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Employability Skills for 21st Century STEM Students: The Employers' Perspective

Doreen McGunagle
Embry-Riddle Aeronautical University, mcgunagd@erau.edu

Laura Zizka
Ecole hoteliere de Lausanne//HES-SO University of Applied Sciences and Arts, Western Switzerland, Lausanne, Switzerland, laura.zizka@ehl.ch

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Dr. Doreen M. McGunagle
Embry-Riddle Aeronautical University
doreen.mcgunagle@erau.edu

Dr. Laura Zizka
Ecole hôtelière de Lausanne, HES-SO // University of Applied Sciences and Arts Western Switzerland
laura.zizka@ehl.ch

Abstract

Purpose

One of the goals of educational institutions is to prepare their graduates to be workplace-ready. The purpose of this paper is to identify the employability skills lacking in the Science, Technology, Engineering, and Math (STEM) industry from employers' perspectives to assist STEM educational institutions in creating more relevant programs inclusive of employability skills.

Design/methodology/approach

Based on the employability frameworks proposed by Hillage and Pollard (1998) and Knight and Yorke (2003), this study addresses 16 employability skills and their application to STEM students and their future workplaces. The data derives from the responses of 250 Human Resource Managers (HRM) that represent five manufacturing industries (Aerospace and Defense, Automotive, Consumer Products, Electronics, and Industrial Manufacturing) located in five regions (Northeast, Midwest, Southeast, West-Mountain, and Pacific) of the United States.

Findings

The median scores for all 16 skills confirmed their importance for employability in the five manufacturing industries. The five highest-ranking skills were: Team Player, Self-Motivation, Verbal Communication, Problem Solving, and being Proactive, which align with previous studies on workplace skills.

Practical implications

This paper is a call to all STEM educational institution stakeholders, both internal and external, to re-assess current curriculum and programs and collaborate to narrow the gap between graduate competencies and the practical needs of the workplace.

Originality/value

This paper attempts to bridge the gap between the competencies gained in STEM educational institutions and the competencies needed for the future workplace, as confirmed by HRM professionals. Although this study is focused on STEM educational institutions in the United States, it will be of interest to all STEM educational institutions worldwide who play a significant role in preparing the next generation of employees for the global workplace.

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Introduction

One of the goals of educational institutions is to prepare their graduates to be workplace-ready upon graduation. Nonetheless, many traditional programs continue to teach the traditional curriculum in traditional ways at the cost of neglecting the knowledge and skills necessary for today's job market and that of the future (Bunshaft et al., 2015). This has led to employability skills gaps (i.e., lack of communication, team-work, or problem-solving skills) between what students are learning in their educational programs and what the real-world employers are seeking in new graduates. Employability as defined by Knight and Yorke (2003, p.5) is "a set of achievement- skills, understandings, and personal attributes-that make graduates more likely to gain employment and be successful in their chosen occupations, which benefits themselves, the workplace, the community, and the economy" (Harvey, 2005; Maxwell and Armellini, 2018; Yorke, 2006). For Hillage and Pollard (1998, p. 2), employability is about "being capable of getting and keeping fulfilling work" (Dacre Pool and Sewell, 2007). Employability skills or those essential for business competitiveness, prosperity, and fairness (Maxwell et al., 2009) are often under-estimated and under-trained in educational institutions, and, more specifically, in Science, Technology, Engineering, and Maths (STEM) education. STEM programs have the fundamental role of preparing the next generation of scientists, tech experts, engineers, and mathematicians to meet 21st-century real-world demands in a global economy. STEM graduates are the guarantors of a country's economic success and social welfare (Knight and Bennett, 2019; Siekmann and Korbel, 2016).

Nonetheless, while STEM programs produce qualified graduates (based on discipline knowledge), many STEM programs seem to be falling short in teaching employability skills and career readiness that employers require (Rayner and Papakonstantinou, 2016). STEM students do not need more STEM content knowledge; instead, they need 21st-century skills to be able to communicate their ideas, understand corporate and personal ethics, develop social skills, and respect a culturally diverse team of peers. Most importantly, these students learn how to learn as students (Sanchez Carracedo et al., 2018) and continue to learn as lifelong learners in the workplace.

Twenty-first-century skills refers to a broad set of knowledge, skills, work habits, and character traits that are vital to the success in the future world such as ways of thinking (e.g., creativity, innovation, critical thinking, problem-solving, decision making, learning to learn, and metacognition), ways of working (e.g., communication and collaboration), literacy tools for working (e.g., information literacy and ICT literacy), and living in world (e.g., citizenship, life and career, and personal/social responsibility) (Siekmann and Korbel, 2016). According to the US Department of Education's 'Partnership for 21st Century Learning', 21st-century skills entail content knowledge, learning and innovation skills, information/media/technology skills, and life/career skills (Bunshaft, et al., 2015; Jang, 2015). These 21st-century skills have also been referred to as transferable skills (Demaria et al., 2018), cross-disciplinary skills, soft skills, or employability skills (Marbach-Ad et al., 2019). They include, amongst others, communication, teamwork, leadership, critical thinking, problem-solving, and managerial abilities (Swafford, 2017). Employability skills have been identified as crucial to business competitiveness, prosperity, and fairness (Maxwell et al., 2009). While these terms are often used interchangeably, for the purpose of this paper, the term 'employability skills' has been chosen.

Employability is dependent on the contemporary state of the economy (Yorke, 2006). The growth in human capital is the key to the success of knowledge-based economies in a globalized society (Knight and Yorke, 2003; Yorke, 2004). Previous studies have established a dire need for work-ready graduates to ensure sustained economic growth (Clarke, 2018: Ferns et al., 2019). In periods of economic growth, employers can seek employees who have well-developed transferable skills in areas beyond the discipline. Nonetheless, in periods of economic uncertainty and unpredictable labor markets, employers may adopt different measures or criteria for recruitment (Clarke, 2018). While better-qualified graduates may have far greater employment opportunities than their lesser qualified peers (Dacre Pool and Sewell, 2007), in times of economic turmoil, these graduates may be forced to take positions below the level of competencies or outside their area of expertise (Clarke, 2018).

While many previous studies have analyzed the employability skill requirements for STEM students' success in various industries (Appleby et al., 2012; Hartmann and Jahren, 2015; Maxwell et al., 2009; McGunagle, 2016; McGunagle and Zizka, 2018), this study will address 16 employability skills as cited by 250 employers in five industries (Aerospace and Defense, Automotive, Consumer Products, Electronics, and Industrial Manufacturing) that will ensure success of the new STEM workforce. These results can be used to aid STEM educational institutions in their quest of preparing the 'graduate-ness' of their students, i.e., the evolution from student to employee to citizen in the global economy (Chetwyn et al., 2018; Clark, 2018; Maxwell and Armellini, 2018) to face the challenges of volatile, complex, and ambiguous workplaces (Ferns et al., 2019) of the 21st century.

Theoretical Background

Employability frameworks

Over two decades ago, Hillage and Pollard (1998) proposed a model of employability to get and keep fulfilling work based on four components: Assets (i.e., knowledge, skills, and attitudes), deployment (i.e., career management and job search skills), presentation (i.e., CV, cover letter, interviews), and personal/external circumstances (i.e., responsibilities, household status, supply and demand in labor market). Their model included the types of transferable assets to different contexts from baseline assets such as basic skills; intermediate assets, such as occupational skills, and high-level assets, such as teamwork or business acumen. In 2003, Knight and Yorke created the USEM framework (Understanding, Skillful practices, Efficacy beliefs, and Metacognition) to embed employability into the curriculum. These frameworks attempted to fill the gap between educational institutions and the workplace by preparing work-ready graduates who are reflective practitioners willing to learn and equipped with self-management, communication, team-working, and interpersonal skills (Knight & Yorke, 2003). More recently, in 2007, Dacre Pool and Sewell built on these previous frameworks and introduced the 'key of employability' through the CareerEdge framework based on Experience, Degree, Generic skills, and Emotional intelligence.

Nonetheless, despite these attempts to construct a robust employability framework, researchers have not yet found a solution for addressing employability issues. Graduates may be employable for one job but not another (McQuaid and Lindsay, 2005) as there is no single set of skills that employers want from graduates (Maxwell and Armellini, 2018) even within the same industry or field. Further, educators are expected to train the workforce of tomorrow in all of the skills needed by all employers in diverse industries and domains (Ellis et al., 2014), a substantial challenge for programs already crammed with content. For this reason, researchers continue to explore the topic of employability in search of an ideal framework for preparing graduates for the workplace.

Literature Review

Academia versus Employment

With a proliferation of young graduates entering the job market each year and the subsequent increase in choice, employers have begun focusing on the skills they need from these new employees. Previous research has identified the mismatch or gap between the skills attained in educational programs and the transferable skills which are necessary for the workplace (Anajar et al., 2015a; Barnett, 2012; Prinsley and Baranyai, 2015; Ridzwan et al., 2015; Sarkar et al., 2016). Nonetheless, unlike disciplines such as business studies where more general employability skills could suffice, disciplinary knowledge and understanding are crucial for STEM graduates (Yorke, 2006). Thus, although STEM programs have successfully prepared STEM graduates with the academic knowledge necessary for the workplace, these students lack interpersonal and transferable skills, practical experience, general workplace experience, or required business knowledge (Prinsley and Baranyai, 2015). These graduates must be prepared to translate (through heightened communication skills) their achievements into language that is understood and respected by employers (Bunshaft et al., 2015) and demonstrate the self-efficacy, self-confidence, and self-esteem that employers seek (Dacre Pool and Sewell, 2007). Currently, employers posit that graduates cannot contribute effectively to the workplace as they have an inadequate or non-existent understanding of business and how a business runs (Sarkar et al., 2016).

STEM graduates must be able to make connections between their areas of expertise and other disciplines (Madden et al., 2013) by applying their skills to various contexts (Anajar et al., 2015; Knight and Bennett, 2019; Rayner and Papakonstantinou, 2015). They need to produce competitive, innovative solutions to real business problems in a responsive, proactive, adaptable, and creative manner (Anajar et al., 2015; Prinsley and Baranyai, 2015). These graduates need to apply life skills and life experiences beyond their academic knowledge to the workplace setting. According to a study by Akdere et al. (2019), while 95% of US employers believe young graduates should be able to solve problems with others who hold different viewpoints, only 15% of these graduates are prepared to face workplace diversity and 18% to work with people from different backgrounds. Nonetheless, one solution could derive from internship or apprentice opportunities, which provide students with real-life experiential learning in the workplace (Bunshaft et al., 2015; Jackson et al., 2016) to better prepare them for the workplace they will enter upon graduation.

Today's workplaces are evolving with an emphasis on continuous professional development and real-life problem solving, leading to deeper employee engagement (Madden et al., 2013; Maxwell et al., 2009). Specific skills such as leadership, strategy, and decision-making can be learned on the job; however, employers expect young STEM graduates to enter the workplace with higher-level communication skills and the ability to combine competencies and transfer skills from one task to the next, from one job to another (Maxwell et al., 2009). New employees will eventually become leaders in the global workplace, and these potential leaders must be able to demonstrate higher-level skills such as learning from mistakes, reflective thinking, social responsibility, and lifelong learning (Madden et al., 2013). Employers seek STEM graduates who are prepared to continue learning throughout their career, beyond the ‘threshold concept’ of learning only the key concepts to master their subject area and become lifelong learners who are capable and willing to learn new skills in the workplace. As a competent workforce is the base of a thriving economy, STEM graduates must be prepared to face these challenges armed with the employability skills necessary to be successful in one or several industries over their careers.

Educational institutions versus workplace

While educational institutions and employers agree that there is a gap between graduate preparedness and employer needs, employers reported a significantly higher gap between the two (Jackson et al., 2016). There is a gap between the content that is delivered in academic programs and what is valued in education versus the current requirements in the workplace (Bunshaft et al., 2015). For example, academia ensures that students are familiar with curricula (theoretical knowledge and content-specific tasks) and have the ability to learn. At the same time, employers believe that graduates need stronger technical (i.e., practical skills) and interpersonal skills (Jackson et al., 2016). According to Akdere et al. (2019), no new hire has failed because of a lack of technical skills; instead, it is the lack of workplace skills that is problematic. The traditional curriculum seems to reflect what teachers regard as relevant rather than the skills employers require (Jang, 2015).

Moreover, the perception of what skills are essential differ between employers, educational leaders, and employees (Jang, 2015), thus further widening the gap between educational institutions and workplaces. Educational institutions and employers must align to reflect current and future priorities of the workplace to enhance graduates’ work readiness (Rayner and Papakonstantinou, 2015). Young graduates need to be prepared to hold multiple roles in the workforce or complete numerous jobs at the same time (Mark et al., 2018) across a wide variety of situations as companies continuously expand into new business segments (Akdere et al., 2019).

From a student perspective, young graduates reported considerable gaps between what they learned in STEM educational institutions and what they saw as relevant in the workplace, including communication skills, planning skills, and awareness of ethical and social issues (Sarkar et al., 2016). However, different disciplines emphasize different transferable skills. For instance, teamwork is essential for technology and engineering programs but considered unnecessary for science and math studies (John et al., 2018). These students rated communication, critical thinking, and teamwork as essential skills to master (Demaria et al., 2018). Nonetheless, many students believe they have improved these transferable skills during their degree (Demaria et al., 2018), which is not the same impression that employers have.

Further, some students resist or reject the need to develop leadership competencies as they do not see the relevance for their future careers (Akdere et al., 2019). They may resist more active learning approaches if they do not understand the added value of adopting them in their studies (Marbach-Ad et al., 2019).

From a teaching perspective, a further gap has been identified. STEM education has long been linked to standardized testing, school funding, salaries, and the image of the school (Siekmann and Korbel, 2016). As long as students continue to perform well on standardized tests, professors see little reason to change their traditional teaching methods. Teachers are more preoccupied with content acquisition that will be evaluated on standardized tests than adopting a more integrated STEM approach (Siekmann and Korbel, 2016). The latter requires sharing resources and working together (Akdere et al., 2019), which is not a common approach in STEM disciplines. Many faculty members are apprehensive in trying new approaches as they have little or no experience in training professional competencies or bridging the gaps between academic programs and the workplace (Sanchez Carracedo et al., 2018). They may lack awareness of workplace practices (Ferns et al., 2019), believe these skills are learned only in the workplace itself (Yorke, 2006), or question the relevance of including these skills in their curriculum (Knight and Yorke, 2003). Nonetheless, today's education is more about doing than knowing (Bunshaft et al., 2015). STEM educators need to focus more on work-integrated learning or industry-based learning than traditional discipline-specific knowledge (Rayner and Papakonstantinou, 2015) and emulate a collaborative approach to their students (Bunshaft et al., 2015).

Currently, traditional discipline-specific education does not focus sufficiently on the core skills for immediate and future employment (Bunshaft et al., 2015). While educational institutions should teach students the most relevant, in-demand, and universally applicable skills to prepare them for a complex economy, it is the future that is uncertain. Current positions may cease to exist and be replaced by new jobs that have yet to be imagined (Siekmann and Korbel, 2016) with the need for skills not yet defined (Sarkar et al., 2016). According to Knight and Bennett (2019), the most in-demand occupations, particularly in STEM disciplines, did not exist five years ago. For example, graduating with a STEM undergraduate degree no longer ensures a STEM-related position upon graduation (Rayner and Papkonstantinou, 2016) nor ensures that these graduates will remain in the STEM workforce long-term. Twenty-first-century graduates need to be career agile and transfer their knowledge to other sector s of the economy (Knight and Bennett, 2019).

Further, science and engineering are not occupations as such; instead, science and engineering skills are used for a myriad of positions in numerous sectors (Siekmann and Korbel, 2016). For instance, scientists and mathematicians generate knowledge used by engineers to develop technology to support the needs of society (Siekmann and Korbel, 2016). If today's technology solves today's problems, it is outdated before it is implemented. According to Demaria et al. (2018), "60% of students are studying for occupations that may not exist in a decade" (p. 11). Thus, the challenge remains: STEM programs must develop professional competencies today for the future (Sanchez Carracedo et al., 2018), and educational institutions must recognize the value of providing employability skills in the curriculum.

Previous literature has attempted to define employability skills for young graduates (See Table 1) from employers', educational institutions', and graduates' perspectives.

INSERT TABLE 1 HERE

While the semantics differ from one study to another, specific skills such as communication, problem-solving, critical thinking, and teamwork have consistently ranked in the top 10 skills. Previous literature was used as a base for the 16 employability skills examined in this study.

Research Questions

The following research questions have been defined to address employability skills and STEM students:

RQ1: What are the most important skills employers in the manufacturing industry are seeking in new graduates?

RQ2: How do the skills of employees in the manufacturing industry compare to that of other STEM industries?

RQ3: How can the skills identified in the survey with employers in the manufacturing industry be used to revise existing educational programs to produce more effective and workplace-ready graduates?

Methodology

Data

Fayer et al.'s (2017) study reflects that STEM occupations account for 6.2% of the overall national employment. Computer and peripheral equipment manufacturing accounted for nearly 60% of the jobs from that industry. Communications equipment, semiconductor, and electronic component manufacturing accounted for nearly 40% of that industry.

Mechanical engineers work in many different industries. Their employment was 278,340 jobs nationwide. Mechanical engineers work in several manufacturing industries, which include aerospace and parts manufacturing (14,850), motor vehicle parts manufacturing (12,760), navigational, measuring, electro-medical, and control instruments manufacturing (10,820), general-purpose machinery manufacturing (10,250), and metalworking machinery manufacturing (7,920). STEM occupations can also include employment in professional, scientific, and technical services. These occupations can be held by students with differing backgrounds, from STEM higher education institutions to vocational schools, community colleges, and 4-year universities. In short, there is no one ideal educational path to prepare an employee for a successful and rewarding STEM career. The purpose of this study is to examine one of the largest STEM employment areas, i.e., the manufacturing industry, to gauge if there is any difference in the demands from the employers in STEM occupations in general and STEM positions in manufacturing so that the skills meet the demands for those positions.

This study was based on primary data that was collected from the survey responses of 250 Human Resource Managers (HRM) that represent the manufacturing industries located in five regions (Northeast, Midwest, Southeast, West-Mountain, and Pacific) of the United States. The data collection was completed in the summer of 2019 by CheckMarket. The surveys derived from five manufacturing groups: Aerospace & Defense, Automotive, Consumer Products, Electronics, and Industrial. See Table 2 for the breakdown of manufacturing groups in the study. The HRM sample was 95 female and 155 male respondents. The age group for the population was 165 from 26-45 years old and 85 from 46-65 years old.

INSERT TABLE 2 HERE

Instrumentation

McGunagle’s (2016) case study established the baseline for the job skills needed to meet the requirements by employers for STEM-based jobs. The study completed an exhaustive analysis of the essential workforce skills that were being required in current job openings by the top 14 Aerospace and Defense (A &D) companies. Appendix A Workforce Skills Survey identified 16 workforce skills from the job openings with the A & D companies.

McGunagle and Zizka (2018) validated the survey instrument with hiring managers from five organizations who had hired 432 STEM students.

The purpose of this research survey was to explore the employer's perspective on the job skills that influence the success of STEM graduates. A corporate perspective will provide a framework for understanding the skills that affect new employee's success. Lastly, the data will allow STEM institutions to develop courses that match the level of importance of the skill to the employer's expectations.

Checkmarket is an online survey company that handled the recruitment of the 250 HR Managers through their extensive contacts. Checkmarket has a vast network of panel providers, which provides them access to more than 8 million respondents worldwide. The contacts are highly profiled so they can target the exact individuals needed, based on demographic or behavioral characteristics.

The 250 HR Managers were recruited by Checkmarket to complete the Appendix A Workforce Skills Survey, which was administered online. The survey of 16 employability skills took the participants 5 minutes to complete. The entire process of recruitment and completing the survey results by the 250 HR managers from the manufacturing industry took 15 days. The participants did not receive any compensation for participating in the survey.

The essential STEM competencies were established in previous research by McGunagle (2016), and their importance was supported in further research by McGunagle and Zizka (2018). Ratings were made on a five-point Likert scale (1=not important; 2=somewhat important; 3=moderately important; 4=highly important; 5=extremely important), participants were asked to evaluate the job performance skills relevant to the manufacturing industry. The following question was used: How important is this [skill] to the performance of the jobs in this industry. The 16 skills included: Team player, negotiation skills, verbal communication, written communication, oral presentations, problem-solving, decision making, assertiveness, proactivity, self-motivation, high self-confidence, ability to synthesize, ability to gather data, leadership, customer focus, and adaptability. To explore the distribution of each rating, mean, median, and standard deviation for all HRM responses for each skill was calculated.

Results

Table 3 shows the breakdown of the skills as noted in the surveys by the 250 HR Hiring Managers from the manufacturing industry. The median score for all skills was 4 which reflects that all skills were important to jobs in the five manufacturing industries examined in this study.

INSERT TABLE 3 HERE

More precisely, Table 3 indicates the five highest-ranking job skills by the Manufacturing HR professionals. The five highest-ranking skills are noted as being a team player, self-motivation, verbal communication, problem-solving, and being proactive. The five lowest scores were customer focus, assertiveness, oral presentations, ability to synthesize, and negotiation skills. Of the five highest skills listed, self-motivation and being proactive could be considered as an appropriate attitude toward work or work ethic as defined in the literature (See Table 1). The question is one of semantics. The ideal employee then would be a proactive team player who is motivated to find innovative solutions and share them with others. Unlike the competitive academic programs some STEM students face at prestigious universities where individual achievement is vital, employable candidates are those who can work in harmony with others to solve the world’s most significant challenges.

Table 4 shows a comparison of skills by the HR Hiring Managers for the manufacturing industry and a previous study of Airline, Aerospace, and Defense (A&D) HR professionals industry who employed 432 STEM students in STEM positions (McGunagle and Zizka, 2018). The A&D HR professionals reported the highest-ranking job skills as problem solving, adaptability, the ability to gather data, being a team player, and being proactive were the most sought after employability skills. The differences between A&D HR professionals and manufacturing HR professionals are interesting because all 16 workforce skills scored 3.72 and above in the recent study. In contrast, Assertiveness and Negotiation Skills scored below three in the previous study.

INSERT TABLE 4 HERE

As seen in Table 4, the results from this study confirm eight of the top ten skills cited in an earlier study with A&D HR professionals (McGunagle and Zizka, 2018). While in the earlier study, customer focus and ability to synthesize also featured in the top ten, for this current study, decision making and leadership have made the top ten. Written communication (number 9), being proactive (5), and negotiation skills (16) are the only three that are rated the same in both studies.

Discussion

In order to align STEM educational programs with employers, educational institutions must take into account the expectations and perceptions of employers that represent the work that the students will be doing upon graduation. Bridging the gap entails the building of relationships with external stakeholders by gathering data that can be used in the quality of the educational process. Drawing from stakeholder theory, educational institutions must build relationships with their stakeholders to involve them in developing the skills necessary to meet the demands of employers. Thus, the responses to the three research questions will explore how this can be accomplished in STEM educational institutions.

RQ1: What are the most important skills employers in the manufacturing industry are seeking in new graduates?

As seen in Table 3, Manufacturing HR professionals were quite explicit in the employability skills new employees should have upon entering the workplace. The five highest-ranking skills are noted as being a team player, self-motivation, verbal communication, problem-solving, and being proactive. Manufacturing HR professionals need employees who can work well alone, in a proactive and self-motivating manner and with others effectively in a team. These HR professionals seek candidates who can solve problems and communicate (orally) the solutions they are proposing. Nonetheless, employees deriving from STEM educational backgrounds must still have the technical competencies to complete specific discipline-related tasks. Employability skills would need to be added to existing courses or programs to ensure a more holistic educational experience and, subsequently, a more well-rounded talent base for the industry.

Bunshaft et al. (2015) posited that traditional discipline-specific education does not focus enough on the essential skills that are necessary for current and future employment. Table 4 reflects the top five most important skills employers in the manufacturing industry are seeking in new graduates: Team Player, Self-Motivation, Verbal Communication, Problem-Solving, and Being Proactive.

RQ2: How do the skills of employees in the manufacturing industry compare to that of other STEM industries?

The top three skills from the previous literature for both employees and students (See Table 1) indicated that communication skills, autonomous/lifelong learning, and critical thinking/reasoning/analysis were the most sought after employability skills. As confirmed by the literature, communication skills appear on every list regardless if the population consists of employers or students. It is no surprise, then, to see similar results in this study as well. Communication skills again appeared in the top three employability skills sought by Manufacturing HR professionals.

However, a previous study using the same 16 employability skills conducted with A&D HR Professionals found that problem solving, adaptability, the ability to gather data, being a team player, and being proactive were the most sought after employability skills (McGunagle and Zizka, 2018). From this study with Manufacturing HR professionals, the top five employability skills identified were team player, self-motivation, verbal communication, problem-solving, and being proactive. The three skills that appeared in the top five in both studies were problem-solving, being a team player, and being proactive. The most surprising result derived from the ranking of communication skills. Compared to the earlier study, this study showed the growing importance of communication in the manufacturing industries as well.

Previous research (Anajar et al., 2015a; Barnett, 2012; Prinsley and Baranyai, 2015; Ridzwan et al., 2015; Sarkar et al., 2016) has identified a gap between the skills attained in educational programs and the transferable skills in the workplace. Table 4 compares the skills required by employers in the manufacturing industry to those of other STEM industries such as A&D. As seen in Table 4, the top five essential skills for manufacturing industry HR professionals are: Being a team player, self-motivation, verbal communication, problem-solving, and being proactive, while hiring managers in the A&D STEM industries were looking for problem-solving, adaptability, ability to gather data, being a team player, and being proactive (McGunagle and Zizka, 2018). Of note, the ability to gather data was an extremely critical skill in the A&D STEM industries as compared to the manufacturing industries in this study where the ability to gather data was ranked 10th of the 16 skills examined.

RQ3: How can the skills identified in the survey with employers in the manufacturing industry be used to revise existing STEM programs to produce more effective and workplace-ready graduates?

The results from this study could offer the basis for a reassessment of academic programs to create courses and programs that ‘fit’ the needs of the global workplace. If STEM institutions adhere to the recommendations made by industry HR professionals, a new curriculum inclusive of the employability skills highlighted in this study could be implemented. Further, a closer relationship between industry professionals and external partners at all levels, not just HR professionals, could be included in the creation of more innovative STEM programs that better reflect their expectations for future employees in the workplace.

Maxwell et al. (2009) and Sarkar et al. (2016) discussed the importance of employability skills that improve productivity and, subsequently, increase the earning potential for graduates. Hiring managers in the manufacturing industries noted in their surveys that the median score was 4 for all of the 16 skills. The score reflects that all of these skills should be taught in educational programs. Throughout the program, students should have the skills introduced, reinforced, and mastered by the time that they graduate from their respective programs. Additionally, these skills need to be demonstrated through learning activities like case studies, consulting activities, and simulations. The employability frameworks of Hillage and Pollard (1998) and Knight and Yorke (2003) suggested the need for embedding employability skills into the academic programs in various ways: Embedding in curriculum across the institution (Harvey, 2005); scaffolding employability-based learning within the curriculum (Maxwell and Armellini, 2018); project-based learning (Chetwynd et al., 2018; Dacre Pool and Sewell, 2007); learning by doing (Knight and Yorke, 2003; Yorke, 2006); learning with others in groups, communities of practice, and collaboration (Knight and Yorke, 2003; Jones et al., 2019; Maxwell and Armellini, 2018). Other solutions included: Career development learning, work experience (part of program or external to the program, paid or unpaid), (Dacre Pool and Sewell, 2007; Harvey, 2005), or workplace transition help (Ferns et al., 2019). To include external stakeholders, educational institutions can encourage: Employability studies to assess current curriculum offer (Ellis et al., 2014); partnerships with industry to prepare work-ready graduates and work-integrated learning that is longer and more often and lead to inspiring, engaging, and beneficial work placement opportunities (WIL) where role models and mentors are essential (Ferns et al., 2019); and employability development opportunities from curriculum, career services, or outside the university (Harvey, 2005). Students should be able to demonstrate that they have mastered those skills through assignments outside of their standard testing.

Conclusions/Implications

This study has shown that employability gaps exist in STEM educational institutions. The 16 skills that were examined in this study were all considered as necessary by Manufacturing HR professionals who currently hire STEM graduates. While Table 1 summarized many studies that have previously ranked employability skills and show similar results, STEM educational institutions seem slow to react. Thus, employability skills continue to be a crucial area of research (Harvey, 2005; Hillage and Pollard, 1998; Maxwell and Armellini, 2018; Maxwell et al., 2009; Yorke, 2006). For some academic stakeholders, there is a misperception that these skills can or should be learned in the workplace; if that were true, they would be called employment skills or employee skills, not employability skills. Nonetheless, as seen in the literature, no clear solutions to bridging the gap between studies and the workplace have been found.

To summarize previous research findings, employability skills are those that help HR professionals to decide between two qualified candidates who are applying for the same job. These skills make the difference between an employee who does a task when commanded to do so versus an engaged employee who takes initiatives alone and thrives when working in a team. Employability skills lead to satisfied employees who do better work and lessen the risk of absenteeism, job-hopping, or turnovers. The necessity of preparing today's STEM students to be the best candidates for the future workplace is apparent. The only question is when STEM educational institutions will implement these changes.

Limitations/Future Studies

This study has numerous limitations. Like previous studies, this study focused on HR professionals and their perceptions of the employability skills needed in the workplace. However, no study focused on the same list of employability skills, and no one list of employability skills has been defined. Depending on the industry or participants in the study, the employability skills vary; thus, it is difficult, if not impossible, to make concrete recommendations that are suitable for all. Future studies could investigate students who are about to graduate or young graduates themselves to gauge which skills they perceive as necessary for the workplace. One limitation lies in conducting this study with employers in the manufacturing industries. Future research could target specific STEM employers individually or by area of expertise.

Nonetheless, as STEM graduates tend to work in many different industries, focusing on one specific area of expertise could prove challenging. Another limitation resides in the 16 employability skills tested in this study. A future study could combine these 16 skills with the most cited skills deriving from previous studies. A final limitation lies in the context of this study: It focused uniquely on STEM students and employers in five regions of the United States. Further studies could be conducted on an international scale to confirm or dispute the findings of this study.

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Employability Skills TABLES

TABLE 1: *Synthesis of skills, attributes, and competencies for STEM graduates*

Perspective	Skills/competencies/attributes	Source
Employer	**4 levels of STEM skills:** 1.Basic information processing skills; 2. Advanced cognitive skills; 3. Technical job-specific skills, 4. Socio-Emotional skills Employability skills: socio-emotional, higher-order cognitive skills, basic cognitive skills/ technical skills	(Siekmann & Korbel, 2016)
Employer	**Nine competences that are deemed important by employers:** Deeper learning; Analytical reasoning; Effective communication; Critical thinking; Managing complexity; Collaborative work; Self-directed learning; Cultural awareness; Innovation	(Akdere, Hickman, & Kirchner, 2019)
Employer	**10 skills/attributes (5 generic/5 interpersonal) – employer perspective** Written/oral communication; Problem-solving; Critical thinking; Numeracy; Teamwork; Understanding ethical conduct; Flexibility/adaptability; Self-confidence/independence; Personal planning/organization	(Rayner & Papakonstantinou, 2015)
Employer	**Job performance skills (by STEM employers)- in order of importance** Problem solving; Adaptability; Ability to gather data; Team-work; Proactive; Self-motivated; Customer oriented; Verbal skills; Written skills; Synthesize; Decision making; Leadership; Oral presentations; Self-confidence; Assertive; Negotiation	(McGunagle & Zizka, 2018)
Employer	**20 skills ranked by practitioners necessary for STEM employees** Communication; Work ethic; Problem solving; Team work; Decision making; Competency; Accuracy; Analytical skills; Time management; Efficiency; Continuing education; Organizational skills; Knowledge retention; Business acumen; Technical writing; Empathy; Mathematical skills; Internships/coops; Finance/accounting; Exposure/roleplay	(John, Chen, Navaee, & Gao, 2018)
University	**Vocational attributes:** Discipline knowledge; Ability to develop/apply relevant knowledge **Generic attributes:** Communication skills; Critical thinking; Problem-solving; Numeracy **Interpersonal attributes:** Teamwork; Understanding of ethical conduct; Flexibility/adaptability	(Rayner & Papakonstantinou, 2016)
STEM and non-STEM students	**Attributes important for future career (by STEM/non-STEM students)** Problem solving; Critical thinking; Lifelong learning; Creative thinking; Entrepreneurship; Psychological well-being; Communication; Interpersonal effectiveness	(Mark, So, Chan, Luk, & Ho, 2018)
Students	**10 skills (Seven general workplace/ Three workplace specific by biomedical science students**) Assessing information; Evaluating evidence; Compiling essential components into 1-page summary; Presenting data as graphs; Determining data reliability; Researching literature for solutions; Writing financial reports; Pipetting accurately; Measuring and collecting data; Presenting data to colleagues	(Demaria, Hodgson, & Czech, 2018)
Science students	**20 areas of knowledge and skills important for employability** Content knowledge in discipline; Application to disciplinary area; Ability to explain the role and relevance of science in society; Research skills; Appreciation of ethical scientific behavior; Technical analysis; Knowledge/appreciation/awareness of business/commerce/industry;	(Sarkar, Overton, Thompson, & Rayner, 2016)

	Mathematical skills; Information/ technology skills; Analytical/ critical thinking skills; Problem solving skills; Report writing/ written communication skills; Oral presentation/verbal communication skills; Ability to retrieve/locate information; Leadership skills; Team working skills; Time management/ organizational skills; Flexibility/ adaptability; Ability to use own initiative; Independent learning	
Students	Problem solving; Applying quantitative reasoning; Acquiring major scientific concepts; Decision-making based on evidence; Creativity/ innovation	(Marbach-Ad, Hunt, & Thompson, 2019)

TABLE 2: *Manufacturing Industries*

What manufacturing industry represents your firm?

Aerospace & Defense	17	6.80
Automotive	52	20.80
Consumer Products	67	26.80
Electronics	32	12.80
Industrial	85	34
Total respondents:	250	

TABLE 3: *Breakdown of Skills (highest to lowest) for Manufacturing HR Professionals*

Skills	Mean, Median, SD
Team Player	4.28, 4. .84
Self-Motivation	4.24, 4, .893
Verbal Communication	4.2, 4, .946
Problem Solving	4.18, 4, .0951
Proactive	4.17, 4, .861
Decision Making	4.16, 4, .930
Adaptability	4.16, 4, 870
Leadership	4.06, 4, .971
Written Communication	4.06, 4, .858
Ability to Gather Data	4.06, 4, .848
High Self Confidence	4.03, 4, .922
Customer Focus	4.02, 4, .942
Assertiveness	3.93, 4, .924
Oral Presentations	3.89, 4, 1.016
Ability to Synthesize	3.83, 4, .989
Negotiation Skills	3.72, 4, 1.104

TABLE 4: *Comparison of Manufacturing versus A&D HR Professionals (highest to lowest)*

Skills for Manufacturing HR Professionals	Mean and SD	Skills for A&D HR Professionals *	Mean and SD
Team Player	4.28, .84	Adaptability	4.8 .4472
Self-Motivation	4.24, .893	Problem Solving	4.8 .4472
Verbal Communication	4.2, .946	Ability to Gather Data	4.6 .5477
Problem Solving	4.18, .095	Team Player	4.4 .5477
Proactive	4.17, .861	Proactive	4.2 .4472
Decision Making	4.16, .930	Self-Motivation	4.0 .7071
Adaptability	4.16, .870	Customer Focus	4.0 .7071
Leadership	4.06, .971	Verbal Communication	3.8 .4472
Written Communication	4.06, .858	Written Communication	3.8 .4472

Ability to Gather Data	4.06, .848	Ability to Synthesize	3.8 .4472
High Self Confidence	4.03, .922	Decision Making	3.6 .8944
Customer Focus	4.02, .942	Leadership	3.6 .8944
Assertiveness	3.93, .924	Oral Presentations	3.2 1.095
Oral Presentations	3.89, 1.016	High Self Confidence	3.2 1.095
Ability to Synthesize	3.83, .989	Assertiveness	2.8 .4472
Negotiation Skills	3.72, 1.104	Negotiation Skills	2.2 .4472

*(McGunagle & Zizka, 2018)

Appendix A: Workforce Skills Survey

Evaluate the new recruits with specific job performance skills needed in your industry. Range on scale (5) extremely important, (4) very important, (3) moderately important, (2) slightly important, (1) not important.

1. Team Player	5	4	3	2	1
2. Negotiation Skills	5	4	3	2	1
3. Verbal Communication	5	4	3	2	1
4. Written communication skills	5	4	3	2	1
5. Oral Presentations	5	4	3	2	1
6. Problem Solving	5	4	3	2	1
7. Decision Marking	5	4	3	2	1
8. Assertiveness	5	4	3	2	1
9. Proactive	5	4	3	2	1
10. Self-Motivated	5	4	3	2	1
11. High Self Confidence	5	4	3	2	1
12. Ability to Synthesize	5	4	3	2	1
13. Ability to Gather Data	5	4	3	2	1
14. Leadership	5	4	3	2	1
15. Customer Focus	5	4	3	2	1
16. Adaptability	5	4	3	2	1