Future Directions of Space Education

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The future of space operations graduate education is reliant on industry leaders' contributions to help forecast the needs of the industry. The aim of the current study is to build consensus on the future direction of the space industry and generate new knowledge on what the industry expects to occur in the future of space studies education. This study documents the responses of 14 industry experts who currently or previously held highly visible senior leadership positions in a company or organization within the government or the commercial space industry and have extensive experience in a variety of management and leadership roles at space-related companies.

The panelists' qualitative responses were coded by themes related to the future of work for senior leadership in the industry. The findings from the consolidated responses included 20 educational and training content areas and nine shortcomings. The Delphi technique, a group consensus building process, was used to gain insight into the panelists' responses (Dalkey, 1972). The research contributes to the body of knowledge on workforce education that can be used to inform faculty and administration in higher education on the relevance of program and curriculum content to address the future needs of the industry.

Purpose/Research Questions

The purpose of the study is to identify the future skills gaps in the space industry and generate new knowledge on what industry expects to occur. The following overarching research questions set direction for the study:

1). What are the solutions to the skills gap as well as innovative alternatives to address the educational and training processes in space operations?

2). What educational and training areas support the advancement of space workforce development and the preparation of our future leaders?

3). What will be the most important skills needed from a graduate of a master's level graduate program focused on space?

4). What are the greatest training shortcomings in the future?

Literature Review

The literature on the future workforce in the space industry covers academic and professional skills as well as industry-sector technical competencies. The skills identified include management competencies and occupation-specific competencies needed by mid-level career employees in public and private companies who contribute to the advancement of the industry. Technical skills consist of professional experience in space engineering, programming, and data analytics. These skills are complimented by business and workplace competencies such as space-related aspects of business acquisition and management, cross-cultural understandings, space policy and law, principles of space science and essential principles of entrepreneurship. This review leverages the aerospace competencies and skills identified by the Aerospace Industry Association and National Defense Industrial Association in partnership with the U.S. Department of

Labor Employment and Training Administration (U.S. Department of Labor [USDOL], 2021).

Technical Skills

The technical skills needed for career advancement require a foundational knowledge of engineering systems and data science integrated into many of the complex systems used within the industry (Brunton, 2021). Although the technical skills necessary for scientific computing and engineering are occupation-specific, mid-level managers benefit from a strong understanding of emerging methods in machine learning and the ability to make data-driven improvements to the systems in place (Brunton). Additionally, skills and professional experience in building and integrating spacecraft systems is valued by employers as well as an understanding of satellite and ground acquisition and mission operations.

Technical skills include a broad-based understanding of the design and construction of unmanned autonomous systems and space launch systems. With private space vehicle development, many private companies have capitalized on advancements in new automation technologies and in machining (GF Solutions, 2022). As a result, private companies are now able to contribute to the spaceflight industry with more production flexibility and fewer restrictions than in the past (GF Solutions). These dynamic changes within the space industry impact the supply chain, the investors, customers, and employees and require leaders to be adaptable and agile when challenged with the complexities that come with the integration of new technologies into existing systems (De Zúñiga, 2019).

The use of robotic automation systems to meet the manufacturing needs of the space vehicle business requires skilled operators as well as leaders to oversee the production. The change from an enterprise that was primarily controlled by government organizations offers a competitive advantage as the commercial space companies as well as the manufacturers aggressively look for ways to increase production time and reduce costs through the adoption of new technologies (GF Solutions, 2022). This transformation of the industry, specifically in the pace of AI/ML, requires managers to employ a wide range of knowledge and skills to contribute to the development and implementation of new initiatives through strategic planning and forecasting of changes to the current systems.

Engineering Systems

Competencies in engineering functions are necessary within the aerospace domain and includes the ability to determine the appropriate uses of technology and make decisions on new product adoption for a company (U.S. DOL, 2021). Although the mathematical and engineering aptitudes of individuals may differ between specific occupations, the use of engineering principles for project analysis, design, testing, and implementation is a necessary skill set. Brune (2016) makes two distinctions between the talent needed at space companies such as SpaceX. First, skillsets of engineers and systems folks are needed to offer support for the

physical manufacturing facility. Next, the industry needs leaders within operations who represent a diverse group of skilled workers to assemble the rockets, test the rockets, and assemble the composite materials needed for the build (Brune).

By understanding the opportunities available to cut down on the cost of launching a rocket, private commercial space companies have been able to revolutionize the space industry and make low earth orbit accessible (Patel, 2021). This evolution requires capable decision-makers who can leverage new production technologies and the ability to analyze project requests and engineering data to determine feasibility, costs, and production time along with critical operation research and analysis.

Next, data analytics skills are essential in the industry and required for remote sensing and data engineering. The industry has unique opportunities to integrate data-intensive analysis, specifically with machine learning and future growth is reliant on the improvement of the data management and interaction throughout the entire design, manufacturing, testing process (Brunton, 2021). The computational and technical proficiencies require leaders to have a general knowledge of both data science and engineering principles that are instrumental in managing a team involved in research and development.

Business Management and Policy

Part of the advancement of space is leveraging the human capital available with the workforce and creating specific benchmark criteria to put the most qualified individual in the most appropriate position to move the industry forward (Iacomino & Ciccarelli, 2018). This requires leaders to have essential management skills to define performance expectations and measure proficiency to ensure an individual is meeting the requirements to advance a team. It also requires visionaries who can motivate others towards a common goal while understanding how to make things profitable along the way. These types of leadership skills can build direction for the industry by casting a large vision to show societal benefits and ensure economic growth and profits for investors.

In the space industry, part of strategies in directing developments is employing management skills such as being responsive and adaptable to the introduction of new products and constant changes in the design process of new space vessels (GF Solutions, 2022). Unconventional, forward-thinking managers can anticipate changes within the industry and help their organization adapt quickly to the expectations of new investors and customers (Guimaraes & Paranjape, 2017). The role and opportunities available to new leaders in the industry is to connect individuals, specifically within the value chain, to contribute to innovative production with minimal risks to the investors and employees (Iacomino & Ciccarelli, 2018).

Additionally, recent changes in policy allow entrepreneurs to increase innovation and have access to participate in ways that were not available when

space exploration was exclusively run through government and military contractors (Muegge & Reid, 2019). As a result, industry leaders benefit from the ability to understand and influence policymaking as greater accountability now exists between private sector investors in space and the public (Iacomino & Ciccarelli, 2018). Through changes in the commissioning process, leaders with effective management skills can capitalize on these business fundamentals and build public trust through their understanding of trends in the industry and the company's position in the market.

Methods

The study offers an exploratory approach through the Delphi technique with guidelines on identifying the most relevant items to the research questions being explored as well as an analysis of qualitative data collected from the panelists' round one feedback (Creswell & Poth, 2018). This technique provides a systematic approach to gathering opinions from a panel of experts while maintaining anonymity (Dalkey, 1972; Stitt-Ghodes & Crews, 2004). Through consecutive rounds, the panelists identify a list of specific items related to skills and training topics with explanatory descriptions on future directions.

Panel Size and Composition

A diverse panel of 14 individuals were invited to participate in consecutive rounds of the survey data collection from March-April 2022. The size is based on Dalkey's (1972) group estimation process in achieving experimental results with small groups. Table 1 outlines the qualifying eligibility criteria used to select panelists from the purposive sample type.

Table 1

Eligibility Criteria for the Panelists

Inclusion Criteria
1. Current or former managers and executives who served on hiring committees of mid-level supervisors within the aerospace industry.
2. Current or former hiring manager or directors of human resources at a company recognized within the aerospace industry.
3. Hold active membership in national and regional chapters of organizations that promote workforce development in the aerospace industry such as AIAA.
4. Industry leaders actively involved in the Space Generation Advisory Council (in conjunction with the Space Symposium) who have experience hiring mid-level managers within the aerospace industry

To ensure a variety of aerospace-related industries are represented, the researcher recruited panelists who represent a diverse group of companies and have relevant experience across government as well as public and private industries. This

includes representatives who were employed at companies such as Boeing, Lockheed Martin, Northrup Grummet, Spaceforce, NASA SpaceX, or served on workforce development boards associated with American Institute of Aeronautics and Astronautics (AIAA). Initial individuals who meet the eligibility criteria were identified. A snowball sampling technique was used to recruit additional panelists from among their peers until the participation of 14 eligible panelists were confirmed. Additional selection criteria were used to avoid selection bias to ensure the most appropriate panelists were enlisted. Criteria included position held within the industry, professional experiences, and participation in prominent aerospace networks.

Data collection from round one took place April 4-22, 2022, and explored the future direction of the space industry through five open-ended questions. The 14 panelists responded to the survey questions either online or in-person depending on the panelists' availability during the 37th Space Symposium held in Colorado Springs, CO. The panelists represented leaders from the commercial, government, and military space sectors and were considered experts for planning future directions and achievements in space. Table 2 describes the type of organizations represented and the number of panelists associated with the organization type.

Table 2

Panelists' Workforce Affiliation and Organizational Type

Organization	# of Panelists
Space Force, Military Branch of Armed Forces	1
Private aerospace and communication industry	12
NASA	1
Total	14

Note. Private companies represented included organizations such as Blue Origins, Redwire, Aerojet RocketDyne, Special Aerospace Services (SAS), Voyager Space Holdings, Sierra Space, United Launch Alliance (ULA), Space Force Association (SFA), AIAA, and Lockheed Martin. Table 3 describes the panelists associated positions.

Table 3
Panelists Current or Former Administrative Roles

Administrative Roles	# of Panelists
President/CEO	5
Senior Vice President	3
Vice President, Engineering	1
Senior Governmental Official	4
Chief Technical Officer	1
Director	1
Total	14

Findings

The analysis identified four major themes related to education and training needs for the future workforce: 1) space law and policy; 2) business, economics, and finance; 3) government and private relations; and 4) professional skills. These themes emerged from panelists' responses when asked to identify the most important skills and training needed from mid-level managers to advance in the space industry. Following the completion of the first round, the researcher categorized the responses by themes through qualitative coding (Leedy et al., 2019) with the assistance of a qualitative data analysis software.

Education and Training Content Areas

Twenty items related to training and educational content areas were identified once the items were categorized by similarities. The items included associated descriptions for context. The common descriptions were gathered from the panelists' responses and direct quotes were included based on themes. Table 4 shows the compiled lists of items.

Table 4

Categorized List of Education and Training Content Areas

Theme	Descriptions and Examples from Participants
Space law and policy	International and national laws; dispute resolution; legal and regulatory requirements; laws applicable to outer space activities (tax, finance, contracts, tort); major space treaties and international agreements; intellectual property.
Contracts	Government contracts, launch services agreement, hosted payload agreements, satellite manufacturing agreements, commercial procurement process, understanding fixed costs, T&M concepts.
Economics	The economics behind space debris, launch systems, ground systems, space commerce.
Finances	How companies grow and evolve in the industry and expand into different markets utilizing space technologies. Understanding how to access growth capital in the market.
Satellite communications	Developing, building, operating, distributed, on-orbit metal processing and space debris recycling facilities; commercialization of remote sensing satellites; satellite architecture predictive analysis.
Commercial space launch	Commercial space transportation industry segments. Understanding the current government regulations and the relationship to the commercial space sector.
Government and industry relationships	Public and private interactions; NASA commercial space activities; export control; space operation resources.
Service	How to satisfy customers, develop long-lasting relationships, understand various sized companies from the prime

	contractors through the supply chain. Value preferences.
NRO and security	How companies grow and evolve in the industry and expand into different markets utilizing space technologies. Understanding how to access growth capital in the market.
Satellite communications	Level of service to ensure the US maintains and expands its advantage considering current adversaries. Space-based intelligence and surveillance. Cybersecurity threats.
Environmental issues	Policy and debris mitigation; Natural resource mining.
Team dynamics	Skills to lead high-performing teams and interact with peers. An understanding on how to create cross-functioning teams.
Business acumen	Understanding on how to prepare for and capitalize on changes in the industry. Market analysis, balancing growth plans. Project management. Utilizing capabilities and resources. Attributes such as strategic thinking, marketing, project management, team skills. Being able to implement new technologies and make product adoption decisions.
Leadership	People management and developing talent. How to manage teams. Strategic thinking.
Management	Managing contracting. Providing U.S. regulations and oversight. Understanding the rate system and pricing for proposals.
Engineering	System engineering and technical skills related to engineering systems. Mechanical engineering. Need for project-related learning with hands-on components.
DEI	Understanding DEI programs and developing strategies to change culture.
Training the whole ecosystem	Educating outside of engineering. An understanding of how to work as liaisons

	to engineers and other areas needed to build a diverse workforce. Understanding globalization strategies. Educating outside of engineering. An understanding of how to work as liaisons to engineers and other areas needed to build a diverse workforce. Understanding globalization strategies.
Data communications	Data analytics and processing. Data systems and space-related aspects of business.
Interpersonal skills	Reliability, dependability, working within a team, and communication.

Descriptive Responses

Under the themes of space law, policy, and contracts panelists (P14) stressed the need for "training to include the growth in the space industry by market and sector such as government vs commercial control." Panelist (P9) mirrored these thoughts and discussed the importance of understanding "government contracts, the commercial procurement process, launch services agreements, hosted payload agreements, and satellite manufacturing agreements."

Another panelist (P8) described the need to understand the current government policies and regulations and "the impact these policies have to the commercial space sector." For example, leaders in the industry need to "understand where sources of revenue are coming from and the gap from funding through government contracts to the commercial sector."

The content areas of business, economics, and finance overlapped significantly with contracts and were given considerable contributions across the panel. One panelist (P2) mentioned that "finances are the most important aspect [of the space industry] and the ability to talk finances" is critical for one's career advancement. Another panelist (P8) discussed the importance of understanding the rhythm of government appropriations, and the commercial procurement process and went on to emphasize the need to understand PBR proposals and cash cycles. Further consensus was reinforced by panelist (P9) that stated there had to be a strong understanding of the sustainable economics of the space industry. In addition, one must understand "where the profit is" and how to access "growth capital in the market." Panelist (P14) shares the importance of a leader to be able to determine if their investment in space activities is a profitable opportunity.

Business skills such as educational training that comes through an NBA was also mentioned as critical for career advancement and success in the industry. Panelist (P3) discussed the need for having business acumen and the ability to

understand the "invisible hand in the market" along with our global position. Another panelist (P9) commented on the need to acquire knowledge about building and owning a business as well as understanding how re-imaging a business works. The panelist also mentioned the importance of applying knowledge and knowing how to enter the space launch business. Panelist (P6) echoed the importance of "understanding innovators trends" to successfully navigate the space economy.

The theme of government and private relations emerged separately but carried similarities across other themes. For example, one panelist (P14) advocates for the need to understand strategic partnerships to develop, launch and operate satellites and support commercial partners to "implement programmatic and technical management structures and processes under government contracts."

Last, the panelists had common agreement on various professional skills that include leadership, working within a team, inclusivity, communication skills, strategic thinking, and interpersonal skills needed to successfully advance and lead others in the industry. Panelist (P8) stressed the need to be able to navigate human factors with emotional intelligence awareness. Another panelist (P6) said there is a struggle for individuals to move from their technical areas into being a manager or liaison to engineers.

Additionally, the ability to develop talent and serve others through team dynamics is a critical component of career advancement. Panelist (P11) reinforces this idea by stating "empowering talent with a focus on velocity and decision making" is an aspect of leadership needed from senior leaders. In agreement, panelists (P11), remarks that leaders need to be able to determine priorities to allocate the necessary resources to the right programs and projects for the overall success of the enterprise. Panelist (P9) states that the success of the whole space ecosystem comes from mutual support in which leaders teach others to be inclusive and "accept diversity at an international level." Part of these skills include being able to work in a team and communicate with others from different backgrounds.

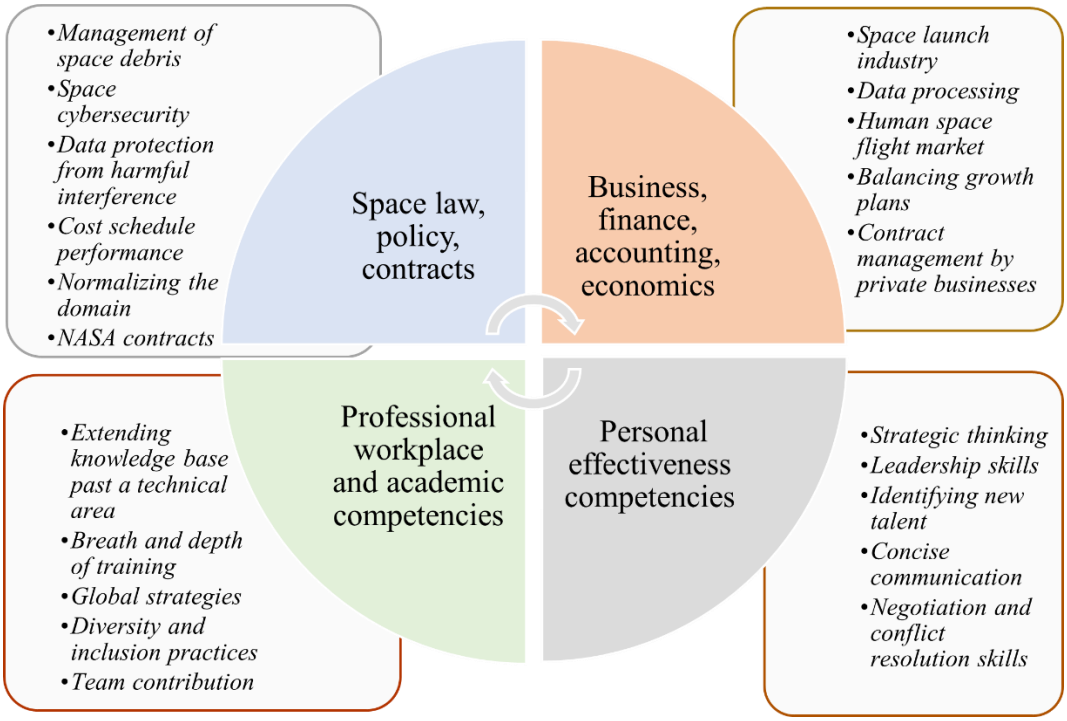
Discussion of the Findings

Twenty common themes related to education and training content areas were identified. Given the potential impact of the commercialization of space on career outcomes, these items may be considered by educators and supervisors in developing curricula and employee training programs. Many skills related to both personal competencies, business, and academic competencies, and industry-specific competencies were identified. The competencies reinforce the Aerospace Competency Model (U.S. DOL, 2021) and highlight actionable recommendations for industry leaders to gain skills to lead high-performing teams. The model includes personal effectiveness competencies such as reliability, dependability, professionalism, and interpersonal skills that were also highlighted as extremely important by the panelists in the study.

Panelists emphasized the need to have leaders who can collaborate with others and know how to effectively manage projects and appropriately assign resources to programs and projects. These competencies are further described and validated by the workplace competencies in the Model (2021) to include planning and organizing, teamwork, business fundamentals, problem-solving and decision-making. Figure 2 offers a conceptual framework of the themes identified by the panelists along with professional (i.e., academic and workplace) and personal competencies needed to complement industry-specific competencies.

Figure 2

Conceptual Framework About the Impact of the Findings on the Future Workforce



For new managers and entrepreneurs, an understanding of space law, policy and contracts is a critical skill identified in this study. Legal and regulatory items that are applicable to new entrepreneurs as well as a boarder understanding of international space law are required to be successful in navigating legal issues and contracts associated with aerospace activities (Lal, 2016). As small businesses quickly make their way into the launch business, the political landscape is changing to become quicker to adapt to the transformation into the commercial regime. This requires changes to policy and regulation so smaller business can have opportunities to successfully handle the future changes coming with outer space activities.

Export control is another area that requires new entrepreneurs to navigate and understand the regulatory gaps in the future (Vedda, 2017). For example, there is a greater need to understand on-orbit operations such as the impacts of privatizing the space station or placing a lunar orbit on the moon. New leaders must learn to maneuver within these areas that are still uncertain. This is also important for space situational awareness. Although the FAA regulates re-entry, there is limited regulation on the export control to handle the increasing changes in the outer space activities and space traffic (Pelton, 2019).

Next, business, economics and finance skills are necessary in a rapidly changing space economy. Accounting principles are required to understand the challenges that exist within space commerce and opportunities available to address these challenges. Alewine's (2020) research confirms these findings highlighting the importance of economics and finance, specifically, on how companies grow and evolve in the industry and expands into different markets. The findings show that interdisciplinary inquires and problem solving allow individuals to capitalize on new future opportunities in space accounting and space economics (2020). Comparatively, the research of Lal (2016) emphasizes the global trends and need to understand general contracts. For example, NASA contracts out over 90% of its products and service needs and has to work collaboratively with private contractors to achieve cost-effective goals such as carrying cargo to the ISS.

Contracting services provides political cover for large government expenditures by showing how the practices promote positive economic development across multiple congressional districts. Agencies involved in all contracted services must then have a strong understanding of their role with an overarching rationale for any outsourcing and partnerships, especially when government entities are choosing when and how to leverage private businesses that can be more efficient in operations such as carrying cargo to low-Earth orbit (Lal, 2016).

An understanding of government and private relations is another area of importance highlighted by the panel as more companies enter the space market. This creates a greater need to maneuver the regulatory regime so that small businesses can quickly change in accordance with the commercial landscape in the launch business. With skilled leaders, private companies can be more agile and have the necessary flexibility to succeed, but also require individuals who understand how to work with and abide by both national and international space law requirements (Stone, 2018).

Recommendations

Forecasting future workforce needs requires an analysis of the skill and training needs of industry partners in areas specific to space and space exploration. The foundation of the technical and workplace competencies required for and accepted in the industry and can be further validated by the findings in this study.

These findings can be used to tailor courses to the specific industry needs, evaluate and update existing program material, and identify disparities between the curriculum and the expectations of the industry. Based on the findings, educational and training providers have an opportunity to create, programs and learning initiatives in education fields that are interdisciplinary and offer practical applications to increase student interest and career mobility in the industry (Hong et al., 2019). Additional training may include short-term certificates in coding, public policy and contracts, and business fundamentals to build a well-rounded aerospace workforce (Nite et al., 2020).

Part of the identified needs in mid-level management is for individuals to pursue leadership roles in areas such as business, law, systems engineering, and policy. The shortage of rising leaders in the industry to pursue these fields may be instigated by an unengaging, highly technical workforce that comes out of content-driven, conventional format types of engineering and aerospace programs. For example, programs that offer highly complex, technical knowledge that is broken into its discipline-specific theoretical elements without emphasizing overarching industry-wide learning competencies. Therefore, the application of knowledge gained through graduate programs can be used to transmit new concepts to the workplace through skills developed that address the leadership needed in space activities as well as the management of teams at an international scale.

As such, the findings can be used to build programs that help students acquire subject-specific knowledge while establishing a clear understanding of when or how this knowledge will be applicable in the industry. Both industry-wide and sector-specific technical competencies listed under the theme “Professional Skills” build on the academic theoretical content but require an understanding of the critical work functions related to principles and application of engineering-related concepts such as electrical systems, industrial safety, product management, and quality assurance, computers, mechanical components as well as a demonstration of troubleshooting through design and development phases.

The need for future space employees to develop both industry-sector skills along with soft skills was identified as professional and personal effectiveness competencies. The findings indicate the need to develop negotiation and conflict resolution skillsets that would enhance overall team contribution. Additionally, a desire to create a workplace culture that embraces, and supports, diversity and inclusion was identified. The overarching theme is to establish an organizational culture based on trust and collaboration. Wriston (2012) tends to support these findings identifying that a collaborative environment is one of the four pillars of a high-performing organizational culture as well as Volhohammadi and Roshanzamir (2015) who argued that an organization’s culture is the largest reason for poor performance and failure.

The globalization of the space industry presents challenges for organizations as well as opportunities for improvement in graduate space curriculum. One recommendation is for graduate space programs to incorporate components of cross-cultural training into the existing curriculum. Prebitero and Toledano (2018) found that cross cultural training improved cultural intelligence and an improvement in cultural intelligence resulted in an increased ability to work across cultural boundaries. The increase in performance increases organizational capacity. The inclusion of cross-cultural competencies as part of graduate space curriculum could lead to a graduate better prepared to enter into the space industry and immediately function as an effective team member.

Conclusion

The themes related to education and training content areas in the future of the industry offer guidance on training and curriculum that can be introduced into graduate study programs including concepts related to cross-cultural competencies, entrepreneurship, business and finance, public policy, engineering, and computer technologies. Graduates need opportunities to build professional competencies while being exposed to the latest trends in areas such as space policy and law, the space economy, and the commercial launch market. Concepts such as the development of basic knowledge and skills to operate small businesses within the agile commercial space market is an essential educational need as well as the ability to navigate contracts and the regulatory regime within both government and private entities.

For future growth of a promising talent pipeline and support of the changing commercial landscape, educational program designers can consider the recommendations based on the twenty educational and training concept areas. These recommendations offer opportunities to include learning outcomes to teach leaders how to 1) adopt and use integrated technologies, 2) employ project management skills, 3) understand foundational systems engineering and STEM concepts, 4) leverage best practices in accounting principles, business, finance, contracts, economics, and 5) demonstrate effective leadership skills, a cross-cultural understanding, and soft skills for solving current and future problems faced by the industry.

References

Alewine, H. C. (2020). Space accounting. *Accounting, Auditing & Accountability Journal, 33*(5), 991-1018. https://doi.org/10.1108/AAAJ-06-2019-4040

Brune, B. (2016, May 17). Siemens gives some details of digital twin work with SpaceX, Maserati. *SME Smart Manufacturing.* https://www.sme.org/technologies/articles/2016/may/siemens-gives-some-details-of-digital-twin-work-with-spacex-maserati/

Brunton, S. L., Nathan Kutz, J., Manohar, K., Aravkin, A. Y., Morgansen, K., Klemisch, J., Goebel, N., Buttrick, J., Poskin, J., Blom-Schieber, A. W., Hogan, T., & McDonald, D. (2021). Data-driven aerospace engineering: Reframing the industry with machine learning. *AIAA Journal, 59*(8), 2820-2847.

Dalkey, N. C. (1972). The Delphi method: An experimental study of group opinion. *Futures, 1*(5), 408-426.

Delbecq, A. L., Van de Ven, A. H., & Gustafson, D. H, (1975). *Group techniques for program planning: A guide to nominal group and Delphi processes*. Scott, Foresman.

De Zúñiga, S. A. P. (2019). *Exploring competencies aerospace leaders need to prepare US subordinates to lead within a global aerospace industry* [Doctoral dissertation, Colorado Technical University].

GF Solutions. (2022, February 16). Automation puts rocket part production into orbit. *SME.* https://www.sme.org/technologies/articles/2022/february/automation-puts-rocket-part-production-into-orbit/

Guimaraes, T., & Paranjape, K. (2017). The effect of organization innovativeness on company innovation success. *International Journal of the Academic Business World, 11*(2), 79-92.

Hong, H.-Y., Lin, P.-Y., Chen, B., & Chen, N. (2019). Integrated STEM learning in an idea-centered knowledge-building environment. *Asia-Pacific Education Researcher*, *28*(1), 63–76. https://doi.org/10.1007/s40299-018-0409-y

Iacomino, C., & Ciccarelli, S. (2018). Potential contributions of commercial actors to space exploration. *Advances in Astronautics Science and Technology, 1*(1), 141-151.

Lal, B. (2016). Reshaping space policies to meet global trends. *Issues in Science and Technology, 32*(4), 63-74.

Leedy, P. D., & Ormrod, J. E. (2019). *Practical research: Planning and design*. Pearson.

May, A. (2021). *The space business: From hotels in orbit to mining the moon – how private enterprise is transforming space*. Icon Books.

Muegge, S., & Reid, E. (2019). Elon Musk and Space X: A case study of entrepreneuring as emancipation. *Technology Innovation Management*

Review, *9*(8), 18-29. https://www.proquest.com/scholarly-journals/elon-musk-space-x-case-study-entrepreneuring-as/docview/2292914887/se-2

Patel, N. (2021, February 3). The space tourism we were promised is finally here. *Space MIT Technology Review*. https://www.technologyreview.com /2021/02/03/1017255/space-tourism-finally-here-sort-of-spacex-inspiration4/

Pelton, J. (2019). A path forward to better space security: Finding new solutions to space debris, space situational awareness and space traffic management. *The Journal of Space Safety Engineering*, *6*(2), 92–100. https://doi.org/10.1016/j.jsse.2019.04.005

Stone, D. (2018). A new era in space flight: The COTS model of commercial partnerships at NASA. In: Hatton, S. (eds) *Proceedings of the 13th Reinventing Space Conference. Springer, Cham.* https://doi.org/10.1007/978-3-319-32817-1_12

U.S. Department of Labor. (2021). Aerospace competency model. *Department of Labor. Employment and Training Administration.* https://www.careeronestop.org/CompetencyModel/competency-models/aerospace.aspx

Valmohammadi, C., & Roshanzamir, S. (2014). The guidelines of improvement: Relations among organizational culture, TQM and performance. *International Journal of Production Economics*, *164*(1), 167-178.

Vedda, J. A. (2017). International commercial spaceflight regulation: Assessing the options. *The Aerospace Corporation.* https://aerospace.org/sites/ default/files/2018-05/SpaceflightRegulation.pdf

Wriston, M. (2007). Creating a high-performance culture. *Organization Development Journal, 25*(1), 8-16.