Exploring The Influence Of Industry-led STEM Outreach On Career Perceptions Toward Manufacturing

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Manufacturing is one of the most important factors in global business and continues to influence a nation's economic success today. However, manufacturers continue to protest a deficiency of skilled employees to fulfill open positions in their production facilities (National Science & Technology Council, 2018b). It has been estimated that by 2028 the United States manufacturing industry will face a shortage of over two million workers (Deloitte, 2017). One study conducted by Deloitte and the Manufacturing Institute (2018) revealed that global manufacturing executives ranked the search for skilled talent as their number one concern for manufacturing competitiveness. As countries, and specifically the United States, grapple with this shortage, questions persist about its origins and potential solutions. Policymakers, educational leaders, and industry representatives are increasingly turning to enhanced STEM education in elementary and secondary schools as a remedy to address these workforce challenges and secure the future success of industries like manufacturing (Durazzi, 2021; McGunagle, & Zizka, 2020; National Science & Technology Council, 2018a; b). For example, the 2018 *American's Strategy for STEM Education* report states that developing "STEM skills" are critical for having a workforce to manufacture smarter products and navigate an increasingly high-tech and interconnected world. In addition, the 2018 *Strategy for American Leadership in Advanced Manufacturing* set a goal for providing the appropriate educational outreach, from elementary through post-secondary education, to help develop the "STEM skills" now deemed necessary for the jobs in this sector which have become increasingly situated in a digitized, automated, and data-driven workplace. It is important to note that these "STEM skills" have now become a seemingly all-encompassing list of capabilities often linked to what are referred to as a) 21st century skills (e.g., critical thinking, problem-solving, creativity, collaboration), b) new workforce competencies related to engineering/technology (e.g., additive manufacturing, data analytics, computational thinking, systems thinking, computer aided design), and/or c) employability skills (e.g., being a team player, self-motivated, being proactive) (Durazzi, 2021; Kuper, 2020; McGunagle, & Zizka, 2020; National Science & Technology Council, 2018a; b; Partnership for 21st Century Skills, 2016). However, none of these "STEM skills" may matter to industries such as manufacturing if perceptions of the related careers, and how these perceptions align with the STEM outreach activities, are not better understood—which serves as the focus of this study.

Manufacturers and scholars have begun to point to the perceptions of manufacturing careers as one of the top causes of the skills/talent shortage (Deloitte & the Manufacturing Institute, 2018; Masters & Barth, 2022). The 2018 Deloitte and the Manufacturing Institute "skills gap" report states that many manufacturing jobs will go unfilled because of the negative perceptions students, and their parents, have of the manufacturing industry. As studies have revealed, society appears to maintain a negative perception of manufacturing careers (i.e., unclean, hazardous, and tedious) (Deloitte, 2017; Strimel et. al., 2020), which may avert people from entering potential careers within the industry. Masters and Barth (2022) note that jobs in middle-skills STEM fields such as manufacturing are some of the hardest to fill due to children's' interests in these roles and that the lack of middle-skill workers is of global concern.

In an effort to change these career perceptions, manufacturers have begun to host events, often branded as STEM outreach, to introduce youth to the new skills/techniques employed in the industry as well as potential career pathways (National Science & Technology Council, 2018a; 2018b). One such event in the United States is "*Manufacturing Day,*" which has been developed to "address common misperceptions about manufacturing by giving manufacturers an opportunity to open their doors and show, in a coordinated effort, what manufacturing is — and what it isn't" (National Association of Manufacturers, 2019). The National Association of Manufacturers (2019) states "by working together during and after *Manufacturing Day*, manufacturers will begin to address the skilled labor shortage they face, connect with future generations, take charge of the public image of manufacturing, and ensure the ongoing prosperity of the whole industry." These types of initiatives can showcase how manufacturers are beginning to realize the need to move beyond short-term solutions to the ongoing skills shortage. Yet, the 2018 Deloitte and The Manufacturing Institute study found that minimal manufacturers are involved with long-term partnerships with education institutions focused on creating a skilled talent pool for tomorrow's manufacturing ecosystem. Furthermore, their study highlights a void in exposing the industry to elementary school students, which they believe can be important to developing career awareness/interests and building the foundational STEM skills needed to succeed in programs in the secondary grades.

While manufacturers have begun engaging with STEM education outreach efforts to address future workforce concerns and researchers have suggested that increasing students' familiarity with these occupations through activities such as site visits and career days as a viable solution (Masters & Barth, 2022), a critical step is now determining the influence of these experiences on the occupational perceptions of children. Essentially, there is a gap in research on how industry-public education initiatives can influence a child's, from elementary school to secondary school, perception of manufacturing careers as well as how this influence is aligned to STEM-focused activities. Moreover, very few scholars have studied the relationship between STEM initiatives, career expectations, and alternative types of STEM career pathways into fields like manufacturing that may not require traditional 4-year bachelor's degree (Sevilla & Rangel, 2022). Even though events such as *Manufacturing Day* were created to increase the number of local students entering the manufacturing career pathway, there is limited evidence to support this claim. Therefore, this study sought to investigate children's perceptions of manufacturing before and after two iterations of an industry-led STEM education event. More specifically, the study focused on the research questions of:

RQ1. How do children, across grades K-12, perceive careers within the modern landscape of manufacturing?

RQ2. What influence, if any, does industry-led STEM outreach have on children's, across grades K-12, perceptions of manufacturing careers?

RQ3. How, and in which ways can industry-led STEM outreach be better designed to connect industry needs and educational output?

The industry-led STEM outreach examined in this study was an extended form of *Manufacturing Day* activities that were expanded to become a full week event including children from, not only secondary schools, but

also elementary schools. This *Manufacturing Week* initiative was co-hosted by local manufacturers, colleges, and the local economic development and commerce group. The weekly events were aimed toward informing participants about the opportunities available at local manufacturing companies, showing the technological improvements in manufacturing careers, and teaching students about STEM concepts related to manufacturing.

Theoretical Perspective

In framing this study, it is important to provide a theoretical perspective to view how career perceptions and interests may be formed. The Social Cognitive Career Theory (SCCT) describes three connected facets of career development (Lent, Brown, & Hackett, 1994). These three facets include 1) the construction of career-relevant interests, 2) the choice of both educational and career routes, and 3) the performance and persistence in academic and job-related pursuits. Overall, SCCT provides a viable framework for understanding how students may form career perceptions, as well as perceptions of their own abilities in specific occupational domains, and how these perceptions can lead to personal interests and career goal-setting (Marcus, 2017; Sevilla & Rangel, 2022). For example, SCCT posits that individuals form interests in a career when they have a) self-efficacy, or a perceived competence, in the related career activities as well as b) positive outcome expectations from participation in these activities. On the other hand, individuals are unlikely to develop interests for a career if they are not confident in their abilities and expect negative outcomes from their participation in the related activities. In addition, SCCT describes personal career interests as dynamic; meaning that they are developed through activities and observational modeling whereas they are reinforced, or weakened, through experiential, social, and cultural feedback (Lent et al., 1994). As a whole, literature emphasizes this dynamic nature of career perceptions and how the process of developing perceptions and interests is related to a series of events and choices over an extended period of time (Bandura, 2001; Lent et al, 1994; Walsh, Savickas, & Hartung, 2013).

SCCT views individuals as living within a social environment with a myriad of influential opportunities that are occasionally random. This theory then emphasizes that career decisions are sometimes influenced more directly by environmental variables than by interests alone. Environmental variables can include items such as a) supports provided to an individual, b) the barriers toward career pathways, c) the values and norms of one's culture, and d) the opportunities available to the individual. While interests are influential on one's educational and career choices under the most supportive environmental conditions, many individuals are unable to follow their interests as there can be many environmental barriers in place. As such, career perceptions and choices are likely constrained by environmental variables and, in some instances, individuals may need to compromise their interests on the basis of their perceived outcome expectations and self-efficacy beliefs in their social environment.

In regard to this study, it is possible then that career perceptions and interests related to manufacturing may be based on environmental factors such as the educational experiences that children are exposed to in both formal and informal settings. These educational opportunities are often linked to other environmental variables such as family income and demographics (American Society for Engineering Education, 2020; Sevilla & Rangel, 2022). Today, in many formal educational settings learning about manufacturing typically occurs from a historical perspective in social studies classrooms (Bosman et al., 2020). The result may be that many students, without informal educational experiences such as industry-led STEM outreach, continue to perceive manufacturing careers as dirty, dangerous, and monotonous; thus, influencing their interest and career goal setting. This influence may be based on their expectation of potential negative outcomes from such a career choice and a perception of their being limited environmental supports toward a related occupation. Therefore, this study then hypothesizes that students across the grade-levels maintain a limited understanding, and negative perception, of the industry, and consequently, are uninterested in the related careers in manufacturing. However, if students are exposed to the environmental and social supports through industry-led STEM outreach it is possible that their perceptions may change, potentially leading to increased awareness of, and interests in, related careers. Due to the limited understanding of this topic, investigating children's perceptions of careers before and after industry-led STEM outreach can offer valuable insights. These insights, in turn, can contribute to the establishment of industry-education partnerships grounded in a better understanding of the development of career perceptions as well as the alignment of theory with early-age career development for middle-skilled STEM careers

Methods

Participants and Procedure

Participants for this study were students from grades K-12 who attended an industry-led STEM/career awareness outreach experience, referred to as *Manufacturing Week*. The *Manufacturing Week* event was held in the fall of 2018 and again in 2019. Data from a total 1,340 participants were collected across both iterations of the event using a pre- and post-manufacturing career survey. The organizers of *Manufacturing Week* administered these surveys to gain insights on children's perceptions of careers within manufacturing before and after the outreach experience. The surveys were voluntary and administered by the outreach organizers using a web-based survey platform. The surveys were completed by the participants in their classrooms up to a week before, and within a week after, their involvement in Manufacturing Week. The *Manufacturing Week* organizers then deidentified the data and shared them with the researchers, through protected channels, for analysis for this study's purpose following the Institutional Review Board's research guidelines. It is important to note that this study was done as a secondary analysis of deidentified data collected by the organizers which confined the researchers to the data collection procedures of the organizers themselves. Therefore, the length in time between the implementation of the pre and post surveys (up to one week before and one week after the event) is a limitation to keep in mind when interpreting the results.

As the *Manufacturing Week* event was divided into three different grade-level specific activities (elementary school: grades K-5, middle school: grades 6-8, and high school: grades 9-12), the participant data were grouped and analyzed accordingly. The elementary school survey respondents included 512 participants (194 male, 225 female, and 93 undisclosed), the middle school survey respondents included 396 participants (194 male, 187 female, and 15 undisclosed), and the high school survey respondents included 432 participants (291 male, 126 female, and 15 undisclosed). Nearly 62% of the *Manufacturing Week* survey respondents reported themselves as Caucasian/White, approximately 15% Latino/Hispanic, 4% Black/African American, 1.4% Asian, and approximately 20% reported themselves as "other" or chose not to disclose their information. While the survey response rate for each grade-level group varied, the total number of participants who completed both the pre- and post-manufacturing career surveys were reflective of nearly 28% of the total students who attended the event over the two years. Furthermore, the participants examined in this study were enrolled in schools across a 6-county region within one midwestern state. The region has a population of approximately 267 thousand and is known for being the home of the state's public land-grant research university as well as several large manufacturers. In fact, the manufacturing sector is one of the largest economic drivers in this region.

The Context: Manufacturing Week

Manufacturing Week aimed to raise community awareness about the regional manufacturing ecosystem, communicate diverse occupational pathways in manufacturing to the prospective workforce, introduce local youth to STEM skills and concepts in modern day manufacturing, and provide students with experiences to explore opportunities for working, learning, and living within the region. To accomplish these objectives, *Manufacturing Week* was divided into to three distinctive activities based on the grade-level participant groups. First, the elementary students (grades K-5) participated in a *Manufacturing Work-*

shop that concentrated on manufacturing awareness and introductory-level "STEM skills" related to manufacturing today. Then, the middle school students (grades 6-8) took part in a *Manufacturing Expo* which was devoted to career discovery through hands-on STEM activities (including robotics, computer-aided design, programming, additive manufacturing, virtual reality, as well as employability skill focused exercises). Lastly, the high school students (grades 9-12) participated in *Manufacturing Tours* which were focused on preparation for potential manufacturing related careers within active manufacturing facilities. Each student that attended *Manufacturing Week* only participated in one, day-long iteration of their grade-level specific activity during that week.

The *Manufacturing Workshop* (grades K-5) was offered as a morning or afternoon session during two days of *Manufacturing Week*. This provided multiple options for local teachers to bring their class to the event. Each workshop session lasted for two hours and consisted of four activities for students to rotate through. Each activity was led by associates from the partnering manufacturers and provided students with experiences that highlighted production processes, lean manufacturing concepts, local supply chain systems, and interactions with a "mascot" from one of the local manufacturers.

The *Manufacturing Expo* (grades 6-8) was offered as three duplicate sessions over three days. The expo sessions were four hours long with four different activity stations for the students to rotate through. Local manufacturers operated each station which allowed students to explore what their company actually does and how specific occupations design, produce, move, and support their products. The activities at these stations included:

a. "Design it" Station: This station focused on learning about additive manufacturing and computer-aided design (CAD). Students explored how 3D printers work and completed a challenge to design an object on CAD software (e.g., a name plate or trophy for a teacher) to be 3D printed.
b. "Move it" Station: This station focused on learning about how products are moved within manufacturing facilities. Students completed forklift challenges using virtual reality and remote-control vehicles as well as programmed a robotic arm to move along a linear rail system while picking and placing products along the way.
c. "Produce it" Station: This station focused on learning about how products are made at the local manufactures. Students completed a welding challenge using a virtual welding training system and experienced the use of Computer Numerically Controlled (CNC) machines.
d. "Support it" Station: This station focused on learning about how manufacturing operations are supported to ensure worker success and promote continuous improvement. Students completed activities related to ergonomics, human resources, and optimizing a simulated assembly line using Legos to produce a set amount of model vehicles within the best takt time.

The *Manufacturing Tours* were provided to students in grades 9-12. There were six different tour packages for the participating schools to select from over the course of the week. Each tour package included either "two 90-minute factory visits "or "three 60-minute factory visits." Each tour package focused on allowing students to observe, first-hand, the kinds of skills used within manufacturing careers and what actually happens inside the manufacturing facilities on a daily basis. Tours were offered in a variety of manufacturing facilities within the region which included manufactures of automobiles, large engines, electrical supplies, electrical wire, custom gears, pharmaceuticals, aluminum products, and semi-truck trailers.

Lastly, each event provided participants with a guidebook, in the theme of a comic book, that detailed the breadth of jobs in manufacturing ranging from nursing to engineering to welding. The guide also detailed the salaries associated with these careers and the related educational pathways.

Data Collection

To answer this study's research questions, the researchers analyzed data collected from a pre- and post-manufacturing career perception survey administered to the participants of *Manufacturing Week* by the event organizers. While the study was limited to the secondary analysis of data collected via the event organizers, the surveys used were based upon previous studies to explore people's views related to a variety of aspects of manufacturing careers—enhancing its reliability and validity. For example, the survey was originally based upon a survey created by Deloitte (2017) to determine parent's perceptions of manufacturing careers that was refined by Strimel et al. (2020) to use with K-12 students. A variety of strategies were conducted by the event organizers to optimize the use and reliability of the survey results. First, different versions of the survey were used for the different age groups to account for the cognitive development of the participants. These survey variations presented participants with a series of statements related to manufacturing careers (e.g.,'I think manufacturing is safe.') and asked them to report the degree at which they either agreed or disagreed with each statement using a Likert scale (i.e., 'Strongly Disagree', 'Disagree', 'Neutral', 'Agree', 'Strongly Agree') or with a yes/no response for the younger participants. The dichotomous Yes/No response items were used for younger students to avoid placing excessive cognitive demands on them with a larger range of options while also encouraging to express their current views (Bell 2007; Borgers & Hox 2000, 2001; Borgers, De Leeuw, & Hox, 2000). That being said, each question on the survey was designed to reflect one single manufacturing perception construct to facilitate a clear choice for their perception on that aspect. The quantity and kind of questions/statements on each survey also differed based on the age of the participant. For example, the participants in grades 9 through 12 were questioned about the impact of manufacturing occupations on the nation's economy whereas those in elementary and middle school were not asked about this topic.

To help address the limitations associated with the surveys (i.e., effect of the survey timing, criterion validity of the survey items, and the regionally specific sample of participants), open-ended questions were also posed to the participants. These open-response questions allowed the participants to provide supplementary details about their experience to better understand their perceptions of manufacturing careers and their level of engagement with the various STEM-related activities. The survey items and open-response questions can be found in Tables 2 through 8. While several steps were taken to enhance the validity and reliability of the study, it is important to consider the results regarding changes in perceptions within the context of the study's limitations.

Data Analysis

The pre- and post-manufacturing career perception survey responses underwent a thorough examination, focusing on three main objectives: 1) revealing initial career perceptions among participants, 2) identifying any significant differences in these perceptions post-outreach event, and 3) pinpointing ways to improve industry-led STEM outreach to better align with educational goals with industry needs. Additionally, the study aimed to explore how data collected during outreach events could inform industry practices, addressing concerns related to manufacturing career perceptions within the framework of social cognitive career theory.

Initially, the survey data were organized by grade level, with pre- and post-survey responses matched for each participant. Likert-style question responses were then converted to a 5-point scale for numerical analysis (e.g., 'Strongly Disagree' = 1, 'Strongly Agree' = 5). Descriptive statistics were calculated to determine mean responses and average changes from pre- to post-survey for each Likert-style question. Subsequently, statistical significance between pre- and post-surveys for each Likert-scale item was assessed using a sign test, chosen for its suitability with ordinal scale data (de Winter & Dodou, 2010). A 95 percent confidence interval was employed to establish statistical significance (p-values ≤ 0.05), indicating potential perceptual changes among participants—suggesting that the outreach event may have influenced shifts in participants' perceptions.

The analysis extended further to the open-response questions, delving deeper into the potential influence of the *Manufacturing Week* experience on participants' career perceptions and its alignment with provided STEM-relat-

Statement	Pre-Survey		Post Survey		Sign Test
	Mean	Std. Dev.	Mean	Std. Dev.	P-Value
I would consider a job in manufacturing.	2.800	1.280	3.400	1.280	<0.001*
There are many career opportunities in manufacturing.	3.700	0.998	4.200	0.960	0.0002*
Manufacturers need to be well educated.	4.100	1.008	4.300	0.881	0.4781
Manufacturing jobs are safe.	2.800	1.120	2.900	1.140	0.2965
Manufacturing jobs are clean.	2.300	1.150	2.700	1.240	0.0004*
I believe a manufacturing job would let me be creative.	3.800	1.160	3.800	1.180	0.1205

Note. A Likert-scale of 5-Points was used: 5=Strongly Agree to 1=Strongly Disagree. *Significant difference at a 95% confidence level.

Table 1. Manufacturing Workshop 2018 (Grades K-5) Survey Analysis ($N = 92$)

ed activities. Using NVivo qualitative data software, the research team applied descriptive coding techniques to analyze open-ended survey responses. Noteworthy statements, emerging themes, and responses related to participants' experiences and career perceptions were identified (Saldaña, 2016). These items helped the research team to develop an emergent codebook to facilitate the systematic coding of all responses and the subsequent organization of coded instances for presentation and further analysis.

To enhance the study's reliability, several strategies were implemented. Peer debriefing and code-recode procedures were employed during the open-response coding process (Hays & Singh, 2011). Additionally, the researchers utilized multiple data sources, including Likert-Scale and Open-Ended Response items, along with supporting literature, to strengthen the quality of the analysis and obtain corroborating evidence when making conclusions and recommendations (Onwuegbuzie & Leech, 2007). These strategies aimed to bolster the reliability of the study, providing a comprehensive understanding of students' career perceptions and outreach experiences.

Results

Research Questions 1 & 2

To 1) understand how children, across grades K-12, perceive careers within the modern landscape of manufacturing and 2) investigate what influence that industry-led STEM outreach can have on these perceptions, data were obtained and analyzed from responses to a pre/post-manufacturing career perception survey that was administered to participants of the *Manufacturing Week* event. The descriptive statistics for these responses, by age group, as well as sign test results are presented in the subsequent sections for each component of the *Manufacturing Week* event.

For the 2018 *Manufacturing Workshop* (Grades K-5) portion of Manufacturing Week, a total of 92 participants completed both the pre- and post-surveys. A complete overview of these survey results can be found in Table 1. The most noticeable change in responses from pre- to post-survey for this age group was their increased consideration of a job in manufacturing ($M_{pre} = 2.8$, $M_{post} = 3.4$) followed by their increased belief that there are many career opportunities in the manufacturing industry ($M_{pre} = 3.7$, $M_{post} = 4.2$). The smallest perception change for the Manufacturing Workshop participants was related to the belief that manufacturers need to be well educated—on average the participants maintained their agreement with this statement across the pre- and post-surveys ($M_{pre} = 4.4$, $M_{post} = 4.3$). Using both pre- and post-survey data, a sign test was performed to determine if there was a statistically significant difference in the responses to each survey question between the start and the conclusion of the outreach event. These significant differences may indicate where the event might have had the most potential influence on the students' perceptions. For grades K-5, half of the career perception survey questions had a statistically significant difference between pre and post survey responses (See Table 1). This included a significance difference in their increased consideration of a career in manufacturing ($p < 0.001$), their belief that there are many career opportunities in the industry ($p < 0.001$), and that manufacturing occupations are clean ($M_{pre} = 2.3$, $M_{post} =$

Statement	Pre-Survey		Post Survey		Sign Test
	Mean	Std. Dev.	Mean	Std. Dev.	P-Value
I have been encouraged to consider a career in manufacturing.	2.78	0.957	3.25	1.040	<0.001*
I would consider a job in manufacturing.	2.73	0.882	2.98	0.994	<0.001*
Manufacturing careers pay well.	3.46	0.764	3.78	0.765	<0.001*
There are many career opportunities in manufacturing.	3.75	0.752	4.17	0.711	<0.001*
Manufacturers need to be well educated.	3.79	0.890	3.52	0.885	0.003*
Manufacturers need to have a college degree.	3.42	0.925	3.13	0.927	0.005*
Manufacturing jobs are safe.	2.70	0.843	3.14	0.944	<0.001*
Manufacturing jobs are clean.	2.64	0.914	3.23	0.951	<0.001*
I believe a manufacturing career would let me be creative & innovative.	3.30	1.010	3.61	0.929	<0.001*
Manufacturing jobs use new technology.	3.87	0.702	4.05	0.713	0.0002*
Manufacturers needs to be highly skilled.	3.61	0.889	3.57	0.920	0.9500

Note. A Likert-scale of 5-Points was used: 5=Strongly Agree to 1=Strongly Disagree. *Significant difference at a 95% confidence level.

Table 2. Manufacturing Expo 2018 (Grades 6-8) Survey Analysis ($N = 238$)

Statement	Pre-Survey		Post Survey		Sign Test
	Mean	Std. Dev	Mean	Std. Dev	P-Value
I have been encouraged to consider a career in manufacturing.	3.125	1.136	0.532	1.008	<0.001*
I would consider a job in manufacturing.	3.075	1.074	3.226	1.067	0.0103*
There are many career opportunities in manufacturing.	4.2	0.734	4.283	0.806	<0.001*
Manufacturers need to have technical/trade skills.	3.932	0.704	3.74	0.851	0.2650
Manufacturers need to have a college degree.	3.17	0.995	2.706	0.948	0.2089
Manufacturing jobs are safe.	2.706	0.786	3.128	0.865	<0.001*
Manufacturing jobs are clean.	2.732	0.839	3.109	0.945	<0.001*
Manufacturing jobs use new technology.	3.875	0.677	4.083	0.646	0.2940
I believe a manufacturing career would let me be creative & innovative.	3.457	0.925	3.498	0.93	<0.001*
Manufacturing is important to the United States economy.	4.279	0.752	4.37	0.701	0.0277*
There is a need for more manufacturers in the United States.	3.777	0.853	4.03	0.783	0.2671

Note. A Likert-scale of 5-Points was used: 5=Strongly Agree to 1=Strongly Disagree. *Significant difference at a 95% confidence level.

Table 3. Manufacturing Tour 2018 (Grades 9-12) Survey Analysis (N = 167)

2.7, $p < 0.001$). However, there was no significant difference in the responses to whether or not manufacturing employees need to be well educated (on average the participants started with, and maintained, a view that manufacturers need to be well educated), if manufacturing occupations are safe (on average the participants started with, and maintained, a view that manufacturing is unsafe), or if a manufacturing career would allow them to be creative (on average the participants started with, and maintained, agreement that there is creativity involved with manufacturing).

For the 2018 *Manufacturing Expo* (Grades 6-8) portion of *Manufacturing Week*, a total of 238 participants completed both the pre- and post-surveys. A complete overview of these survey results can be found in Table 3. The greatest change in career perceptions was related to the increased belief that manufacturing jobs are clean ($M_{pre} = 2.70$, $M_{post} = 3.14$) followed by participants being encouraged to pursue a job/career in manufacturing ($M_{pre} = 2.78$, $M_{post} = 3.25$). The smallest change for grades 6-8 was related to the perception that manufacturers need to be highly skilled ($M_{pre} = 3.61$, $M_{post} = 3.57$). Based on the p-values obtained from a sign test, all but one statement given to students achieved a statistically significant difference in responses between pre- and post-surveys (see Table 2). This included a significant difference in their consideration of a career in manufacturing ($p < 0.001$, $M_{pre} = 2.70$, $M_{post} = 2.98$), their encouragement toward a manufacturing career ($p < 0.001$, $M_{pre} = 2.78$, $M_{post} = 3.25$), that manufacturing jobs pay well ($p < 0.001$, $M_{pre} = 3.46$, $M_{post} = 3.78$), their belief that there are many job opportunities in the industry ($p < 0.001$, $M_{pre} = 3.75$, $M_{post} = 4.17$), their belief that a higher education degree may not be necessary for manufacturing careers ($p = 0.005$, $M_{pre} = 3.42$, $M_{post} = 3.13$), and that manufacturing jobs are safe ($p < 0.001$, $M_{pre} = 2.70$, $M_{post} = 3.14$) and clean ($p < 0.001$, $M_{pre} = 2.64$, $M_{post} = 3.23$). However, there was no significant difference in whether or not they believe that manufacturers need to be highly skilled as, on average, the participants started with and maintained a more neutral view on this statement.

For the 2018 Manufacturing Tour (Grades 9-12) portion of Manufacturing Week, a total of 167 participants completed both the pre- and post-surveys. A complete overview of these survey results can be found in Table 3. Overall, perception changes for students in grades 9-12 were lesser than the ones observed from the participants before and after the Manufacturing Workshop and Manufacturing Expo events. The greatest change was related to participants increased agreement with them "being encouraged to contemplate an occupation in manufacturing" ($M_{pre} = 3.13$, $M_{post} = 3.53$) closely followed by their increased belief that "manufacturing jobs are clean" ($M_{pre} = 2.73$, $M_{post} = 3.11$). However, there was a minimal increase in interest of students to consider a career in manufacturing ($M_{pre} = 3.08$, $M_{post} = 3.23$). In addition, the most minor changes for the *Manufacturing Tour* participants were related to the perceptions that manufacturers need to be well educated and that manufacturing careers use new technology—as on average they maintained

Statement	Pre-Survey			Post Survey		
	Yes	No	Not Sure	Yes	No	Not Sure
Do you know any adults that work in manufacturing?	7	14	12	15	8	10
Would you consider working in a manufacturing job?	13	20	0	14	19	0
Do you think that there are many job opportunities in manufacturing?	23	10	0	23	10	0
Do you think manufacturers need to be well educated?	22	11	0	19	14	0
Do you think manufacturing jobs are safe?	17	16	0	20	13	0
Do you think manufacturing jobs are clean?	13	20	0	12	21	0
Do you think you could be creative in a manufacturing job?	22	11	0	22	11	0

Note. Participants responded either 0-No, 1-Yes, or 2-Im Not Sure for these statements.

Table 4. Manufacturing Workshop 2019 (Grades K-2) Survey Analysis (N = 33)

Statement	Pre-Survey			Post Survey			Sign Test
	Yes	No	Not Sure	Yes	No	Not Sure	P-Value
Do you know any adults that work in manufacturing?	211	75	101	258	71	58	0.0043*
Have you been on a manufacturing tour before?	99	288	0	259	126	2	<0.001*
Have you learned about manufacturing in school?	96	289	2	248	139	0	<0.001*
Would you consider working in a manufacturing job?	162	225	0	213	174	0	<0.001*
Do you think that there are many job opportunities in manufacturing?	337	48	2	350	37	0	0.0649
Do you think manufacturers need to have a college degree?	291	95	1	265	122	0	0.0139*
Do you think manufacturing jobs are safe?	133	253	1	157	229	1	0.0192*
Do you think manufacturing jobs are clean?	74	312	1	85	301	1	0.1208
Do you think you could be creative in a manufacturing job?	301	85	1	33	54	0	0.0003*
Do you think manufacturing jobs pay well?	337	50	0	311	32	44	0.0030*

Note. Participants responded either 0-No, 1-Yes, or 2-Im Not Sure for these statements. *Significant difference at a 95% confidence level.

Table 5. Manufacturing Workshop 2019 (Grades 3-5) Survey Analysis (N = 387)

their agreement with these statements. Using the survey data in a sign test, a significant difference was found in the responses to eight of the thirteen survey statements. These results showed a statistically significant difference in participants' contemplation of a manufacturing vocation ($p < 0.001$, $M_{pre} = 3.08$, $M_{post} = 3.23$), perception of cleanliness ($p < 0.001$, $M_{pre} = 2.73$, $M_{post} = 3.11$), and belief of job availability in the industry ($p < 0.001$, $M_{pre} = 4.20$, $M_{post} = 4.28$). However, there was no significant difference in whether or not manufacturers need to be well educated or that a college degree is required. While the change on these statements were insignificant, the participants did show a minimal shift toward viewing a higher education degree as not necessary for working in manufacturing ($M_{pre} = 3.17$, $M_{post} = 2.71$). This view aligns to the *Manufacturing Week* messaging that there are career opportunities after graduating high school and/or obtaining an associate's degree, which can lead to company funded higher education pathways. Moreover, there was no significant difference in the participants beliefs of a) that manufacturing careers use new technology (participants maintained their agreement with this statement), b) manufacturers need to be highly skilled (participants maintained a neutral to agree response to this statement), and c) that there is a need for more manufacturing in the United States (participants maintained a neutral to agree response to this statement).

For the 2019 *Manufacturing Workshop* (Grades K-2) portion of Manufacturing Week, a total of 33 participants completed both the pre- and post-surveys. Table 4 provides an overview of the survey responses. Participant responses from pre- to post-survey largely remained the same with only a maximum of three participants changing their responses for the questions provided. A sign test was not performed with these data as there was not a sufficient number of respondents to determine any statistical significance.

For the 2019 Manufacturing Workshop (Grades 3-5) portion of Manufacturing Week, a total of 387 participants completed both the pre- and post-surveys. The career perception survey for this group included three additional Yes/No format questions and two open-ended questions. Table 5 shows the mean responses for each career perception survey statement in addition to the average response change values for each statement. The most noticeable change from pre-survey to post-survey was students agreeing that they have learned about manufacturing in school. This change may indicate an increased potential in participants exposure to manufacturing through school activities. The smallest perception change in the participants was for the question "Do you think that there

Statement	Pre-Survey		Post Survey		Sign Test
	Mean	Std. Dev.	Mean	Std. Dev.	P-Value
Do you know any adults that work in manufacturing?**	1.139	0.633	0.975	0.517	0.0013*
Have you been on a manufacturing tour before?**	0.253	0.436	0.842	0.366	<0.001*
Have you learned about manufacturing in school?**	0.399	0.491	0.646	0.48	<0.001*
I have been encouraged to consider a career in manufacturing.	2.519	1.081	2.892	1.165	<0.001*
I would consider a job in manufacturing.	2.551	1.170	2.639	1.084	0.0223*
There are many career opportunities in manufacturing.	3.614	0.929	4.076	0.834	<0.001*
Manufacturers need to have technical/trade skills.	3.582	0.925	3.753	0.857	0.1332
Manufacturers need to have a college degree.	3.487	1.014	3.297	1.025	0.0428*
Manufacturing careers are safe.	2.399	0.859	2.323	0.919	0.1841
Manufacturing careers are clean.	2.101	0.918	2.152	0.876	0.1477
Manufacturing careers pay well.	3.500	0.804	3.665	0.849	0.0027*
Manufacturing jobs use new technology.	3.411	0.799	3.722	0.866	<0.001*
Manufacturing jobs offer job security.	3.120	0.768	3.342	0.788	0.0013*

Table 6. Manufacturing Expo 2019 (Grades 6-8) Survey Analysis (N = 158)

Statement	Pre-Survey		Post Survey		Sign Test
	Mean	Std. Dev.	Mean	Std. Dev.	P-Value
Do you know any adults that work in manufacturing?	1.040	0.559	0.910	0.526	0.0048*
Have you been on a manufacturing tour before?	0.350	0.479	0.740	0.440	<0.001*
Have you learned about manufacturing in school?	0.650	0.479	0.860	0.351	<0.001*
I have been encouraged to consider a career in manufacturing.	3.120	1.136	3.530	1.008	<0.001*
I would consider a job in manufacturing.	3.080	1.074	3.230	1.067	0.0150*
There are many career opportunities in manufacturing.	4.20	0.734	4.280	0.807	0.0063*
Manufacturers need to have technical/trade skills.	3.930	0.704	3.740	0.851	0.0059*
Manufacturers need to have a college degree.	3.170	0.995	2.710	0.948	<0.001*
Manufacturing careers are safe.	2.710	0.786	3.130	0.865	<0.001*
Manufacturing careers are clean.	2.730	0.839	3.110	0.945	<0.001*
Manufacturing careers pay well.	3.580	0.789	3.770	0.714	<0.001*
Manufacturing jobs use new technology.	3.880	0.677	4.080	0.646	0.0001*
Manufacturing jobs offer job security.	3.370	0.754	3.670	0.730	<0.001*
I believe a manufacturing career would let me be creative & innovative.	3.460	0.925	3.500	0.930	0.2518
People working in manufacturing are able to keep their jobs for a long time.	3.470	0.788	3.660	0.787	<0.001*
Manufacturing is important to the United States economy.	4.280	0.752	4.370	0.701	0.1011
There is a need for more manufacturers in the United States.	3.780	0.853	4.030	0.783	<0.001*

Note. A Likert-scale of 5-Points was used: 5=Strongly Agree to 1=Strongly Disagree. **These questions used a scale of 0-No, 1-Yes, or 2-Im Not Sure. *Significant difference at a 95% confidence level.

Table 7. Manufacturing Tour 2019 (Grades 9-12) Survey Analysis (N = 265)

are many job opportunities in manufacturing?" showing that the outreach initiative did not likely influence participants' perceptions as the majority of the participants (n_{pre} = 337, n_{post} = 350) believed this to be true both before and after the event. Using the sign test, all but two questions ("Do you think manufacturing jobs are clean?" and "Do you think there are many job opportunities in manufacturing?") resulted in a p-value less than 0.05, meaning Manufacturing Week may have influenced students' perceptions toward manufacturing.

For the 2019 *Manufacturing Expo* (Grades 6-8) portion of Manufacturing Week, a total of 158 participants completed both the pre- and post-surveys. Participants in this group received more questions with a mixture of Yes/No and Likert-scale statements regarding the manufacturing industry. A complete overview of these survey results can be found in Table 6. Similar to the results from grades 3-5, participants believed there were many job opportunities in manufacturing after *Manufacturing Week* (M_{pre} = 3.614, M_{post} = 4.067). The largest perception change in a "negative numerical" direction centered about the belief that manufacturers need to have a college degree—meaning participants agreement with this statement became lesser (M_{pre} = 3.49, M_{post} = 3.29). The least change from pre-survey to post-survey was related to the belief that manufacturing jobs are clean—as on average the participants maintain their disagreement with this statement (M_{pre} = 2.101, M_{post} = 2.152). The results of a sign test revealed that 11 of the 15 survey statements received a statistically significant difference in participant responses after the event (see Table 6). The four statements that did not see a difference in responses focused on the need for technical/trade skills, the safety and cleanliness of manufacturing facilities, and stability in manufacturing jobs.

For the 2019 *Manufacturing Tours* (Grades 6-8) portion of *Manufacturing Week*[1], a total of 265 participants completed both the pre- and post-surveys. A complete overview of these survey results can be found in Table 7. Overall, grades 9-12 had more positive response changes for each statement and therefore more positive perception changes than grades 6-8. Notably, participants in this group experienced a positive perception change toward the safety of manufacturing jobs (M_{pre} = 2.71, $Mpost$ = 3.13) and a lesser agreement towards their belief that manufacturers need to have a college degree (M_{pre} = 3.17, M_{post} = 2.71). It can be important to note that students responded with a higher positive perception change towards cleanliness and safety in grades 9-12 than other groups. This may be contributed to the fact that the high school participants actually got to experience a tour of several manufacturing facilities while other age groups did not. In addition, the high school participants had the lowest perception change about whether a manufacturing career would allow them to be creative and innovative as they maintained a neutral to agreeable view with this statement on average (M_{pre} = 3.46, M_{post} = 3.50). Of all 17 questions given to grades 9-12, only two were determined statistically insignificant. These two questions centered on creativity and innovation being involved in manufacturing and the importance of manufacturing to the Unites States economy—on average the participants maintained a neutral to agreeable view with these statements.

Overall, students initially held the common perceptions that manufacturing jobs are dirty and unsafe before their respective *Manufacturing Week* activity and had a notable perception change after the event. These results may indicate that industry-led STEM outreach can have the capability to influence children's perceptions toward manufacturing careers. However, these perceptions, while shifting toward a more positive view of manufacturing after the event, may still be at a level that could influence individuals away from manufacturing-related careers.

Research Question 3

To answer the question of how, and in what ways, can data inform practice regarding industry-driven STEM outreach, the open-ended sections of the career perception surveys were the main focus of this analysis. In addition to yes/no and Likert-scale question formats in the career perception survey, participants were also given open-ended questions. Each participant's response was thematically coded with the purpose of gaining a deeper insight into student perceptions towards manufacturing and the outreach activities. The 2018 iteration of Manufacturing Week only included the open-ended questions in the post-survey and collected a total of 167 responses. Participants from grades 6-12 indicated their enhanced knowledge of the:

- safety measures in manufacturing facilities—51 coded comments noted the safe working conditions with statements such as *"There are so many more careers than building and it is safe and clean."*
- diversity of opportunities in manufacturing careers—193 coded comments noted the range of careers in manufacturing with statements such as I liked *"learning about the wide range of jobs in manufacturing."*
- skills necessary to pursue careers in manufacturing—65 coded comments noted the range of careers in manufacturing with statements such as *"I learned that you're going to need different skills for different manufacturing jobs, and that it's not always going to be easy."*

Participants were also surprised by the vast variety of technology used in the manufacturing industry. Furthermore, the participants mentioned that if they were asked to explain manufacturing to another person that they would say manufacturing is clean, well-paying, and has a diverse range of jobs (example comment: *there are many benefits: great facilities, amazing programs, very good paying*). Participants also liked learning about the education benefits offered by some local manufacturing companies (example comment: *It surprised me that you can get a "paid for education" and work at the same time*).

For the second iteration of *Manufacturing Week*, post-survey open-ended responses showed that participants in grades 3-8 enjoyed the activities centered around lean manufacturing and wished they could have taken a tour of the manufacturing facilities. Participants in grades 9-12 seemed to be influenced by the tours of the local manufacturing facilities, noting that seeing the actual facilities as their favorite part of *Manufacturing Week* (example comment: *I liked just about everything. Getting an inside look on what some jobs in manufacturing look like. I liked*

seeing the workplaces and the type of machines and tools used to manufacture specific things.). When asked to explain manufacturing to a friend on the pre-survey, participants in grades 6-8 mostly claimed to have limited knowledge of the industry, with some noting the diversity of manufacturing careers. Post-survey data showed an increase in knowledge of the diversity of manufacturing careers with the same group of students in addition to further mentions of salary benefits in manufacturing. Participants in grades 9-12 noted the high salary for careers in manufacturing in both the pre-survey and the post-survey, but increasing in the post-survey. Participants from grades 9-12 also showed an increased awareness of cleanliness and safety in manufacturing facilities after seeing the facilities in-person (example comment: *I learned that manufacturing is much cleaner than I had first expected*). Data collected from the open-ended questions can indicate that participants had a greater understanding of careers in manufacturing after *Manufacturing Week*.

Lastly, these career perception data and participant feedback on these surveys became valuable information for the industry outreach organizers to use to revise the STEM activities provided and how they align to the manufacturing workforce. By making meaningful partnerships to collect and analyze data from the outreach, the industry leaders and outreach organizers were able to establish a baseline for how children perceive manufacturing careers and determine potential influential outreach activities for their participants. As a result, adjustments were able to be made to the outreach activities to align with the perceptions of the different age groups and the events could be better scaffolded to account for the different age groups and their interests.

Discussions & Recommendations

Despite the exploratory nature of this research and the limitations of the surveys, the findings offer valuable insights for a) discussions on youth manufacturing career perceptions and b) suggestions for industry STEM outreach initiatives. The subsequent sections will delve into the study's results pertaining to its purpose and career development, offering recommendations for both research and practical applications derived from the survey data, the coded open-responses from participants, and the outreach event.

A Manufacturing Perceptions Gap

Before delving into the influence of the outreach on career perceptions, it's essential to first examine the initial perceptions of participants regarding the broader manufacturing industry. This is important as the purpose of this research is related to understanding the perceptions of manufacturing careers held by the next generation. These perceptions are believed to be a contributing factor to the current manufacturing workforce challenge colloquially known as the "skills gap." The "skills gap" refers to the inability for manufacturers to find skilled workers to fulfill their open job roles.

The pre-survey responses from this study do seem to indicate that children have little experience with manufacturing and hold what can be viewed as negative perceptions of the industry. For example, when reviewing the pre-survey results from the 2019 iteration of *Manufacturing Week*, 107 out of 158 participants from grades 6-8 either strongly disagreed or disagreed with the statement that manufacturing jobs are clean. Only 6 of these students agreed or strongly agreed with the same statement. Also, the 2019 pre-survey revealed that only 34% of the participants ($n = 387$) from grades 3-5 viewed manufacturing jobs as safe and only 19% believed the jobs to be clean. These perceptions are interesting as some modern manufacturing facilities local to the event have some of the lowest occupational safety incident rates in the industry and have even been operating as a "zero landfill" organization. Furthermore, the pre-survey results showed that most of the participants from these events believed there are a lot of available jobs in manufacturing. However, the majority believed that these jobs require a college degree to enter which may not always be the case. Regardless, the data seem to support the idea that a major challenge for the future of manufacturing is a "perception gap" related to manufacturing career pathways. This may likely mean that without any type of engagement with the manufacturing industry, children may not view a manufacturing career as a possible option, or even a "backup" option, in their lives. This could leave them with missed opportunities for a job that may fit with their personal and professional goals at any particular time in their lives as "doors open and close" related to their careers. It then seems important to address the perceptions gap so that these individuals can choose a career path based on an accurate understanding rather than ignorance. However, it is important to note that the participants likely do not know what they do not know. This industry outreach, *Manufacturing Week*, is likely the participants first encounter with manufacturing as it is often discussed in schools from a historical perspective. This perspective likely contributes to children establishing outdated perceptions (dark, dirty, unsafe, monotonous, etc.) of manufacturing from a first industrial revolution viewpoint. The *Social Learning Theory of Career Decision Making* suggests that indirect learning experiences are likely the most influential element for children's career perceptions in this industry (Krumboltz, Mitchell, & Jones, 1976). It is likely then that children's perceptions are driven by associative media which can be inconsistent, and as literature has indicated, historically negative or less than prestigious. In regard to SCCT, individuals may then base their outcome expectations on these indirect experiences and set career and educational goals accordingly, which will likely limit individuals pursuing a career in this field—especially those considered "middle-skilled" STEM jobs. Accordingly, this knowledge will be important to consider when aligning outreach to the variety of job roles and actually determining the goal of these educational experiences and addressing workforce concerns, specifically in the "middle-skilled" STEM area. So, it is suggested that scholars further explore the connection between industry-educational engagement, public perceptions, as well as the meaningfulness of work.

Industry STEM Outreach: Is it Worth It?

The pre-survey data indicate that participants either held a "negative" perception of the manufacturing industry or, more likely, had no conception of it at all. However, the data analysis suggests that children's career perceptions can be influenced through industry-driven STEM outreach initiatives. Whether the results of these influences are good, bad, or indifferent for different stakeholders remains open for debate. Nevertheless, the analysis showed that most individual Likert-scale survey questions, when compared from pre- to post-, experienced a statistically significant difference in participants' responses. This statistical significance may suggest that the outcome of the outreach experience aligned with the industry's goal of addressing perceptions around, and awareness of, manufacturing careers.

While the changes in responses on the Likert scale from pre-survey to post-survey indicate a potential "positive" shift in the perception of manufacturing, the responses may still not be at a level that would foster interest. Yet, the learning experiences provided could start shaping their self-efficacy and outcome expectations at a younger age when interests and career/educational goals are being formed. For example, survey responses showed that K-5 students had a greater change toward an interest in manufacturing careers. Additionally, the responses revealed a change in the perception around the need for a college degree in manufacturing. These data suggest that the outreach messaging around "not everyone needs a 4-year degree" was received and retained by many participants. This could play a role in future educational decision-making.

Looking more closely at the potential influence on interest in manufacturing careers, both iterations of Manufacturing Week show increased interest among participants. For example, the survey data suggest a relationship between the encouragement to consider a career in the industry during the event and the increased interest in pursuing manufacturing careers by the participants. Post-survey data show a greater number of participants felt encouraged to pursue manufacturing careers after the industry-led outreach event. In 2018, 41% of participants in grades 6-8 felt encouraged to pursue a manufacturing career (a 22% increase from the pre-survey), in addition to 66% of participants in grades 9-12 (a 25% increase from the pre-survey).

This information then raises questions manufacturers

may have regarding their STEM educational outreach efforts: Are these efforts worth the investment? To answer this question, it is important to consider the goals and metrics established for such efforts. For example, is the goal to spread awareness of careers, provide meaningful learning experiences, change student perceptions, attract a future workforce, develop "STEM skills" with students, or enhance public relations through community engagement? While none of these goals are mutually exclusive, there seems to be a need to continue developing clear, concise goals for industry STEM outreach and, with that, metrics for determining success. When these goals are clearly defined, efforts can be better designed and assessed. For example, if the goal is to provide long-lasting and meaningful learning experiences, efforts can be made to extend beyond informal learning events to more long-term engagements with schools.

Regarding perceptions of the industry, the data collected in this study suggest that events such as the *Manufacturing Week* experience can improve students' awareness, interest, and potential understanding of careers in the manufacturing ecosystem. However, this improvement may not result in scaffolded, authentic learning or influence on participants' career trajectories. It is challenging to change mindsets and personal goals with a one-day experience. While this can be considered a drawback or concern, it may not have to be. Life does not always offer a clear career pathway. So, these outreach experiences might offer awareness of how "middle-skill STEM occupations" in manufacturing can build a bridge to a rewarding, worthwhile career that helps the community. This awareness may open a door for careers as one's life plans may change.

This idea is supported by Gottfredson's Theory of Circumscription and Compromise (Gottfredson & Lapan, 1997), where individuals are believed to abandon preferred careers when obstacles are faced along their career pathways. The increased exposure to the industry through outreach may represent a long-term return on investment for talent acquisition later down the road and provide enhanced opportunities to showcase community engagement and public relations. Therefore, it seems valuable for manufacturers to open their doors to our youth and their surrounding communities but with clear goals for their efforts. This approach can help demystify what many of our youth see as the "manufacturing mystery box" or solely the large block building they pass by with no access to or understanding of what occurs inside (Strimel et al., 2020).

STEM Outreach & Career Alignment

Another consideration revolves around the activities provided during industry-led outreach. Most of the *Manufacturing Week* activities were "STEM-branded," including computer-aided design, additive manufacturing, robotics, and programming, aligning with the "STEM skills" discussed earlier in this article. However, the use of "STEM" as a universal term prompts scrutiny regarding how these STEM activities a) portray the broad spectrum of careers, particularly middle-skill occupations, within the manufacturing industry, and b) align with current/future job demands. The polysemy and widespread use of the STEM acronym may create a gap between the hands-on activities provided by manufacturers to engage children and the actual day-to-day tasks of industry employees. Without experiencing the authentic work environment and facilities, participants may gain a misleading impression of manufacturing roles. This misalignment could result in delivering enjoyable yet inauthentic activities that lack a genuine connection to the industry's workforce and job needs. Alternatively, such potentially misaligned activities might expose students to aspects they dislike, diverting them from viable career pathways.

Another perspective, however, is that the STEM activities provided (programming, automation, robotics, additive manufacturing, etc.) are preparing students for the future of work in the evolving digital landscape of manufacturing, encompassing Industry 4.0 and beyond, rather than meeting current workforce demands. While reports highlight the impending shortage of manufacturing jobs, particularly middle-skill roles (Deloitte, 2017; Deloitte & the Manufacturing Institute, 2018), others predict that automation will replace millions of manufacturing jobs (Oxford Economics, 2019). In light of these considerations, it remains crucial to sustain initiatives related to industry-led STEM outreach. However, a nuanced understanding of their impact on participating youth and an assessment of how provided experiences align with current and future careers within the industry are essential.

A Regional Ecosystem Approach: Data to Inform Practice

Research Question 3 aimed to investigate how participant data from industry-driven STEM outreach events could inform their activities. A noticeable observation through this research was how the manufacturers involved in the outreach have developed a regional ecosystem approach to these types of activities. This ecosystem included collaboration with the regional economic development and commerce group, coordinating outreach among partnering manufacturers, local schools, universities, and community colleges. The ecosystem's effectiveness was maintained through the establishment of a future workforce council, providing a platform for collaboration in designing outreach activities and collecting/analyzing participant data to enhance outreach practices. Each partner in the regional ecosystem leveraged their strengths: 1) industry associates offered facility access, career knowledge, event volunteers, and funding; 2) in-service and pre-service teachers designed age-appropriate activities; 3) university faculty supported data collection and analysis; and 4) community college partners provided guidance on career pathways. This regional approach presents a replicable model for other regions to scale outreach efforts with consistent goals, messaging, and a data feedback loop to refine activities. For instance, career perception data and participant feedback became valuable information for the future workforce council, guiding revisions to regional industry outreach activities. Meaningful partnerships facilitated data collection, establishing a baseline for how children perceive manufacturing careers and informing adjustments to align with different age groups and their interests. This data also showcased the potential impact of outreach activities, aiding in securing continued support, resources, and funding for future events.

Conclusion

The aim of this exploratory study was to better understand youths' perceptions of manufacturing careers and the ways in which industry-led STEM outreach can influence these perceptions. Moreover, the study investigated how participant data collected during industry-led STEM outreach events could help inform industry practice toward addressing concerns related to the future workforce and awareness of relevant career pathways. Accordingly, 1,340 participants from grades K through 12 were surveyed before and after two iterations of an industry-driven STEM outreach event, titled *Manufacturing Week*. The overarching goal of this outreach was to support the awareness/understanding of manufacturing career pathways and the related "STEM skills" for children in the region. The survey responses were then analyzed to determine a) the initial career perceptions of children, b) any significant changes in these perceptions after the industry outreach event, and c) ways in which industry-led STEM outreach could be better designed and scaffolded.

As evidenced by the analyzed data, the results supported a lack of children awareness and understanding of manufacturing, negative perceptions surrounding the careers within, and a potential disconnect between industry needs and educational output. These results may indicate that a major challenge for the future of manufacturing competitiveness is a "perceptions gap" related to manufacturing career pathways. This "perceptions gap" could leave many without the mindset to view a manufacturing career as a possible option, or even a "backup" option, in their lives. The data do seem to indicate that children have limited exposure to manufacturing and may maintain outdated perceptions of the industry potentially stemming from learning about manufacturing from a more "historical perspective" in schools. That being said, the analysis of the data collected across the pre- and post-surveys do indicate that the industry-led STEM outreach likely led the participants to an improved understanding of the manufacturing ecosystem and provided an opportunity for local schools to engage with the industry. For example, significant differences were found in the way participants 1) felt encouraged to explore manufacturing-

related careers, 2) perceived cleanliness and safety of the workplace, 3) considered manufacturing-related careers, and 4) viewed the education needed for the related career pathways. Participants also noted their new understanding of the diversity of careers within the manufacturing industry, their enjoyment with the hands-on STEM activities provided, and their enhanced perception of the creativity, innovation, and complexity ("STEM skills") related to manufacturing careers.

While these perceptions changes may be viewed as positive from an industry standpoint, the perceptions may still not be of a level that drives any goal setting toward related careers. However, it does appear to be important for industry to continue engaging with schools through expanded outreach efforts. Although the outreach may not have a clear connection to actually obtaining skilled talent within individual companies, it can potentially open doors to careers through more accurate career perceptions, enhanced awareness of career options, and enriched public relations with communities. Yet, it is important to proceed with caution when developing outreach efforts as industry representatives should consider the alignment of current and future workforce demands with the STEM activities they provide. If caution is not taken, one may provide a false sense of what manufacturing jobs may entail, be disingenuous about the work performed or the educational pathways necessary, and further drive misperceptions of the workplace by using language that may not convey information appropriately for the age of the students. Without these considerations, it may be possible for the influence of the outreach to be oppositional to the industry's future talent goals and place additional barriers for accessing related careers. Therefore, a recommendation was provided for manufacturers to establish a regional ecosystem approach to outreach. This approach should enable partnerships across industry and education that provides opportunities for schools, universities, manufacturers, and community colleges to work together with a unified approach that is informed by the collection and analysis of participant data.

While this research highlighted the influence of a regional approach to industry-outreach on students' perceptions of manufacturing careers, there is obviously no one easy fix for the ongoing workforce concerns of manufacturing. But it seems valuable for manufacturers to continue to open their doors to students/teachers/families to demystify today's manufacturing industry in which many likely have limited exposure to while in school. If not for opening pathways for students to careers within a manufacturer's own facilities, then at least this informed industry-led STEM outreach can support enhanced public relations for the company and a greater appreciation for what occurs within their walls.

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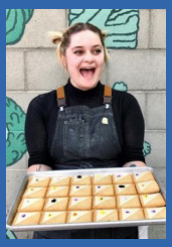

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