[KE-01-023] GIS&T Workforce Development

Abstract

Professional workforce development, the education of an individual for a particular task or trade, traces its origins from the programs that linked apprentices with the master craftsmen of pre-industrial societies. With the emergence of digital technologies, the emphasis has shifted to making an individual more technically proficient across ever-changing technological platforms. In the Geographic Information Science & Technologies (GIS&T) sector, individuals generally acquire knowledge and skills through degrees and certificates offered by colleges and universities, as well as the various professional and technical certifications that provide evidence of training and development for the workforce. Establishment of the GeoTech Center, the Geospatial Technology Competency Model, and the GIS Certification Institute have all been significant in GIS&T workforce development. Challenges include the lack of standardized duties and responsibilities for occupational titles as well as gaps between industry needs and skill sets provided through formal degrees and certificates.

Keywords: certificate, competence, education, framework, GIS&T workforce, GTCM, professional certification

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Explanation

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1. Workforce Development History and Background

Workforce development has been defined as “the co-ordination of public and private-sector policies and programs that provides individuals with the opportunity for a sustainable livelihood and helps organizations achieve exemplary goals, consistent with the societal context.” (Jacobs and Hawley, 2009, p. 2543). It provides a benefit to the individual workers through an increase in skill level, to an organization through providing a quality employee, and to society with a stable economic platform coming from a well-paid, productive workforce (Hunter-Johnson 2023). .

In the United States, the federal government has championed workforce training of individuals back to the 19th century. These programs and projects have long been linked to education, such as the Morrill Acts of the early 1860s, that established several land-grant universities whose missions included training in the “agricultural and mechanical” arts to

“promote the liberal and practical education of the industrial classes in the several pursuits and professions of life” (Morrill Act, quoted in Lee 1963). In the early 20th century, the creation of the Department of Labor in 1913 and its subsequent of the New Deal and the Works Progress Administration of the late 1930s were the real beginning of the workforce development in the US. Other programs of this type, enacted over the years, have advanced the cause and scope of government-backed workforce development (MacLaury, n.d.), including:

- Manpower Development and Training Act (1962-1973) - John F. Kennedy sponsored this program that focused on unemployed youth and adults.
- Comprehensive Employment and Training Act (1973-1982) - The CETA was a logical expansion of Kennedy's program.
- Job Training Partnership Act (1982-1998) - This act was the beginning of setting up state-located programs in job training.
- Workforce Investment Act (1998-2014) - President Clinton signed this act into law, which centered on community-based programs.

Traditionally, government-backed or sponsored workforce development programs have been concentrated within specific industrial sectors. For example, the National Science Foundation (NSF), which was first established in 1950, has led the way in science and technology-specific workforce development. As examples, the Directorate for STEM Education has as its mission to “develop a well-informed citizenry and a diverse and capable workforce of scientists, technicians, engineers, mathematicians and educators,” (National Science Foundation 2024a) and the NSF Research Traineeship (NRT) Program is designed for students “to develop the skills, knowledge, and competencies needed to pursue a range of science, technology, engineering, and mathematics (STEM) careers” (National Science Foundation 2024b).

The “demand side” of the sector-based workforce development targets those fields where the needs are the greatest. Many programs target dislocated workers, the unemployed, and the underemployed, particularly with skills transferability from one employment sector to another. Federal and state governments may support individuals to pursue educational degrees, certificate programs, or specific industry and employer trainings. Alternatively, place-based workforce development concentrates on increasing workers in specific regions or communities and this could be across several sectors. A regional focus can have a significant impact on communities in an area but may or may not reflect problems from a larger geographic context.

Regardless of the approach, nowadays many workforce programs target the demographic representation from a gender, ethnic, racial, or economic perspective, with a goal of increasing diversity with a highly trained workforce. The 2014 Workforce Innovation and Opportunity Act (WIOA) has programs that address both supply and demand factors such as JobCorps, National Farmworker Jobs Program, the Indian and Native American Program, and the Adult & Dislocated Worker Program.

2. Geospatial Workforce Development Programs, Activities, and Centers

The geospatial workforce itself does not have a long history compared to many other professions. GIS was not developed until the 1960s and its broad availability was limited until more recently. Initially the primary mode of professional development was self-

learning and networking with peers until the late 1980s when the NSF first supported the National Center for Geographic Information and Analysis (NCGIA), an entity that spanned multiple university campuses. The NCGIA supported the development of a “core curriculum” that reflected what might be taught at the university-level but the educators who focused on this were more likely research-focused (Sinton and Kerski 2020). In 2006 the first Geographic Information Science and Technologies Body of Knowledge (GIS&T BoK) was released (DiBiase et al. 2006). A primary purpose of this first GIS&T BoK was to inform curricular design to best prepare graduates for workplace needs.

In May 2013, the Obama Administration published the 5-Year Federal Science, Technology, Engineering, and Mathematics (STEM) Education Strategic Plan, prepared by the Committee on STEM Education (CoSTEM) of the National Science and Technology Council. The effort became a catalyst for numerous governmental, academic, and private sector groups to help create a diverse and well-educated workforce within the math and science disciplines. For the geospatial sciences to be linked unambiguously to the greater STEM ecosystem has been an important factor for a workforce within this high-tech industry.

2.1 GeoTech Center

An emphasis on geospatial education and training based at community colleges, rather than only research universities, was envisioned by the early 2000s and planned for through the National Forum on Geospatial Technology Education for Community Colleges (Sullivan 2007; Johnson 2012). The resulting entity, the National Geospatial Technology Center of Excellence (the GeoTech Center, https://www.geotechcenter.org/) has been funded through NSF’s Advanced Technology Education (ATE) program since 2008. ATE programs specifically target technical training and educational opportunities, primarily at 2-year institutions. The GeoTech Center, whose tagline is “Empowering Colleges: Growing the Workforce,” has contributed significantly to GIS-related workforce through its model curricula and capacity-expanding endeavors. It is currently based at the Jefferson Community and Technical College in Louisville, Kentucky.

2.2 Geospatial Technology Competency Model (GTCM)

One of the major efforts to define geospatial expertise has been the Geospatial Technology Competency Model (GTCM) originally produced in 2003 under the guidance of the Geospatial Workforce Development Center at the University of Southern Mississippi, together with the Geographic Information Technology Association (GITA) and the Department of Labor’s Employment and Training Administration (DOLETA) (Gaudet et al. 2003; Johnson 2012; Jackson 2014). First published in 2010, the GTCM underwent revisions in 2014 and 2018. The GTCM has served to create professional employment standards and competencies for workers in the geospatial technology industry. The GTCM is an example of cooperation among the academic and professional communities, in collaboration with the Federal government, to define a standard set of competencies that covers the entire workforce requirements for a profession.

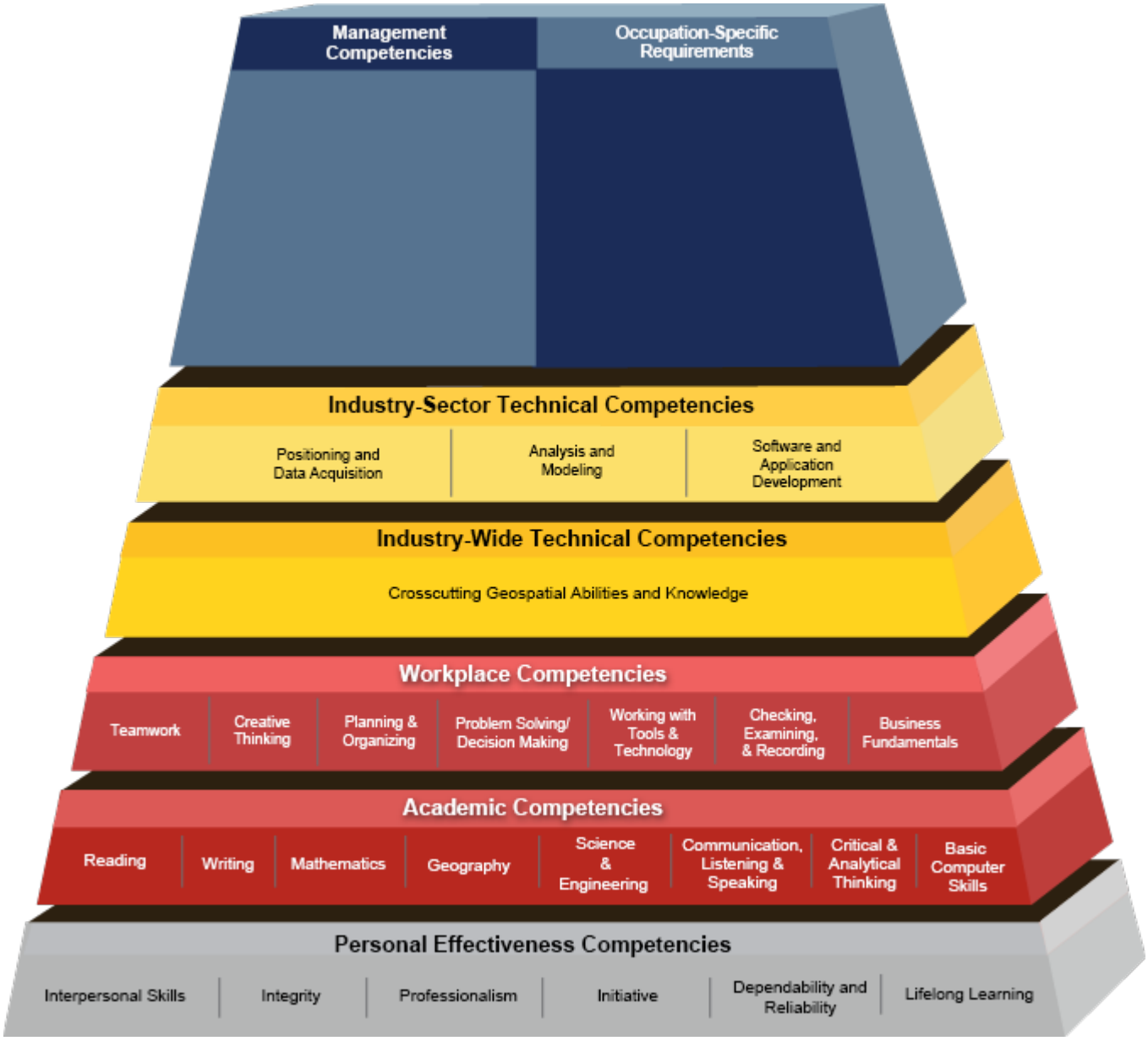


Figure 1. The Geospatial Technology Competency Model.
Source: https://www.careeronestop.org/CompetencyModel/Competency-Models/geospatial-technology.aspx.

The GTCM pyramid (Figure 1) defines the key knowledge and skills included within the domain of geospatial technology (Jackson 2014; DiBiase 2018), and this has allowed the Department of Labor to track this employment sector more effectively. This is particularly helpful for specific industry sectors, to provide guidance and coordination in keeping the workforce numbers and training consistent with the employer's needs.

For certain geospatial occupations, the GTCM has be used in alignment with a related activity known as Developing a Curriculum (DACUM). By gathering together many individuals working in different industries and sectors but under the same job title, the DACUM process can filter and summarize the main duties and tasks which can be expected by someone working within that occupation. For example, DACUMs have been created for the job titles of GIS Technicians, GIS Analysts, and GIS Specialists (Johnson 2010) though these have not maintained standardization over time (Wikle 2018).

2.3 The Federal Geographic Data Committee (FGDC) and other Federal-level Activities

The Federal Geographic Data Committee (FGDC) was established in 1990 by the Federal Office of Management and Budget to promote great coordination of national-level geospatial data. In 2012, while seeking input into the implementation of the government's Science, Technology, Engineering, and Mathematics (STEM) strategic plan, the FGDC tasked the National Geospatial Advisory Committee (NGAC) to assist in this process by summarizing key activity areas and producing recommendations. The result was a compendium of three white papers, authored by NGAC's Geospatial Workforce Development Subcommittee. This document, Geospatial Workforce Development: A compendium of white papers focused on advancing geospatial workforce development (National Geospatial Advisory Committee, 2012), summarized the recommendations from the white papers for the then-Administration to consider:

1. Identify synergies with the Administration's Science, Technology, Engineering, and Mathematics (STEM) education initiatives, assess opportunities to incorporate Geospatial and Geomatics education into the four STEM categories, and assess potential role/involvement/support from FGDC and NGAC.
2. Utilize the DOL Geospatial Competency Model to meet Federal/State/Local/Tribal Government needs for assisting in succession planning, knowledge management and transfer, employee development, and work or organizational change.
3. Update the "externally" focused [GIS themed] SOC Standard Occupational Classification Codes and "internally" focused Federal Occupational Series Classifications.

Altogether, this document highlighted the importance of bringing together geospatial competence (via the Geospatial Technology Competency Model) with a geospatially enabled STEM model, and supported by federal job descriptions, to build out an expectation of what a Federal geospatial workforce could and should look like.

One of the important accomplishments achieved by the geospatial domain has been in the area of occupational titles and their respective codes, as these facilitate linkages between industry, government, and academia. For example, by 2014 the Department of Homeland Security had added "Geographic Information Science and Cartography" to its list of sanctioned STEM disciplines, allowing non-immigrant individuals holding certain visas to be eligible for training and post-graduate work (for a limited amount of time). However, GIS&T position titles spread across multiple Standard Occupational Classifications (SOCs), and this undermines workforce coordination (Wikle 2018).

An example of training aimed for a particular federal agency is the series of courses created by AmericaView and West Virginia View, initially designed to support workforce development for the United States Geological Survey (USGS). Its courses on remote sensing and geospatial data science, focusing on the use of open source tools and approaches, have been made available to the public (AmericaView, n.d.)

2.4 State and Regional Efforts: St Louis and Geospatial Intelligence

Since the early 1950s, the National Geospatial Intelligence Agency (NGA) has had a headquarters in St. Louis, Missouri, and when it began significantly expanding these facilities in 2019, Missouri and nearby states eagerly launched regional efforts for

geospatial workforce development. By 2022, eight colleges and universities located within 150-miles of St Louis had formed the Taylor Geospatial Institute (TGI) to catalyze collaborative research and training efforts. The lead institution, Saint Louis University, received a $1 million grant from the Missouri Department of Higher Education and Workforce Development program to establish the Taylor Geospatial Institute Advanced Computing, Analytics, and big Data Education for Missouri (TGI Academy) within the existing multi-institutional Taylor Geospatial Institute. The TGI Academy will focus on developing a well-trained workforce not only within the geospatial intelligence field but also within peripherally related subjects such as GeoAI, UAS, and geodesy. A key aspect of this training seeks to target not only youth, but also young professionals in rural areas surrounding St. Louis. One goal is to provide remote jobs in areas that are struggling with attracting high-tech opportunities within the local communities.

3. Alignment Between Educational Achievements and Workforce Skills Needed

Most of education's increased presence in the geospatial profession has occurred within the last 40 years (Sinton and Kerski 2020). Several hundred colleges and universities offer 2- and 4-year undergraduate and graduate degrees in the geospatial sciences, comprised of geographic information systems and science, cartography, and remote sensing. Many of these also offer coursework in a more concentrated form as a certificate, typically designed to teach a foundational set of skills in a shorter time frame. Especially given the increasing cost of higher education, GIS certificates have proliferated and increased in popularity though without any coordination or consistency across their content (Wikle and Sinton 2020).

Many employers count on a recent graduate to be suited as an incoming worker, sufficiently trained at the entry level to provide immediate benefit to the firms. However, a common refrain decries the skills gap and mismatch or misalignment between the academic preparation provided to students completing formal educational programs and the knowledge, skills, and competencies that employers require their workforce. This is particularly problematic at the local scale. A recent report on this quantified the "Great Misalignment" between the credentials earned or available to earn by job seekers and specific labor markets (Georgetown University, 2024). More than 25% of the "middle-skills" credentials earned, e.g. certificates and 2-year associate's degrees), do not have an exact and/or local occupational match.

One approach for an individual to document that their preparation is adequate for an occupation, above and beyond a formal degree, is by acquiring a professional certification. In this situation, a minimal competency in a set of specifically defined skills and abilities is measured and demonstrated, often via an exam as well as other activities. Individuals working within geospatial landscape worldwide can now choose from several professional and technical certifications (Kemp 2016; Mathews and Wikle 2017). By the end of 2023, the Geographic Information Systems Certification Institute (GISCI), established in 2002, had certified approximately 6,400 professionals with its GIS Professional (GISP) credential as of June 2024. GISCI is currently developing a "PreGISP" exam that can be used to document a minimal level of expertise by students or those very early in their geospatial career. Individual geospatial companies are now endorsing the GISP credential and its role in confirming knowledge; their preferences in hiring practices for those with the GISP is a step towards more consistency in the geospatial workforce.

Other geospatial workforce credentials available for individuals include those offered by ASPRS in the fields of photogrammetry and remote sensing. NGA manages a GEOINT Professional Certification Program, and the US Geospatial Intelligence Foundation (USGIF) sanctions a select set of universities whose curriculum has been certified to offer its graduates a GEOINT certificate. All of these professional credentials include an exam component as well as accumulated evidence of additional professional practices, and they are software-neutral. Alternatively, Esri offers a series of technical credentials, also exam-based, that confirm software-based qualifications.

4. Summary

Workforce development has progressed and spread from its beginnings as Federal aid programs for unemployed workers during the Depression to significant contributions to developing a trade. For the geospatial profession there were several significant developments that took place between 2000 and 2010, such as the establishment of the GTCM, the first funding of the GeoTech Center, the publication of the first GIS&T Body of Knowledge, and the creation of the GIS Certification Institute. In the years since, hundreds more formal degrees and certificate programs have been launched. When employers recognize and can trust the value of those credentials, the workforce as a whole would benefit over the long run.

However, widespread efforts at developing and maintaining a highly qualified geospatial workforce in the US have been challenging, and any national effort at comprehensive geospatial workforce development is unlikely. Multiple contributing factors include the lack of standardized titles, duties, and responsibilities across GIS jobs (Mirzoev et al. 2015), the slow uptake for employer endorsement of the GISP credential (Li et al. 2020), a lack of programming courses and a cultivation of quantitative skills in many geography and geospatial degrees (Bowlick et al. 2017); and the skill sets acquired by graduates of formal degree programs that are generally perceived to be misaligned with industry needs (Wallentin et al. 2015; Stout 2022). NSF continues to fund training opportunities for high-tech skill sets such as CyberGIS (Shook et al. 2019) but the outcomes have not scaled effectively. Documenting an exact set of job duties and tasks via a DACUM is a labor-intensive and time-consuming process that is mismatched with the pace of the geospatial industry. Computer-supported approaches to occupational analyses are now more common (Hong 2016; Piróg and Hibszer 2024; Ramezan et al. 2024) but the results themselves do not solve other workforce development challenges.

References

AmericaView. (n.d.). AmericaView USGS Workforce Development, Geospatial Data Science and Remote Sensing. Last accessed June 28, 2024.

Bowlick, F. J., Goldberg, D. W., & Bednarz, S. W. (2017). Computer Science and Programming Courses in Geography Departments in the United States. The Professional Geographer, 69(1), 138-150.

DiBiase, D. (2018). Competence in GIS&T Knowledge Work. The Geographic Information Science & Technology Body of Knowledge (3rd Quarter 2018 Edition), John P. Wilson (Ed.). DOI:10.22224/gistbok/2018.3.10.

DiBiase, D., DeMers, M., Johnson, A., Kemp, K., Luck, A. T., Plewe, B., and Wentz, E. (2006). The Geographic Information Science & Technology Body of Knowledge. First Edition. Washington, DC: Association of American Geographers.

Gaudet, C. H., Annulis, H. M., and J. C. Carr, J. C. (2003). Building the Geospatial Workforce. Urban and Regional Informational Systems Association Journal, Special Education V15, no.1, p.21-30.

Georgetown University Center on Education and the Workforce. (2024). The Great Misalignment: Addressing the Mismatch between the Supply of Certificates and Associate's Degrees and the Future Demand for Workers in 565 US Labor Markets. Last accessed June 28, 2024.

Hong, J. E. (2016). Identifying Skill Requirements for GIS Positions: A Content Analysis of Job Advertisements. Journal of Geography, 115, 147-158.

Hunter-Johnson, Y. (2023). Workforce Development Careers. In Monaghan, C., Isaac-Savage, E. P., and Putman, P. (Eds.) Career Pathways in Adult Education (pp. 222-231). Routledge.

Jackson, R. (2014, July). GTCM Discussions. Blog posting published by the GeoTech Center. Last accessed June 28, 2024.

Jacobs, R. L. and Hawley, J. D. (2009). The Emergence of 'Workforce Development': Definition, Conceptual Boundaries and Implications. In: Maclean, R., Wilson, D. (eds) International Handbook of Education for the Changing World of Work. Springer, Dordrecht.

Johnson, A. (2011). Geospatial Education at US Community Colleges. In Unwin, D., Tate, N., Foote, K. and DiBiase, D. (eds.), in Teaching Geographic Information Science and Technology in Higher Education. London: John Wiley & Sons (UK): 185-197.

Johnson, J. (2010). What GIS technicians do: A synthesis of DACUM job analyses. URISA Journal, 22(2), 31.

Kemp, K. (2016). Professional Certification. The Geographic Information Science & Technology Body of Knowledge (3rd Quarter 2016 Edition), John P. Wilson (ed.). DOI: 10.22224/gistbok/2016.3.1.

Lee, G. G. (1963). The Morrill act and education. British Journal of Educational Studies, 12(1), 19–40.

Li, D., Li, Y., Nguyen, Q. C., & Siebeneck, L. K. (2020). A Study on the GIS Professional (GISP) Certification Program in the US. ISPRS International Journal of Geo-information, 9(9), 523.

MacLaury, J. (n.d.). A Brief History: The U.S. Department of Labor. https://www.dol.gov/general/aboutdol/history/dolhistoxford. Last accessed June 10,

2024.

Mathews, A. J., & Wikle, T. (2017). Assessing Professional Benefits of GIS Certification. Cartography and Geographic Information Science, 44(5), 452-462.

Mirzoev, T., Moore, A., Pryzbysz, B., Taylor, M., & Centeno, J. (2015). GIS as a Job Growth Area for IT Professionals. World of Computer Science & Information Technology Journal, 5(6).

National Geospatial Advisory Committee (NGAC). (2012). Geospatial Workforce Development; A Compendium of White Papers Focused on Advancing Geospatial Workforce Development. NGAC Workforce Development White Paper, published January 2012. Last accessed June 11, 2024.

National Science Foundation (NSF). (2024a). Directorate for STEM Education (EDU). https://new.nsf.gov/edu Last accessed June 10, 2024.

National Science Foundation (NSF). (2024b). National Science Foundation Research Traineeship Program. https://new.nsf.gov/funding/opportunities/national-science-foundation-research-traineeship. Last accessed June 10, 2024.

Piróg, D. & Hibszer, A. (2023). What kind of GEES specialists does the labour market really need? Content analysis of job adverts in selected countries. Journal of Geography in Higher Education, 1-25.

Ramezan, C. A., Maxwell, A. E., & Meadows, J. T. (2024). An analysis of qualifications and requirements for geographic information systems (GIS) positions in the United States. Transactions in GIS.

Shook, E., Bowlick, F. J., Kemp, K. K., Ahlqvist, O., Carbajeles-Dale, P., DiBiase, D., … Wang, S. (2019). Cyber Literacy for GIScience: Toward Formalizing Geospatial Computing Education. The Professional Geographer, 71(2), 221–238.

Sinton, D. S. and Kerski, J. J. (2020). GIS&T Education and Training. The Geographic Information Science & Technology Body of Knowledge (1st Quarter 2020 Edition), John P. Wilson (ed.). DOI: 10.22224/gistbok/2020.1.4.

Stout, W. R. (2022). Bridging the Geospatial Education – Workforce Divide: a Case Study on How Higher Education Can Address the Emerging Geospatial Drivers and Trends of the Intelligent Web Mapping Era. Unpublished dissertation, Liberty University. Last accessed June 28, 2024.

Sullivan, D. E. (2007). Developing a plan for the national coordination of geospatial technology education: a community college perspective. Unpublished Master's Thesis. Oregon State University, Corvallis, Oregon.

Wallentin, G., Hofer, B., & Traun, C. (2015). Assessment of workforce demands to shape

GIS&T education. Transactions in GIS, 19(3), 439-454.

Wikle, T. (2018). GIS&T Positions and Qualifications. The Geographic Information Science & Technology Body of Knowledge (2nd Quarter 2018 Edition), John P. Wilson (ed.). DOI: 10.22224/gistbok/2018.2.9.

Wikle, T. and Sinton, D. S. (2020). The Administration of Academic GIS Certificates: A Survey of Program Coordinators. Transactions in GIS. 24(6): 1681-1694. DOI: 10.1111/tgis.12677.