MANAGERIAL PERCEPTIONS OF STEM WORKFORCE SUPPLY AND DEMAND ISSUES

Kristie Abston, Middle Tennessee State University
Sam Zaza, Middle Tennessee State University
Murat Arik, Middle Tennessee State University
Patrick Geho, Middle Tennessee State University

ABSTRACT

We investigated managerial perceptions of the STEM workforce by surveying over 1,000 managers and executives across five southeastern states that comprise the Tennessee Valley Corridor. We explored their views on the supply of STEM workers in their states, their predictions regarding the demand for STEM workers 12 months out, and their views on how their organizations would be impacted if they could not fill open positions in the short- and long-term. Using open-ended items and textual analysis, we studied the managers' and executives' views on the challenges affecting their states' supply of STEM workers and on the significant challenges affecting their organizations' recruitment of STEM workers. Lastly, we considered their assessments of their organizations' human resource management practices that relate to securing and maintaining a STEM workforce. Results indicate that our managers and executives are challenged by sustaining a STEM pipeline in their states, including the educational components and the economic factors, such as competitive wages. Certain industries reflected stronger results across the empirical questions. Other implications for sustaining a quality STEM workforce are presented.

INTRODUCTION

A recent *Harvard Business Review* article stated, "Hiring talent remains the number one concern of CEOs" and "…chief executives view the unavailability of talent and skills as the biggest threat to their business" (Cappelli, 2019, p. 50). Given how important securing and maintaining a talented workforce is, it is no surprise for organizations to consider their workforces to be their "most important tangible asset" (Louch, 2014, para. 1). Organizational capabilities and constraints, labor market conditions, time, and other resource limitations make the staffing process challenging for any organization. When organizations seek employees with highly specialized, valuable skills, like those represented by science, technology, engineering, and math (STEM) backgrounds, they may face even more challenges sustaining their workforces.

Depending on where one looks, articles highlighting the shortages in the STEM workforce, as well as publications declaring those shortages to be myths, are readily available. With news headlines such as "STEM Worker Shortage at Crisis, Survey Shows" (Radu, 2018) in the *U.S. News & World Report* and "America's High-Tech STEM Crisis" (Herman, 2018) in *Forbes*, one might assume that shortages persist. However, some scholars argue that the

shortages are myths (e.g., Teitelbaum, 2014) or that they depend on the industry or sector (Camilli & Hira, 2019; Xue & Larson, 2015). To add another twist, some scholars and practitioners propose that perceived shortages are due to the speed with which technology is changing (Deming & Noray, 2018; IBM, 2019), immigration issues (Garg, 2019), or the skills gap in U.S. workers, who need retraining (IBM, 2019). As a result, management researchers and practitioners alike may struggle to understand the status of the STEM workforce in the U.S.

The purpose of this study is to add to the literature by exploring managerial perspectives of the status of the STEM workforce and their organizations' abilities to address any existing and predicted future gaps between supply and demand for STEM workers. We sought insights from managers and executives regarding what their organizations are doing to address the supply and demand challenges they are facing. The next section reviews academic literature and the theoretical foundation for focusing on STEM workers. Research questions, data and methodology, and results and discussion sections follow. Lastly, the implications, conclusions, and future research are discussed.

LITERATURE SUPPORT

Based on their 2017 CEO survey, PricewaterhouseCoopers reported that 53% of U.S. CEOs indicated that STEM skills were very important, and 12% felt that STEM skills were very difficult to recruit (PwC, 2017). Even though some organizational leaders recognize the uniqueness and value of STEM workers along with the challenges of sustaining the STEM workforce, academic research on the STEM workforce in the areas of business and management is scarce. An advanced Google Scholar search reveals around 300 sources when searching for the phrases "science, technology, engineering," and "United States" with business or management in the publication name and with some human resource management phrase in the search (e.g., staffing, human resource, and recruit). Most of the search results were related to gender (e.g., Servon & Visser, 2011), education (e.g., Dynarski, Hyman, and Schanzenbach, 2013), and global efforts (e.g., Hunt, 2014; Lewin & Zhong, 2013).

However, three business/management sources were found that examined the STEM workforce. Christo-Baker, Sindone, and Roper (2017) reported on the skills gap in the seven-county area known as Northwest Indiana and highlighted the shortages of workers with requisite skills, particularly in the largest economic contributors: utilities, manufacturing, construction, and healthcare, all of which rely heavily on STEM workers. Arik and Geho (2017b) surveyed 200 human resource professionals to explore their recruitment and retention strategies for STEM workers. They found that organizations preferred investing in their own employees and recruiting as their top two strategic solutions for STEM skills shortages. Arik and Geho (2017a) used the resource-based view theory to examine the role of the STEM workforce as a source of competitive advantage for organizations and for a geographic region, the state of Tennessee. They concluded that there is an economic impact from a STEM skills gap and that a skilled STEM workforce should be considered a source of sustainable competitive advantage.

We also rely on human capital theory (Becker, 1964) and resource-based view (Barney, 1991) as the foundations for this study. STEM workers clearly have strategic value to their

organizations, and this capital increases with experience and additional training (Becker & Huselid, 1998). Their specialized knowledge, skills, and learned capabilities affect organizational performance (Maley, 2019) by producing the results that organizations rely on for sustainable competitive advantage.

RESEARCH QUESTIONS

Managers usually have the ultimate say in staffing decisions for their areas, and their direct reports reflect approximately 80% of an organization's workforce (Hassan, 2011). We surveyed managers, CEOs, CFOs, presidents, and vice-presidents to explore their perceptions of the challenges related to the supply and demand of STEM workers. The data and methodology are described in the next section. Our research questions included:

1. What changes do you predict in your state's supply and demand for STEM workers?
2. What are the challenges affecting the general supply of STEM workers in your state?
3. How effectively are your human resource management practices securing and maintaining your STEM workforce?

DATA AND METHODOLOGY

We addressed these research questions by studying data that was collected as part of a larger project studying the status of the STEM workforce in five southeastern states: Alabama, Kentucky, North Carolina, Tennessee, and Virginia. These five states make up the Tennessee Valley Corridor (TVC), which is an economic development organization that strives to promote federal science and technology vocations. Based on this emphasis of science and technology, TVC was an appropriate population to study managerial perceptions of the STEM workforce.

As shown in Table 1, STEM workers make up 13.8% of the total workforce in the TVC as of 2017 (Census.gov). For a frame of reference, Massachusetts had the highest percentage of STEM workers in the U.S. at 17.9%. Between 2018-2028, STEM occupations are expected to grow 8.8% in the U.S. compared to 5.0% for non-STEM occupations (BLS, 2020). Educational attainment in STEM fields as a percentage of all higher education degrees was over 26% in all TVC states in 2018, but only one state (North Carolina) exceeded the national average (NSB, 2020). Further, every state exceeded the national average in the percentage of disposable personal income undergraduate students were paying at public, 4-year institutions in 2018 (NSB, 2020).

Table 1
TVC WORKFORCE, EDUCATION, AND FUNDING SNAPSHOT

	STEM WORK-FORCE 2017 (%)	BACHELOR'S DEGREES IN SCIENCE AND ENGINEERING CONFERRED PER 1,000 INDIVIDUALS 18-24 YEARS OLD 2018	SCIENCE AND ENGINEERING DEGREES AS PERCENTAGE OF HIGHER EDUCATION DEGREES CONFERRED 2018 (%)	POSTSECONDARY DEGREE HOLDERS AMONG INDIVIDUALS 25-44 YEARS OLD 2018 (%)	AVERAGE UNDERGRADUATE CHARGE AT PUBLIC 4-YEAR INSTITUTION AS PERCENTAGE OF DISPOSABLE PERSONAL INCOME 2018 (%)	ACADEMIC R&D PER $1,000 OF GROSS DOMESTIC PRODUCT 2018 ($)
Alabama	12.9	20.55	26.0	37.8	51.5	4.83
Kentucky	12.3	16.23	26.6	39.2	54.5	2.86
North Carolina	13.9	20.82	34.6	45.9	42.2	5.66
Tennessee	13.2	16.45	26.1	39.2	44.2	3.54
Virginia	16.5	26.85	32.6	51.7	46.3	3.15
U.S.	13.8	22.99	33.0	45.6	41.7	NA

Source: American Community Survey, Census Bureau, BLS, and NSB

Data were collected over a three-month period using a Qualtrics panel. Respondents include 1,008 managers and executives from manufacturing or professional and business service organizations with 50+ employees across the TVC. Descriptive statistics were used to analyze the quantitative answers, while MineMyText was used to conduct a textual analysis of the open-ended items. The MineMyText application identifies probabilistic thematic coverage by clustering unstructured text into thematic categories using the Latent Dirichlet Allocation (LDA) algorithm. This tool is fully automated and removes the chance of researcher bias impacting textual analysis. MineMyText allows us to discern probabilistic topics that are entirely data driven.

RESULTS AND DISCUSSION

Changes in State's Supply and Demand

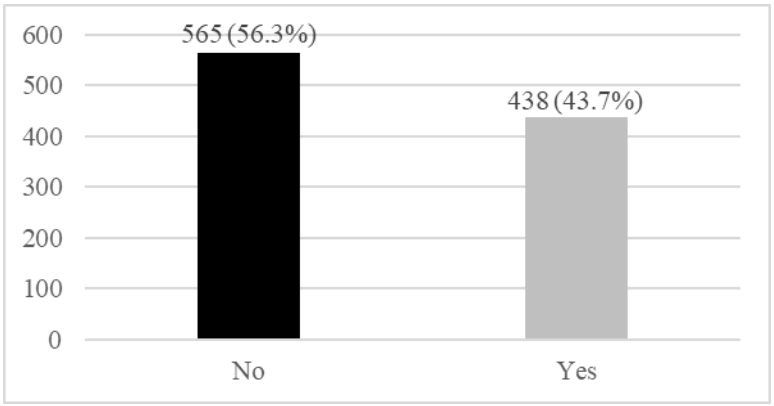
To gain a better understanding of the respondents' views on the supply and demand of STEM workers in their states, we asked three questions. First, we asked if there were enough quality/competitive individuals being produced for STEM jobs in their respective states – yes or no. Next, we asked for respondents' predictions regarding the number of STEM employees they would have in the next 12 months – would that number decrease, remain the same, or increase? Lastly, we asked how their organizations would be impacted if they are unable to fill open positions in the 1-10-year range.

As Figure 1 indicates, 565 respondents, or 56.3%, indicated that no, there are not enough quality workers being produced for STEM occupations in their states. This finding indicates that the STEM pipeline – families, educators, community, industry, and government – still has an important role to play in sustaining the STEM workforce.

A number of factors could explain why a majority of managers and executives perceive an insufficient supply of quality/competitive individuals being produced in their states. Human

resource management (HRM) metrics, such as time to hire, new employee performance, turnover, and salary levels compared to market rates, would all be of concern to managers and executives. If an organization is unable to attract quality applicants for open positions and is unable to hire employees who can perform adequately after the training period, then managers and executives would be concerned, especially if the organization is paying salaries that are competitive in the market. If these managers and executives are also aware of data and trends regarding the workforce in their regions, such as using economic reports from the chambers of commerce in their areas, then they should be well-equipped to assess the supply of quality/competitive STEM workers in their regions.

Figure 1
SUFFICIENT SUPPLY OF QUALITY STEM WORKERS
TENNESSEE VALLEY CORRIDOR



As shown in Figure 2, the proportion of different responses between states varies greatly, which indicates that certain states need more assistance than others with the STEM pipeline. Respondents in Kentucky and Alabama reported the highest numbers of no responses, whereas respondents in Tennessee and North Carolina reported the highest number of yes responses.

Figure 2
SUFFICIENT SUPPLY OF QUALITY STEM WORKERS – STATE LEVEL

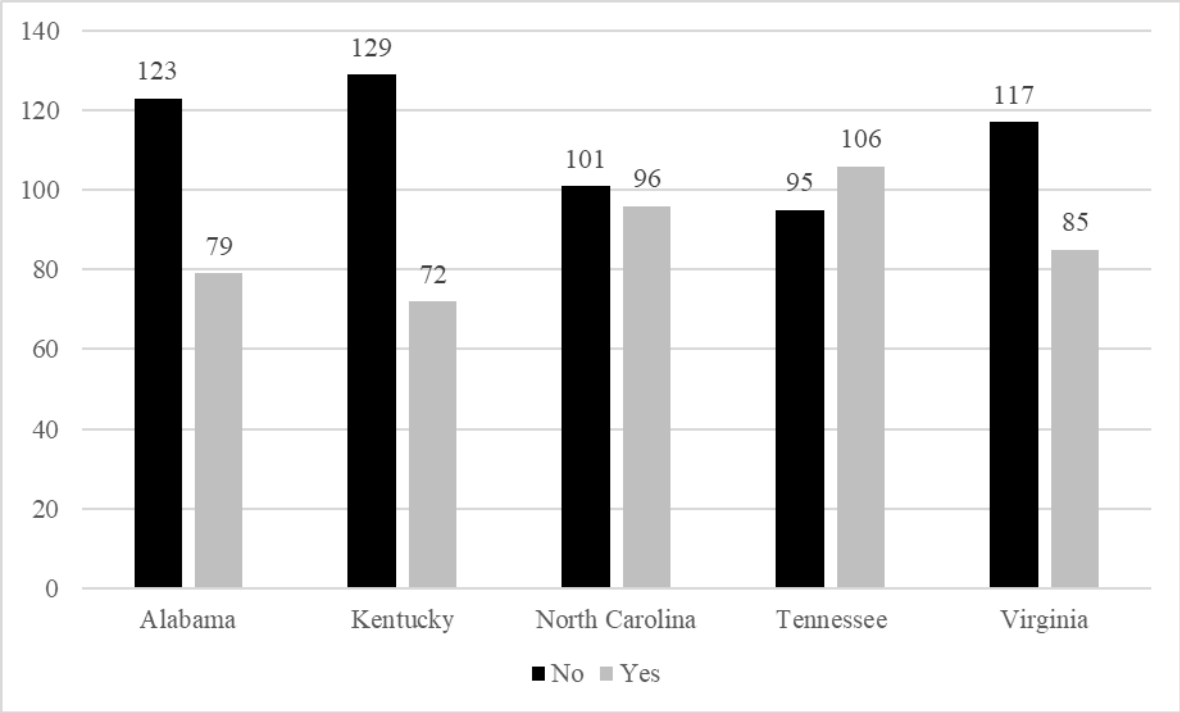


Table 2 provides the percentages of no and yes responses for each state regarding the sufficiency of quality workers being produced for STEM occupations by state. Respondents in all of the TVC states except Tennessee indicated that the quality of the supply of STEM workers was not sufficient. Kentucky had the highest percentage of no responses (64.2%) followed by Alabama (60.9%), indicating that those states may be experiencing more significant problems with their STEM pipeline than the other TVC states.

Table 2
SUFFICIENT SUPPLY OF QUALITY STEM WORKERS
PERCENTAGE BY STATE

STATE	NO	YES
Alabama	60.9%	39.1%
Kentucky	64.2%	35.8%
North Carolina	51.3%	48.7%
Tennessee	47.3%	52.7%
Virginia	57.9%	42.1%

Table 3 provides the responses by industry. The industry-level data shared throughout this paper describes collective responses from a larger study, which included the TVC states

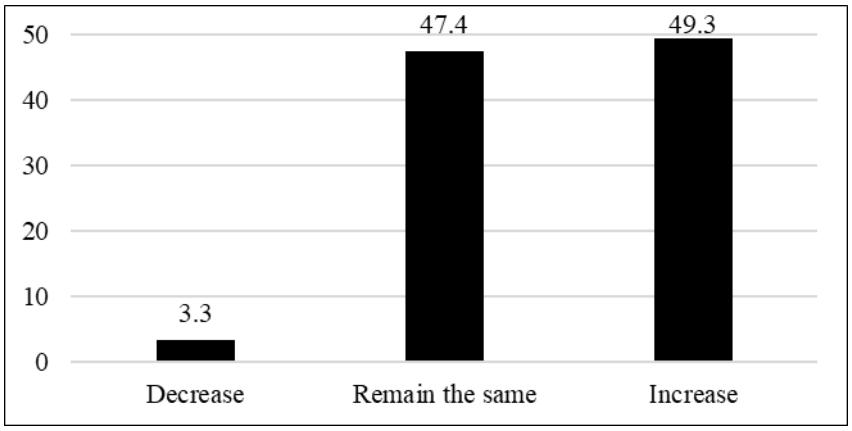
addressed in the present study. Managers and executives in two industries appear to perceive the availability of quality/competitive individuals being produced for STEM jobs as sufficient: energy technologies and transportation, logistics, and distribution services. The industry with the highest perceived shortage in available quality/competitive workers for STEM jobs was the state and local government. This result is not surprising, given that most state and local government workers believe they could earn more by working in the private sector (Bond & Kenneally, 2019). STEM jobs, in particular, are likely to be compensated more competitively in for-profit organizations.

Table 3
SUFFICIENT SUPPLY OF QUALITY STEM WORKERS BY INDUSTRY

INDUSTRY	NO	YES	NO/YES RATIO	% POINT DIFFERENCE (NO-YES)
Advanced Manufacturing	94	75	1.25	11.24%
Automotive	31	21	1.48	19.23%
Chemical Products and Plastics	18	10	1.80	28.57%
Education	45	18	2.50	42.86%
Energy Technologies	20	31	0.65	-21.57%
Healthcare	133	71	1.87	30.39%
Other (e.g., defense, financial services, food, information technology, and other manufacturing)	62	41	1.51	20.39%
Professional and Business Services	232	230	1.01	0.43%
State and Local Government	28	6	4.67	64.71%
Transportation, Logistics, and Distribution Services	17	23	0.74	-15.00%
GRAND TOTAL	680	526	1.29	12.77%

Next, we asked respondents to predict how the levels of STEM employees in their states would change during the next 12 months – decrease, remain the same, or increase. As shown in Figure 3, a slight majority of respondents (49.3%) indicated that their number of employees would increase while 47.4% of respondents reported that their numbers would remain the same. This data tells us that some organizations expect to need more STEM workers while a similar proportion of organizations expects their employment levels to stay the same.

Figure 3
PROJECTED NUMBER OF STEM EMPLOYEES
TENNESSEE VALLEY CORRIDOR



As shown in Table 4, a substantial majority of respondents across all five states report that the number of STEM workers they expect to have 12 months from now will remain the same or increase. Tennessee had the largest percentage of respondents predicting an increase (58.2%), while Kentucky had the lowest percentage of respondents predicting an increase (42.3%).

Table 4
PROJECTED NUMBER OF STEM EMPLOYEES BY STATE

STATE	DECREASE	REMAIN THE SAME	INCREASE
Alabama	5.45	43.07	51.49
Kentucky	3.98	53.73	42.29
North Carolina	2.97	46.53	50.50
Tennessee	1.99	39.80	58.21
Virginia	1.98	53.96	44.06

We can see in Table 5 that seven of ten industries expect the number of STEM employees to increase while three of ten industries expect the number of STEM workers to stay the same. Transportation, logistics, and distribution services was the strongest number (67.5%) to predict the number of STEM employees would stay the same while automotive, professional and business services, and energy technology industries were the strongest numbers (around 52.9-53.9%) to predict an increase in the number of STEM employees.

Table 5
PROJECTED NUMBER OF STEM EMPLOYEES BY INDUSTRY

INDUSTRY	DECREASE		INCREASE		REMAIN THE SAME	
	Number	%	Number	%	Number	%
Advanced Manufacturing	9	5.33%	81	47.93%	79	46.75%
Automotive	3	5.77%	28	53.85%	21	40.38%
Chemical Products and Plastics	2	7.14%	14	50.00%	12	42.86%
Education	3	4.76%	30	47.62%	30	47.62%
Energy Technologies	0	0.00%	27	52.94%	24	47.06%
Healthcare	9	4.41%	98	48.04%	97	47.55%
Other (e.g., defense, financial services, food, information technology, and other manufacturing)	3	2.91%	51	49.51%	49	47.57%
Professional and Business Services	11	2.38%	247	53.46%	204	44.16%
State and Local Government	2	5.88%	15	44.12%	17	50.00%
Transportation, Logistics, and Distribution Services	0	0.00%	13	32.50%	27	67.50%
GRAND TOTAL	42	3.48%	604	50.08%	560	46.43%

To probe further, we asked respondents how their organizations would be impacted if they are unable to fill open positions in the future. As shown in Figure 4, nearly 52% responded that their organizations would experience a negative impact, while 13.5% indicated they were unsure. Unexpectedly, 22% of respondents indicated that the impact of being unable to fill open positions would be positive. Finally, 12.6% reported that there would be no impact from being unable to fill open positions.

Figure 4
IMPACT OF BEING UNABLE TO FILL OPEN POSITIONS IN THE FUTURE
TENNESSEE VALLEY CORRIDOR

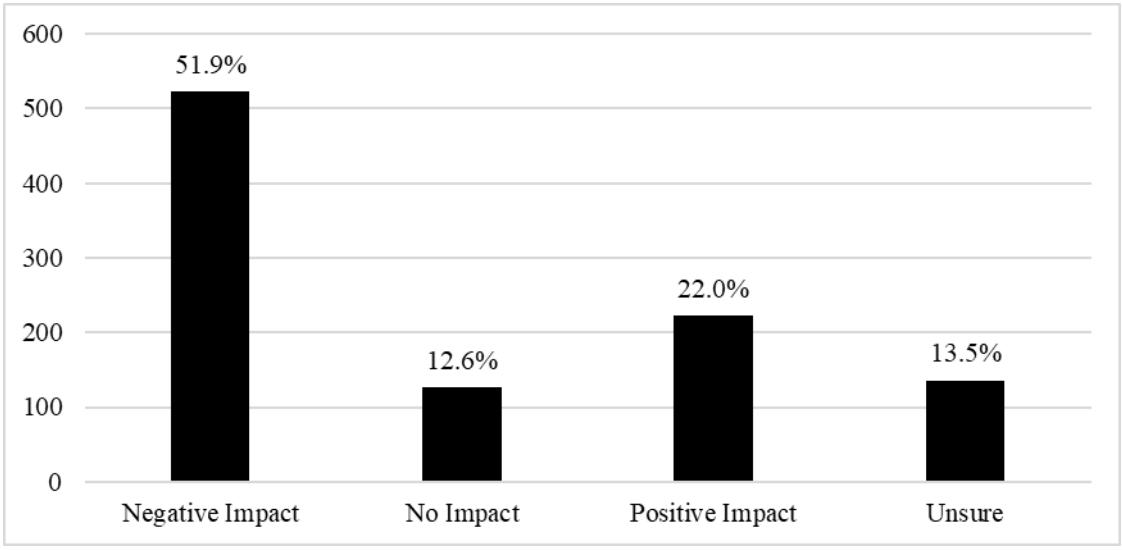


Table 6 provides detailed state responses for each level of impact. The high number of positive impact answers could reflect respondents misreading the question, which stated: How will your business be impacted if you are unable to fill these jobs? However, it is possible that respondents were extrapolating that unfilled jobs would indicate growth and improved organizational performance, hence a good or positive problem. We would need to investigate the individual responses to determine if there are other survey indicators that might explain this result, such as research and development budgets.

Table 6
IMPACT OF BEING UNABLE TO FILL OPEN POSITIONS IN THE FUTURE BY STATE

IMPACT	ALABAMA	KENTUCKY	NORTH CAROLINA	TENNESSEE	VIRGINIA	TOTAL	%
Negative Impact	94	112	105	99	113	523	51.9
No Impact	26	24	23	26	28	127	12.6
Positive Impact	52	41	42	49	38	222	22.0
Unsure	30	24	32	27	23	136	13.5
GRAND TOTAL	202	201	202	201	202	1008	100

When we consider the respondents' perspectives on impact by industry, as shown in Table 7, we see that the three most negatively impacted industries are education, healthcare, and chemical products and plastics. Energy technologies and transportation, logistics, and distribution services projected the lowest negative impact, which is aligned with managers and executives in those industries reporting that there is a sufficient supply of quality/competitive STEM workers (as previously shown in Table 2).

Table 7
IMPACT OF BEING UNABLE TO FILL OPEN POSITIONS IN THE FUTURE BY STATE

INDUSTRY	NEGATIVE IMPACT	NO IMPACT	POSITIVE IMPACT	UNSURE	NEGATIVE/ POSITIVE IMPACT RATIO
Advanced Manufacturing	84	20	44	21	1.91
Automotive	28	5	12	7	2.33
Chemical Products and Plastics	17	1	6	4	2.83
Education	42	5	8	8	5.25
Energy Technologies	20	9	18	4	1.11
Healthcare	103	23	35	43	2.94
Other (e.g., defense, financial services, food, information technology, and other manufacturing)	44	20	22	17	2.00
Professional and Business Services	243	68	101	50	2.41
State and Local Government	22	1	10	1	2.20
Transportation, Logistics, and Distribution Services	17	4	14	5	1.21
GRAND TOTAL	620	156	270	160	2.30

Challenges Affecting the Supply of STEM Workers

To explore the respondents' views on the challenges associated with their states' supply of STEM workers, we asked two open-ended questions. First, we asked a broad question: What are the major challenges associated with the factors affecting the supply of a STEM workforce? Second, we asked a more specific question: What are the major challenges your business faces in recruiting a STEM workforce? MineMyText was used to identify the themes found in this qualitative data.

As shown in Table 8, respondents indicated that the major factors affecting the supply of a STEM workforce were a lack of quality education, a lack of interest in STEM and availability, STEM jobs often require experience, and a lack of resources (funding and support) to provide high-quality STEM workers. These factors highlight the important contributions that a strong STEM pipeline plays for communities, regions, and states. Families, educators, community, industry, and the government may strategically address these factors to sustain the supply of quality STEM workers in their states.

Table 8
TOPIC MODELING RESULTS
MAJOR FACTORS AFFECTING THE SUPPLY OF STEM WORKFORCE

TOPIC ID	FIVE MOST FREQUENTLY USED WORDS	EXEMPLARY CONTENT/QUOTES	INTERPRETATION OF THE TOPIC
1	Train Teacher Skill Information Field	"Science and math are taught in a mediocre way to the lowest common denominator of learning. We need to teach high potential students at a high potential level."	Lack of quality education
2	Interest Availability Work Pay Employee	"There is a lack of interest. Also, there is an issue of availability of STEM and encouragement in poorer areas."	Lack of interest and availability
3	Job School Opportunity Quality Qualify	"Companies require experience way too often rather than hiring fresh outs and educating employees with on the job training."	Jobs often require experienced STEM workers
4	Fund Cost Resource Support High	"There are not sufficient resources to support supply of STEM workforce requirements."	Lack of resources to provide high-quality STEM workers

As shown in Table 9, respondents indicated that the major challenges they faced in recruiting a STEM workforce included the supply is not meeting demand, a lack of skilled STEM workers, and the ability to pay competitive wages. These challenges are similar to the recruiting hurdles an organization would face with any occupation that is experiencing high demand. Organizations that are unable to pay competitive wages may have no choice but to hire lesser-qualified workers and provide them with any additional training that is needed to bring their skills to the necessary levels. Otherwise, these organizations' ability to compete effectively will decrease over time.

Table 9
TOPIC MODELING RESULTS
MAJOR CHALLENGES IN RECRUITING YOUR STEM WORKFORCE

TOPIC ID	FIVE MOST FREQUENTLY USED WORDS	EXEMPLARY CONTENT/QUOTES	INTERPRETATION OF THE TOPIC
1	Find Employee Pay Applicant Availability	"Recruiting is difficult as there aren't enough people to fill the number of jobs being offered to the market."	Supply not meeting demand
2	Qualify Fund Candidate Talent Experience	"There are not enough skilled qualified STEM candidates to hire."	Lack of skilled STEM workers
3	Competitive Work Salary Skill Wage	"We are not able to compete with the private sector. We need to provide competitive wages and good benefits in a high demand career field."	Ability to pay competitive wages

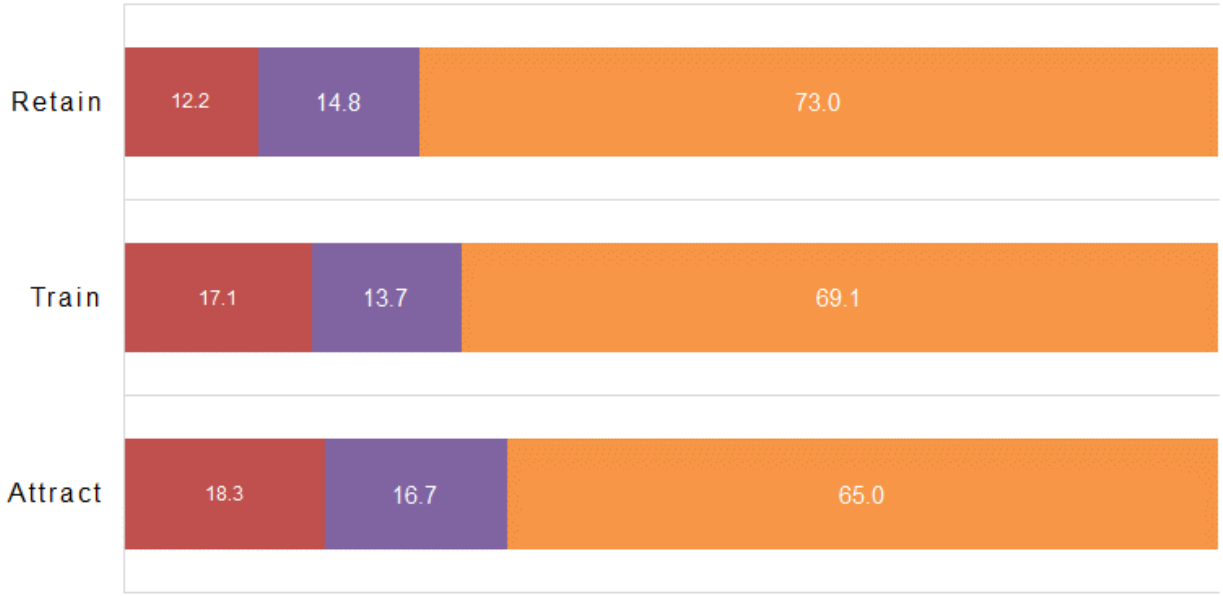
Effectiveness of Human Resource Management Practices

To examine the respondents' perceptions of the effectiveness of their organizations' human resource management (HRM) practices for securing and maintaining their STEM workforce, we asked respondents to rate three questions using a 7-point Likert scale. The three items included:

A. My organization has the resources to attract highly skilled STEM applicants. (Attract)
B. My organization has the resources to train new hires who may be underqualified. (Train)
C. My organization works to retain employees in STEM jobs. (Retain)

As shown in Figure 5, more respondents rated their organization's efforts to *retain* employees more favorably than both the resources to *attract* highly skilled applicants and *train* underqualified new hires. For the retain item, 19.5% of respondents strongly agreed compared to the 14.1% and 14.8% that strongly agreed with the attract and train items, respectively. When looking at the three levels of agreement versus the three levels of disagreement, the results were similar. For the retain item, 73.0% of respondents agreed, while 12.2% disagreed. For the train item, 69.2% of respondents agreed, while 17.2% disagreed. For the attract item, 65.0% of respondents agreed, while 18.4% disagreed. Thus, respondents viewed their organization's resources to attract skilled STEM applicants less favorably than their resources to train underqualified new hires, and both the attract and train items were rated less favorably than the retain item.

Figure 5
EFFECTIVENESS OF HUMAN RESOURCE MANAGEMENT PRACTICES RESOURCES TO ATTRACT AND TRAIN AND EFFORTS TO RETAIN STEM WORKERS



	Attract	Train	Retain
Disagree	18.3	17.1	12.2
Neither Agree nor disagree	16.7	13.7	14.8
Agree	65.0	69.1	73.0

To examine these ratings by industry, we created two categories out of the six agree/disagree variations and left the neutral item, neither agree nor disagree. When we review the respondents' assessment of their organization's resources to *attract* highly skilled STEM applicants by industry, as shown in Table 10, we see that respondents in state and local government report the lowest levels of agreement (50.0%) and the highest levels of disagreement (35.3%). This result is not surprising given that workers in this industry believe the private sector

pays more competitively (Bond & Kenneally, 2019), and salary is an integral part of attracting applicants. Conversely, respondents in the energy technologies industry reported the strongest levels of agreement (74.5%) and the lowest levels of disagreement (5.9%). This result mirrors those presented in Table 2 when we asked respondents about their state's ability to produce enough quality/competitive STEM workers, and the energy technologies industry had the strongest positive assessment of their state's supply.

Table 10
RESOURCES TO ATTRACT HIGHLY SKILLED STEM APPLICANTS

INDUSTRY	AGREE	%	DISAGREE	%	NEITHER AGREE NOR DISAGREE	%
Advanced Manufacturing	120	71.0	26	15.4	23	13.6
Automotive	31	59.6	14	26.9	7	13.5
Chemical Products and Plastics	16	57.1	6	21.4	6	21.4
Education	36	57.1	17	27.0	10	15.9
Energy Technologies	38	74.5	3	5.9	10	19.6
Healthcare	128	62.7	42	20.6	34	16.7
Other (e.g., defense, financial services, food, information technology, and other manufacturing)	56	54.4	27	26.2	20	19.4
Professional and Business Services	322	69.7	66	14.3	74	16.0
State and Local Government	17	50.0	12	35.3	5	14.7
Transportation, Logistics, and Distribution Services	26	65.0	8	20.0	6	15.0
	790	65.5	221	18.3	195	16.2

When we consider the respondents' assessment of their organization's resources to *train* underqualified new hires by industry, as shown in Table 11, we see that respondents in state and local government again report the lowest levels of agreement (44.1%) and the highest levels of disagreement (32.4%). This similar result is likely because limited resources for attracting applicants using competitive salaries also translates to limited resources/low budgets for training.

Table 11
RESOURCES TO TRAIN UNDERQUALIFIED NEW HIRES

INDUSTRY	AGREE	%	DISAGREE	%	NEITHER AGREE NOR DISAGREE	%
Advanced Manufacturing	118	69.8	25	14.8	26	15.4
Automotive	34	65.4	13	25.0	5	9.6
Chemical Products and Plastics	17	60.7	7	25.0	4	14.3
Education	37	58.7	14	22.2	12	19.0
Energy Technologies	36	70.6	5	9.8	10	19.6
Healthcare	141	69.1	38	18.6	25	12.3
Other (e.g., defense, financial services, food, information technology, and other manufacturing)	63	61.2	24	23.3	16	15.5
Professional and Business Services	337	72.9	75	16.2	50	10.8
State and Local Government	15	44.1	11	32.4	8	23.5
Transportation, Logistics, and Distribution Services	31	77.5	1	2.5	8	20.0
Grand Total	829	68.7	213	17.7	164	13.6

When we examine the respondents' assessment of their organization's efforts to *retain* employees in STEM jobs, as shown in Table 12, we see that respondents in the automotive industry report the lowest levels of agreement (59.6%) and the highest levels of disagreement (26.9%). The industry with the highest levels of agreement (81.8%) was professional and business services, which is also the industry with the largest number of respondents (462 or 38.3%).

Table 12
RESOURCES TO RETAIN EMPLOYEES IN STEM JOBS

INDUSTRY	AGREE	%	DISAGREE	%	NEITHER AGREE NOR DISAGREE	%
Advanced Manufacturing	127	75.1	15	8.9	27	16.0
Automotive	31	59.6	14	26.9	7	13.5
Chemical Products and Plastics	20	71.4	5	17.9	3	10.7
Education	44	69.8	11	17.5	8	12.7
Energy Technologies	36	70.6	2	3.9	13	25.5
Healthcare	130	63.7	33	16.2	41	20.1
Other (e.g., defense, financial services, food, information technology, and other manufacturing)	65	63.1	19	18.4	19	18.4
Professional and Business Services	378	81.8	35	7.6	49	10.6
State and Local Government	23	67.6	5	14.7	6	17.6
Transportation, Logistics, and Distribution Services	29	72.5	3	7.5	8	20.0
Grand Total	883	73.2	142	11.8	181	15.0

IMPLICATIONS, CONCLUSIONS, AND FUTURE RESEARCH

"I am convinced that nothing we do is more important than hiring and developing people. At the end of the day you bet on people, not on strategies."
– Lawrence Bossidy, Former COO of G.E. and Former Chairman of Honeywell
(as cited in Rao, 2017)

STEM workers are the especially valuable human capital that can provide their organizations with a sustainable competitive advantage. While some sources say there is no shortage of STEM workers and other sources say the shortage is due to technological advances and immigration issues, we looked to managers and executives in the Tennessee Valley Corridor (Alabama, Kentucky, North Carolina, Tennessee, and Virginia) to shed light on the STEM workforce in the region. Our purpose was to extend the literature by examining managerial perspectives on the STEM workforce, specifically issues related to the supply and demand for quality STEM workers. We gained insights from over 1,000 organizational leaders in terms of what their organizations are doing to address the STEM workforce challenges they are facing.

First, we examined the managers' and executives' perceptions of the supply of STEM workers in their states, specifically whether or not there was sufficient quality. The majority of respondents (56.3%) said no. Kentucky had the highest percentage of no as the response (60.9%), while Tennessee had the highest number of yes as the response (52.7%). These results indicate that the perceptions of supply are mixed, and some states could be experiencing more problems with their STEM pipeline than others. We recommend exploring the various segments of the pipeline – the family, educators, community, industry, and government – to identify opportunities to improve engagement with and commitment to STEM fields and occupations. We then asked the managers and executives to predict how the demand for STEM employees in their states would change during the next 12 months. The majority said the number would increase (49.3%), while a similar proportion (47.4%) said the number would remain the same. By state, those predictions ranged from 42.3-58.2% for increase, 39.8-54.0% for remain the same, and 2.0-5.5% for decrease. Finally, we asked the managers and executives to indicate how their organizations would be impacted if they were unable to fill open positions in the 1-10+ year range. The majority (51.9%) indicated the impact would be negative, but 22.0% indicated there would be a positive impact. This result makes us wonder if the question was answered correctly or if perhaps respondents perceived having more positions than they can fill to be a positive problem. Considering their role in setting strategic direction and resource allocation, we are pleased that the majority of the leaders recognize that unfilled STEM positions could have a negative impact on their organizations.

Second, we explored the managers' and executives' views on the major challenges of their states' supply of STEM workers using qualitative questions. For the broadly-defined supply of STEM workers topic, our leaders reported that the lack of quality education, a lack of interest in STEM and availability, STEM jobs often require experience, and a lack of resources (funding and support) to provide high-quality STEM workers. These findings underscore the essential contributions that a strong STEM pipeline plays for communities, regions, and states. Again, we

recommend that stakeholders reevaluate every component of the pipeline to ensure that optimal investment and performance are being achieved. For the question specifically addressing their challenges with recruiting a STEM workforce, our leaders identified challenges that are similar to the recruitment of any high demand position. The textual analysis revealed three top issues: supply is not meeting demand, a lack of skilled STEM workers, and the ability to pay competitive wages. Organizations must rely on strategic HRM practices and use robust metrics to ensure that they are as competitive as they can be with their sourcing and recruitment, their new hire training and onboarding, and their total reward packages. They must conduct market analyses at least annually to see how their organizations' pay practices stack up against their competitors. When their pay practices fall out of alignment with their pay strategies, then they must make adjustments.

Third, we surveyed the managers and executives regarding their perceptions of the effectiveness of their organizations' human resource management practices related to recruitment, training, and retention. These three processes are essential to securing and maintain a STEM workforce. Organizational efforts to retain employees in STEM jobs were rated most favorably of the three items, followed by training underqualified new hires, followed by attracting highly-skilled STEM applicants. One concern about these items is that the attract and train items start with "my organization has the resources to…" In hindsight, this wording may have significantly affected the way the items were rated, especially if the leaders perceived their organizations as low on resources, which could be attributed to them personally. Likewise, the retain item, "my organization works to retain employees in STEM jobs," may have been rated higher because the organization's efforts could be a direct reflection on the managers and CEOs. Even so, if these ratings are any indication, organizations must spend more resources attracting skilled applicants if they ever hope to have an opportunity to train or retain them.

We suggest that future research on the STEM workforce includes HRM professionals as an additional category to supplement the perspectives of business leaders and executives. HRM professionals might have different perspectives, which could shed additional light on the factors affecting the supply and demand of STEM workers and especially the challenges organizations are facing with recruiting qualified applicants. Another suggestion for future research in this area is to strive to obtain a representative sample of genders and ages. In the current study, a disproportionate number of respondents were female (59.1%), which is noteworthy given our sample was managerial and executive employees. An additional way to strengthen the utility of this research would be to include more open-ended questions to assess the nature of the positive or negative effect of an organization's inability to fill positions and to understand why respondents perceived varying degrees of strength in the recruiting, training, and retention practices. Finally, future studies should incorporate staffing metrics from the surveyed organizations. Metrics such as time to hire, time to fill, and turnover could allow researchers to develop more meaningful and actionable insights, which would help our stakeholders develop more effective strategies for securing and sustaining a high-quality STEM workforce.

REFERENCES

Arik, M., & Geho, P. (2017a). Resource-based theory and STEM workforce dynamics: Strategic implications for businesses and regions. *Global Journal of Business Disciplines, 1*(1), 16-35.

Arik, M., & Geho, P. (2017b). Skill gaps, human capital formation, and strategic choices: What do businesses do when facing critical labor force challenges. *Global Journal of Management and Marketing, 1*(2), 20-45.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.

Becker, G. S. (1964). *Human capital*. New York: Columbia University Press.

Becker, B. E., & Huselid, M. A. (1998). High performance work systems and firm performance: A synthesis of research and managerial implications. *In Research in personnel and human resource management, Vol. 16* (pp. 53–101). Greenwich, CT: JAI Press.

Bond, T., & Kenneally, K. (2019, November). State and local employee vies on their jobs, pay, and benefits. National Institute on Retirement Security. https://www.nirsonline.org/wp-content/uploads/2019/11/NIRS_OR_PublicEmployee2019_FINAL.pdf

Camilli, G., & Hira, R. (2019). Introduction to special issue-STEM workforce: STEM education and the post-scientific society, *Journal of Science Education and Technology, 28*, 1-8.

Cappelli, P. (2019). Your approach to hiring is all wrong. *Harvard Business Review*, May-June 2019, 48-58.

Christo-Baker, E. A., Sindone, A., & Roper, C. (2017). Addressing the skills gap: A regional analysis. *The Journal of Applied Business and Economics*, *19*(8), 10-21.

Deming, D. J., & Noray, K. (2018, September). STEM careers and technological training. Harvard Web Publishing, https://oconnell.fas.harvard.edu/files/kadeem/files/demingnoray_stem_sept2018_final.pdf

Dynarski, S., Hyman, J., & Schanzenbach, D. W. (2013). Experimental evidence on the effect of childhood investments on postsecondary attainment and degree completion. *Journal of Policy Analysis and Management*, *32*(4), 692-717.

Garg, J. (2019, December 4). Where the workers are. *Harvard Political Review*, https://harvardpolitics.com/united-states/where-the-workers-are/

Hassan, F. (2011). The frontline advantage. *Harvard Business Review*, *89*(5), 106-114.

Hunt, E. (2014). An H.R. conundrum: Talent attraction and retention abroad. *Baylor Business Review*, *32*(2), 38.

International Business Machines (IBM) Corporation (2019, September 6). IBM study: The skills gap is not a myth, but can be addressed with real solutions. https://newsroom.ibm.com/2019-09-06-IBM-Study-The-Skills-Gap-is-Not-a-Myth-But-Can-Be-Addressed-with-Real-Solutions

Lewin, A. Y., & Zhong, X. (2013). The evolving diaspora of talent: A perspective on trends and implications for sourcing science and engineering work. *Journal of International Management*, *19*(1), 6-13.

Louch, P. (2014, October 3). Workforce planning is essential to high-performing organizations. https://www.shrm.org/resourcesandtools/hr-topics/technology/pages/louch-workforce-planning.aspx

Maley, J. F. (2019). Preserving employee capabilities in economic turbulence. *Human Resource Management Journal*, *29*(2), 147-161. https://doi.org/10.1111/1748-8583.12211

National Science Board (NSB). (2020). National Science Foundation. Science & Engineering Indicators. State Indicators. https://ncses.nsf.gov/indicators/states

PricewaterhouseCoopers (PwC). (2017). U.S. business leadership in the world in 2017. 20th CEO Survey. https://www.pwc.com/gx/en/ceo-survey/pdf/20th-global-ceo-survey-us-supplement-executive-dialogues.pdf

Rao, M. S. (2017). Innovative tools and techniques to overcome H.R. challenges globally. *Human Resource Management International Digest, 25*(7), 1-4.

Servon, L. J., & Visser, M. A. (2011). Progress hindered: The retention and advancement of women in science, engineering and technology careers. *Human Resource Management Journal*, *21*(3), 272-284.

Teitelbaum, MS (2014, March). The myth of the science and engineering shortage. *The Atlantic*. https://www.theatlantic.com/education/archive/2014/03/the-myth-of-the-science-and-engineering-shortage/284359/

U.S. Bureau of Labor Statistics (USBLS). (2020). Employment projections. Employment in STEM occupations. https://www.bls.gov/emp/tables/stem-employment.htm.

U.S. Census Bureau. (2020). American Community Survey. www.census.gov.

Xue, Y., & Larson, R. C. (2015). STEM crisis or STEM surplus? Yes and yes. *Monthly Labor Review*, U.S. Bureau of Labor Statistics, https://www.bls.gov/opub/mlr/2015/article/pdf/stem-crisis-or-stem-surplus-yes-and-yes.pdf