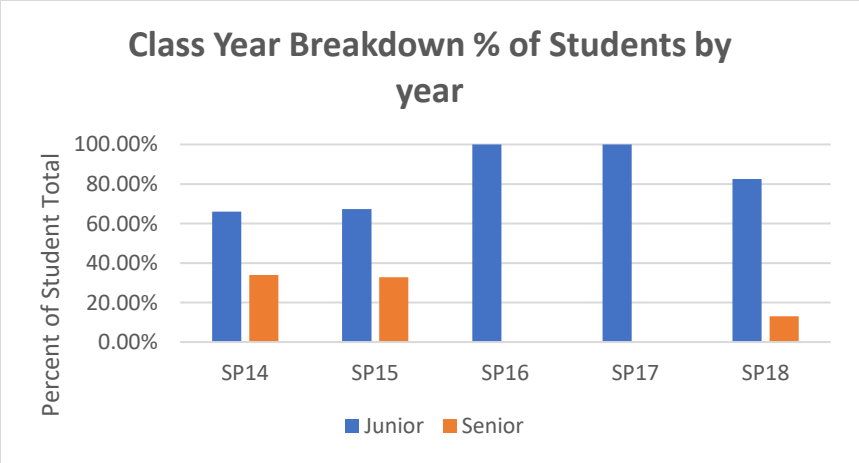

Figure 2: Academic Classification of Students Taking the Survey by Year

At the end of the industrial engineering manufacturing processes course, the students were given a survey to complete regarding their experience in the course as well as their perception and knowledge of manufacturing. The relevant manufacturing knowledge and perception questions asked of the students are shown in Table 1 below.

Table 1: Manufacturing Knowledge and Perception Survey Questions

6. Before taking this course, my knowledge of manufacturing processes was: (Circle Only One) No knowledge or Very Little Some Basic Knowledge Strong Knowledge Base
7. Before taking this course, what was your perception of Manufacturing? _____
8. Before taking this course, did you ever consider a career in manufacturing? YES or NO
9. After taking this course, would you consider a career in manufacturing? YES or NO

The students were asked about their knowledge of manufacturing processes before taking the manufacturing process course. The options given were "No knowledge or very little", "Some basic knowledge", and "Strong knowledge base". The breakdown of the student responses to this question are shown in Figure 3 below.

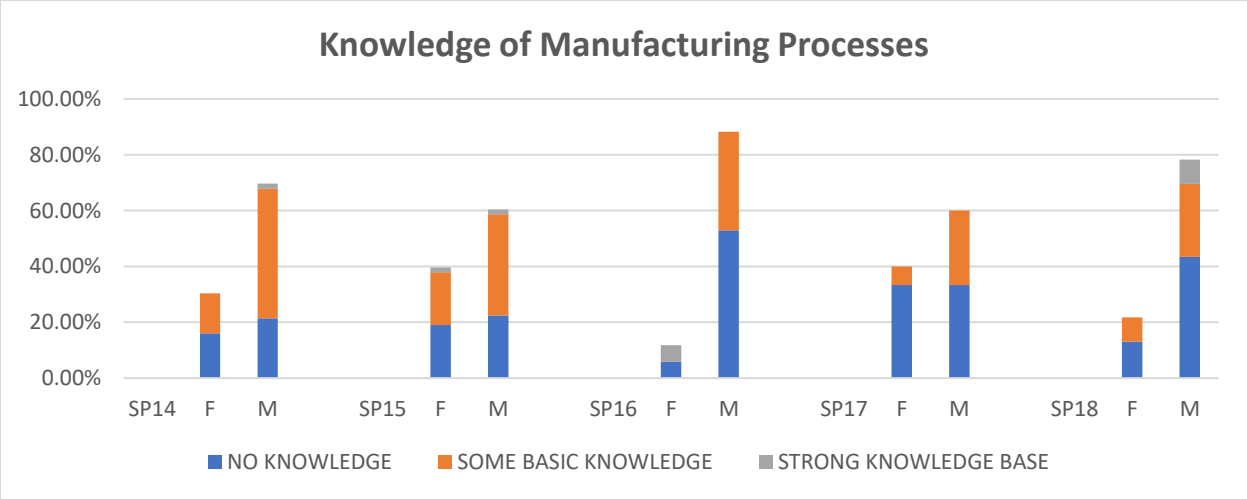

Figure 3: Student Knowledge of Manufacturing Processes Before Taking the Manufacturing Processes Course

At University Park, in 2014, none of the female students responded that they had a strong knowledge base, 8 said they had some knowledge (14.29%) and 9 said they had no knowledge (16.07%). One male student said he had a strong knowledge base (1.79%), 26 said they had some knowledge (46.43%), and 12 said they had no knowledge (21.43%). In 2015 at University Park, 1 female student said they had a strong knowledge base (1.72%), 11 had some knowledge

(18.97%), and 11 had no knowledge (18.97%). One male student said they had a strong knowledge base (1.72%), 21 said they had some knowledge (36.21%), and 13 had little or no knowledge (22.41%).

At the Behrend campus in 2016, 1 female student said they had a strong knowledge base (5.88%), and one said they had little to no knowledge (5.88%). Six of the male students said they had some knowledge (35.29%) and 9 said they had little to no knowledge (52.94%). In 2017 at Behrend, 1 female student said they had some knowledge (6.67%) and the remaining 5 said they had little to no knowledge (33.33%). Of the male students, 4 said they had some knowledge (26.67%) and the remaining 5 had little to no knowledge (33.33%). At Behrend in 2018, 2 female students said they had some knowledge (8.70%) and 3 had little to no knowledge (13.04%). Of the male students, 2 said they had a strong knowledge base (8.70%), 6 said they had some knowledge (26.09%), and the remaining 10 had little to no knowledge (43.48%).

The students were asked an open-ended question about their perception of manufacturing before taking the manufacturing processes course. At the University Park campus in 2014, one half (50%; 28 out of 56) of the students responded to the question. A breakdown of the student responses is shown in Table 2 below.

Table 2: Responses for Student Perception of Manufacturing before taking the manufacturing processes course

(4) Manufacturing is for making or producing goods through processes
(3) No Idea
(3) High production factories or on the floor at a facility
(3) Worked in Manufacturing Company on Internship
(2) Making products in a high volume, efficient or cheap manner
(2) Lots of machines, dirty work
(1) Manufacturing is an important branch in industry
(1) Manufacturing “was” an important part of today’s world
(1) Manufacturing is a good field to pursue
(1) Production lines such as Ford’s assembly lines
(1) Operations that occur after a piece is made
(1) There are different types of manufacturing
(1) The scope and design of manufacturing processes
(1) Production when materials are already supplied
(1) Making some stuff with different machines
(1) Mainly a hands-on field that requires working with many different machines and people
(1) Materials and Processes

At University Park in 2015, 53.4% (31 out of 58) of the students responded to the question. A breakdown of the student responses is shown in Table 3 below.

Table 3: Responses for Student Perception of Manufacturing before taking the manufacturing processes course

(8) Not interested, boring
(7) Interesting/important
(4) Old Factories/Dirty
(4) Making things in bulk/with high production volumes
(3) Done in other countries
(2) Not sure
(1) Automation/Robots

At the Behrend campus in 2016, 88.2 % (15 out of 17) of the students responded to the question. A breakdown of the student responses is shown in Table 4 below.

Table 4: Responses for Student Perception of Manufacturing before taking the manufacturing processes course

(4) Turn raw materials into finished goods
(4) Turn ideas into products
(2) Dirty, dying industry
(1) Based on “How it’s made” videos seen on TV
(1) Hands-on type of job
(1) Backbone of the economy, supports other industries
(1) Limited career opportunities
(1) Happens overseas

At Behrend in 2017, 93.3 % (14 out of 15) of the students responded to the question. A breakdown of the student responses is shown in Table 5 below.

Table 5: Responses for Student Perception of Manufacturing before taking the manufacturing processes course

(3) Mass produced goods
(2) Complicated and complex
(2) Important process/role in economy
(2) No idea
(1) Favorable
(1) Automated, innovative, America’s backbone
(1) “Dirty Jobs”
(1) Automation/Robots
(1) US manufacturing doing well

At Behrend in 2018, 95.7 % (22 out of 23) of the students responded to the question. A breakdown of the student responses is shown in Table 6 below.

Table 6: Responses for Student Perception of Manufacturing before taking the manufacturing processes course

(5) Not a clear opinion or perception
(4) Hands-on, hard labor, dirty
(3) Using different processes to create things
(3) machine work, processes done in assembly lines
(1) taking raw material and transforming it into a product
(1) chemistry
(1) very interested and likely to pursue a career in manufacturing
(1) biggest industry there is
(1) that manufacturing didn't require engineering and was a little out of date
(1) general factory work instead of different processes
(1) large scale mass production

The students at University Park were asked in 2014 and 2015 if they considered a career in manufacturing prior to taking the manufacturing processes course. The students at Behrend were asked this same question in 2016, 2017, and 2018. A summary of the responses for University Park and Behrend is shown in Figure 4 below.

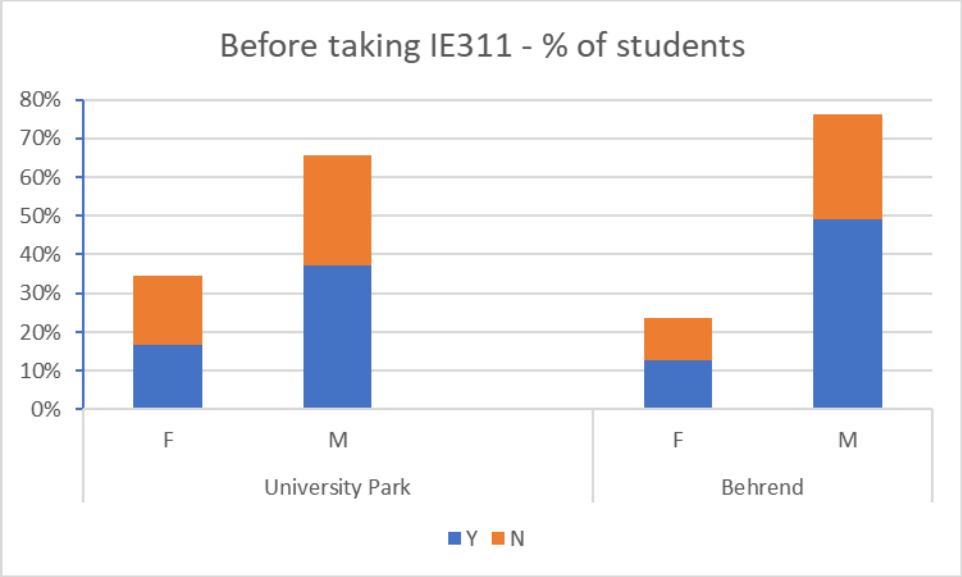

Figure 4: Percentage of students at University Park (Left) vs. Behrend (Right) that considered a career in manufacturing prior to taking Manufacturing Process Course.

The students at University Park were asked in 2014 and 2015 if they considered a career in manufacturing after taking the manufacturing processes course. The students at Behrend were asked this same question in 2016, 2017, and 2018. A summary of the responses for and is shown in Figure 5 below.

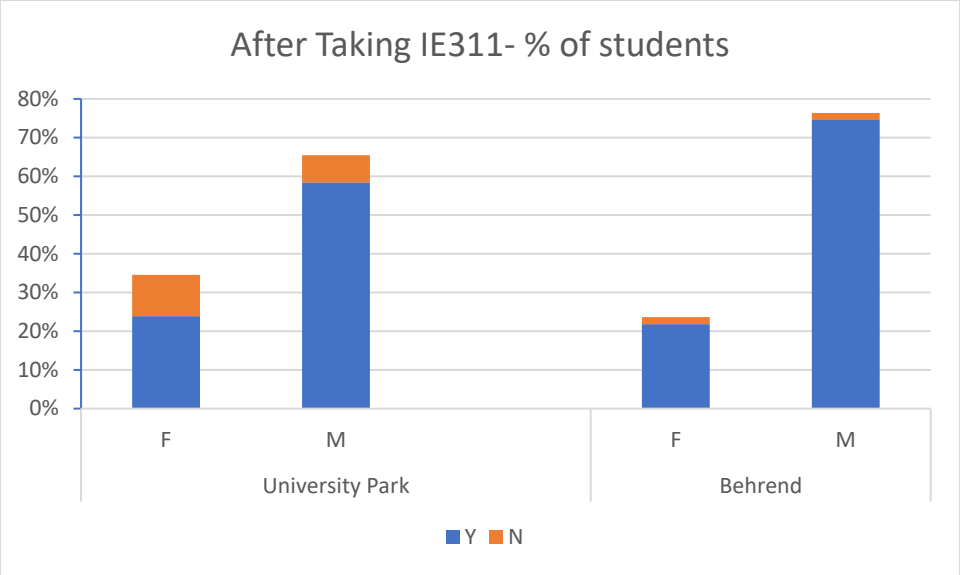

Figure 5: Percentage of students at University Park (Left) vs. Behrend (Right) that considered a career in manufacturing after taking the Manufacturing Process Course.

Before taking the manufacturing processes course at University Park in 2014 and 2015, 19 female students (16.81%) out of 113 students said they would consider a career in manufacturing. The remaining 20 female students (17.70%) said they would not. Of the male students, 42 (37.17%) said they would consider a career in manufacturing and the remaining 32 (28.32%) said they would not. After the course, however, 8 more female students replied that they would consider a career in manufacturing making it 27 (23.89%) female students saying they would versus 12 (10.62%) saying they would not. For the male students, 24 more replied that after the course they would consider a career in manufacturing making 66 (58.41%) who said they would consider a career in manufacturing and only 8 (7.08%) said they would not.

Before taking the manufacturing processes course at Behrend in 2016, 2017 and 2018, 7 female students (12.73%) out of a total of 55 students said that they would consider a career in manufacturing with the other 6 female students (10.91%) saying that they would not. For the male students, prior to the course, 27 (49.09%) said they would consider a career in manufacturing with 15 (27.27%) saying they would not. After taking the course, five more female students said they would consider a career in manufacturing resulting in 12 (21.82%) female students versus 1 (1.82%) who said they would not. For the male students, after the course, all but one responded that they would consider a career in manufacturing with 41 (74.55%) with 1 male student (1.82%) saying they would not.

Manufacturing Internships/Co-Ops

The students taking the manufacturing processes course were asked about their search for a summer internship or co-op opportunity. The students were specifically asked about how they were able to get their experience and whether or not it was with a manufacturing company. The detailed internship/co-op questions can be found in Table 7 below.

Table 7: Internship/Co-Op Survey Question Given to Students in Manufacturing Processes Course

11. Internship/Co-Op		
(A) Did you search for an internship or co-op for Summer XXXX? Y or N		
(B) If yes in (A), were you successful in securing an internship or co-op? Y or N		
(C) If yes in (B), how did you get the internship? (circle only one)		
University Wide Fall/Spring Career Days	Industrial Engineering Fall Career Fair	Metal Casting/ Manufacturing Career Event
University Career Services (eCareer website)	College of Engineering-Engineering Career Fair	College of Business Supply Chain Career Fair
Your Campus Career Fair	Networking through a faculty member	Networking through family or friends
Other: _____		
(D) If yes in (B), what company will you be working for? _____		
(E) If yes in (B), what is the location of the company? _____		
(F) If yes in (B), is the experience with a manufacturing company? Y or N		

In 2014, at University Park, out of the 56 students completing the survey, 50 of the students reported looking for an internship or co-op opportunity for summer 2014. Out of the 50 students that reported looking for an opportunity, 46 said they were successful in landing an internship or co-op opportunity at the time of the survey. After the survey, the course instructor helped 2 of the students obtain summer internship opportunities with metalcasting companies. By the end of the semester, 96% of the students that looked for summer internship opportunities were successful in obtaining an internship or co-op opportunity. One finding from this study was that international students at commonly found it much more difficult to obtain internship, co-op, and full-time opportunities in the U.S. The students were asked how they secured their internship or co-op opportunity. Table 8 below shows results of how students were able to obtain the internship and co-op opportunities.

Table 8: Responses for How Students Secured Internship or Co-Op Opportunities 2014

(14) University Wide Fall/Spring Career Days
(9) Networking Through Family or Friends
(5) College of Engineering Career Fair
(5) University E-Career website
(5) Metalcasting/Manufacturing Career Event in IE Department
(3) Internet/Web
(1) College of Business Supply chain Career Fair
(1) IIE (Institute of Industrial Engineers) IE Department Career Event
(1) Industrial Engineering Department Webpage
(1) Emailed a PSU Alum
(1) Company Hosted Networking Event

When asked if the internship or co-op experience was with a manufacturing company, 66.67% of the students (32 out of 48) said that 'Yes' the experience was with a manufacturing company.

At University Park in 2015, out of the 58 students completing the survey, 51 of the students reported looking for an internship or co-op opportunity for summer 2015. Out of the 51 students that reported looking for an opportunity, 42 or 82.4% said they were successful in landing an internship or co-op opportunity at the time of the survey.

The students were asked how they secured their internship or co-op opportunity. Table 9 below shows results of how students were able to obtain the internship and co-op opportunities.

Table 9: Responses for How Students Secured Internship or Co-Op Opportunities 2015

(12) University Wide Fall/ Spring Career Days
(3) Networking Through Family or Friends
(4) College of Engineering Career Fair
(5) University E-Career website
(1) Metalcasting/Manufacturing Career Event in IE Department
(4) Internet/Web
(1) College of Business Supply Chain Career Fair
(1) IIE (Institute of Industrial Engineers) IE Department Career Event
(1) Industrial Engineering Department Webpage
(2) Other school events
(2) Company Hosted Networking Event
(1) Returning Intern

When asked if the internship or co-op experience was with a manufacturing company, 40.4% of the students (17 out of 42) said that 'Yes' the experience was with a manufacturing company.

At Behrend in 2016, out of the 17 students completing the survey, 14 of the students reported looking for an internship or co-op opportunity for summer 2016. Out of the 14 students that reported looking for an opportunity, 11 or 78.6% said they were successful in landing an internship or co-op opportunity at the time of the survey.

The students were asked how they secured their internship or co-op opportunity. Table 10 below shows results of how students were able to obtain the internship and co-op opportunities.

Table 10: Responses for How Students Secured Internship or Co-Op Opportunities 2016

(3) Penn State Behrend Career Fair
(3) Networking Through Faculty Member
(2) Metalcasting/Manufacturing Career Event in IE Department
(1) IIE (Institute of Industrial Engineers) IE Department Career Event

When asked if the internship or co-op experience was with a manufacturing company, 100% of the students (11 out of 11) said that 'Yes' the experience was with a manufacturing company.

At Behrend in 2017, out of the 15 students completing the survey, all 15 of the students reported looking for an internship or co-op opportunity for summer 2017. Out of the 15 students that reported looking for an opportunity, 11 or 73.3% said they were successful in landing an internship or co-op opportunity at the time of the survey.

The students were asked how they secured their internship or co-op opportunity. Table 11 below shows results of how students were able to obtain the internship and co-op opportunities.

Table 11: Responses for How Students Secured Internship or Co-Op Opportunities 2017

(4) Metalcasting/Manufacturing Career Event in IE Department
(3) Networking Through Family or Friends
(2) Networking Through Faculty Member
(2) Applied on their own

When asked if the internship or co-op experience was with a manufacturing company, 80% of the students (8 out of 10) said that 'Yes' the experience was with a manufacturing company.

At Behrend in 2018, out of the 23 students completing the survey, 19 of the students reported looking for an internship or co-op opportunity for summer 2018. Out of the 19 students that reported looking for an opportunity, 15 or 65.22% said they were successful in landing an internship or co-op opportunity at the time of the survey.

The students were asked how they secured their internship or co-op opportunity. Table 12 below shows results of how students were able to obtain the internship and co-op opportunities.

Table 12: Responses for How Students Secured Internship or Co-Op Opportunities 2018

(5) Applied on their own
(4) Metalcasting/Manufacturing Career Event in IE Department
(3) Networking Through Family or Friends
(2) Networking Through Faculty Member
(1) MMG/AIST Networking Night at Behrend (AMIC Building)
(1) Penn State Behrend Career Fair

When asked if the internship or co-op experience was with a manufacturing company, 93.33% of the students (14 out of 15) said that 'Yes' the experience was with a manufacturing company.

Differences Between Campus Locations

According to ASEE, the University Park location is considered a small town, while the Behrend campus location is considered suburban. The University Park campus is located in the borough of State College with an approximate population of 42,000. The Behrend campus is located 5 miles from the city of Erie which has a population of approximately 276,000. In 2017, University Park had a total undergraduate enrollment of 40,835, while Behrend had 4,345. The University Park engineering program has 14 undergraduate engineering departments while Behrend has 7. In 2017 at University Park, 153 Industrial Engineering (B.S.) degrees were awarded. For the same year at Behrend, 14 Industrial Engineering (B.S.) degrees were awarded [21-22].

Summary of Region Around Campuses – Demographics and Local Industries
Table 13 below displays a summary of the size of the county encompassing each campus along with the population and median income of county residents.

Table 13: Demographic Data for Area Surrounding Campuses

	Erie County	Centre County	State
Square Miles	1,558	1,110	46,054
Population (2017)	277,794	160,646	12,790,505
Median Income (2017)	$48,192	$56,466	$56,951

Both Erie county and Centre county cover about 3% of the area of the state. Erie county is about 440 square miles larger than Centre, with a population in 2017 of 277,794 people while Centre county had 160,646. For context, the entire state had a population of 12,790,505 in 2017. The median income in the state was $56,951 in 2017. The median income for Centre county was about $8,000 more than Erie county at $56,466 and $48,192 respectively [23-25].
Table 14 below displays a summary of the employment % by industry for the county encompassing each campus along with the state percentages.

Table 14: Industry Employment Data for Area Surrounding Campuses

Employment % by Industry			
Industry	**Erie County**	**Centre County**	**State**
Health Care & Social Assistance	20.9%	13.3%	18.0%
Manufacturing	15.8%	5.7%	9.7%
Retail Trade	12.2%	10.9%	10.9%
Accommodation and Food Services	9.6%	9.4%	8.1%
Educational Services	8.5%	ND	8.3%

*ND represents Non-Disclosable information

A major difference in the employment between the counties was the Manufacturing industry. For Erie county, it was the second largest portion of the workforce with 15.8% while Centre county only had 5.7% of the workforce in manufacturing. The state average for employment in Manufacturing is 9.7% [24-25].

Conclusions
The overwhelming recommendation to entice young students to have an interest in the manufacturing sector is a well-designed Manufacturing Processes course. The course should not only serve the academic and curriculum requirements, but also introduce the students to the sector (e.g., tours, industry speakers, and hands-on laboratory exercises). The three conclusions are: that proximity to the manufacturing sector for students and campuses is significant, that internships and cooperative learning experiences are significant, and that faculty and administration involvement are vital.

A major conclusion of the work presented here is that there is a significant difference in students from campuses near more manufacturing industry employment versus campuses that are not near a large manufacturing base. For example, at University Park, after taking the manufacturing processes class, 8 more female students and 24 more male students said they would consider a career in manufacturing. This was an increase of 7.08% of female students and an increase of 21.24% of male students for a total of a 28.32% increase. After taking the class at Behrend, 5 more female students and 14 more male students said they would consider a career in manufacturing. This was an increase of 9.09% of female students and a 25.46% increase of male students. These increases clearly show that the manufacturing process class significantly influenced their perception of manufacturing and their willingness to consider a career in it. It is possible that this location and proximity conclusion is confounded with family members' participation in the manufacturing industry (i.e., a student is more interested in manufacturing if parent worked in manufacturing).

Another major conclusion is that internships and co-ops are significant. With the exception of 2018, the majority of students each year found their internship or co-op through a school job fair or career event. In 2018, at Behrend, the majority of students (5) applied to the internship or co-op on their own, but the next highest response was 4 students who used the Metalcasting/Manufacturing Career Event. At University Park, most of the students (26) were successful using the University-wide career days, either in the spring or fall. The next most popular option was networking through family and friends with 12 students. At Behrend, 10 students found an internship or co-op through the Metalcasting/Manufacturing Career event. This shows that close faculty involvement with the manufacturing community can help bring students and industry together to get students jobs in manufacturing.

In 2018, of the 8 students who changed their mind about pursuing a manufacturing job, 5 were looking for an internship. Four of those 5 students found internships at the time of the survey, and all were in manufacturing or 80%. In 2017, all of the 8 students who changed their mind about pursuing manufacturing jobs were seeking an internship. Four of these students were successful and 3 of them were in manufacturing or 75%. In 2016, of the 3 students who changed their mind about pursuing a manufacturing job, only 2 were looking for an internship. At the time of the survey, they had not found one. In 2015, of the 16 students who changed their mind about pursuing a manufacturing job, 15 were looking for an internship. Of these 15, 13 were successful and 3 of these were in manufacturing or 23.08%. In 2014, of the 16 students who changed their minds about jobs in manufacturing, 14 were looking for an internship. Of these 14, 11 were successful and 8 were in manufacturing or 72.73%.

At University Park, of the 90 students who found an internship or co-op, 49 students, or 54.4%, said that the experience was with a manufacturing company. At Behrend, 33 students out of 36, or 91.7% said that their experiences were with a manufacturing company. This is a 37.7% difference which correlates with the larger amount of the workforce around Behrend working in manufacturing. Almost three times the percentage of workforce is employed in manufacturing in Erie county versus Centre county.

Finally, it is imperative that faculty and administration bridge the gap between students and manufacturing experiences available. This includes planning facility tours, inviting industry speakers, helping students connect with internships and co-ops, and genuinely being engaged in the manufacturing sector.

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