A Plan for the National Coordination of Geospatial Technology Education from a Community College Perspective

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Executive Summary

A Plan for the National Coordination of Geospatial Technology Education from a Community College Perspective was a year-long study to document the needs and concerns of community college educators and use this information to produce recommendations for the development and operation of a National Geospatial Technology Center (NGTC).

Geospatial technology is a rapidly growing and changing field. The term *geospatial technology* (GST) refers to geographical information systems (GIS), global positioning systems (GPS), remote sensing (RS), and emerging technologies that assist the user in the collection, analysis, and interpretation of spatial data. The speed at which new fields are adopting GST and the rate at which equipment and software are modified and updated make it difficult for many industries and educational institutions to keep current. Within the community college network, this issue is further complicated because communication and the sharing of workforce information and educational resources is limited.

Issues Critical to GST Education

Community college educators identified the following ten issues as critical for an NGTC to address: 1) workforce needs; 2) core competencies[1]; 3) professional certification; 4) curriculum development; 5) educational pathways; 6) professional development; 7) communication; 8) awareness and reaching underserved audiences; 9) the role of GST education in supporting college administrative tasks and entrepreneurialism; and 10) future trends in GST.

Methods

This study consisted of five phases:

1. *Online survey.* One hundred seventy GST professionals, predominantly commnity college GST instructors, completed an online survey that gathered information on their practices, views, and challenges in GST education.

2. *Review and analysis.* A team of 12 GST professionals from community colleges, universities, industry, and professional societies researched the literature and reviewed survey responses to produce a written synopsis of the current state of each of the ten critical issues. The team also created a list of questions that remained after their review and analysis.

3. *National forum.* Forty leaders in GST education, industry, and workforce development participated in a national forum on GST education that was held January 5-7, 2007 in Monterey, California. During the forum, participants shared and discussed the results of the background research and the questions that remained and produced a set of draft recommendations for an NGTC.

4. *Validate recommendations.* Forum participants validated and prioritized draft recommendations, which were sent out in survey format five weeks after the forum.

5. *Final report.* The project team developed a final document (this report), that provides a blueprint for the national coordination of geospatial activities at the community college level and a prioritized list of work for an NGTC.

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[1]Core competencies define the knowledge and skills required to carry out specific tasks that are common to a particular profession or occupation. Core competencies are critical links between the workplace and the classroom, since they connect job requirements to educational subject areas.

Recommendations

Based on the recommendations made in this study, community college educators want an NGTC to:

- Represent their interests in national education and workforce initiatives
- Act as a clearinghouse to provide easy access to existing curricula and workforce information
- Provide access to professional development opportunities, among other activities described in this report

Additionally, it is imperative that an NGTC work with existing competency-related efforts[2] to bring them closer together so that core competencies, and in turn a core curriculum that supports many entry-level positions, can be established and agreed upon by a wide range of stakeholders. The consequences of not coming to an agreement will certainly contribute to greater gaps between what the workforce needs and what the educational system is producing.

To remain economically competitive, achieve greater understanding in protecting our resources, make better decisions to promote sustainability, and reduce the chaos and loss of life associated with manmade and natural disasters, the U.S. needs an efficient, responsive, and well-coordinated GST educational system with good communication between all levels and a better understanding of the knowledge and skills needed by workers to be successful in the workplace.

To ensure such a system, *A Plan for the National Coordination of Geospatial Technology Education from a Community College Perspective* documents the issues, needs, and concerns of community college educators and produces recommendations for an NGTC that best reflect this audience while placing the recommendations within the context of the work that has been accomplished by the U.S. Department of Labor, higher education, and other organizations relating to professional certification and accreditation. It is essential that some organization, presumably an NGTC, end the community college silence and act as a collective voice to promote community college interests in GST issues and activities of national importance.

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[2]University Consortium for Geographic Information Science's (UCGIS) *Body of Knowledge*; GeoSpatial Workforce Development Center's (GeoWDC) *Geospatial Technologies Competency Model*; Geospatial Information and Technology Association (GITA) / Association of American Geographers (AAG) study, *Defining and Communicating Geospatial Industry Workforce Demand*, *Phase I Report Recommendations*; and existing DACUMs.

Introduction

Geospatial Technology and the Economy

Geospatial technology is a rapidly expanding industry that crosscuts nearly every discipline and sector of the U.S. economy (Gewin, 2004). Geospatial technology (GST) is a broad term referring to geographical information systems (GIS), global positioning systems (GPS), remote sensing (RS), and emerging technologies that assist the user in the collection, analysis, and interpretation of spatial data (U.S. Department of Labor, 2005a). It deals with the relationship and condition of manmade and natural objects within space on Earth or beyond (Bolstad, 2005). Industries as diverse as health, agriculture, construction technology, emergency services, environmental technology, government, information technology, manufacturing technology, marine science, marketing, national security, resource management, and transportation use GST to collect and analyze data about issues and occurrences that affect everyday life. GST enables other fields to improve productivity, efficiency, and profitability while evaluating environmental impacts to ecosystems. Recent natural disasters from Hurricanes Katrina and Rita to wildfires in California illustrate the need for coordination and sharing of geospatial data among all levels of government and the public. Applying the lessons learned from these events—and adapting to an information age that is increasingly tied to GST—requires a populace and workforce that can effectively understand and use the information derived from GST.

The growth of the GST industry is phenomenal. One study estimated the market for geospatial technologies at $5 billion and projected annual revenues of $30 billion—$20 billion in the RS market and $10 billion in the GIS market—by 2005 (Gaudet et al., 2002). In the abstract *Global Positioning System: The Road Ahead*, it is estimated that market revenue for geospatial technology will be more than $700 billion by the year 2017 (Research and Consultancy Outsourcing Services, 2005).

The U.S. Department of Labor (DOL) highlights the importance of GST in the President's High Growth Job Training Initiative, a strategic effort to prepare workers to take advantage of new and increasing job opportunities in high-growth, high-demand, and economically vital sectors of the American economy. The Initiative recognizes GST as one of 14 existing or emerging industries that are being transformed by technology and innovation and requiring new skill sets for workers. It projects that these sectors will add substantial numbers of jobs, significantly impact the economy, and affect the growth of other industries (U.S. Department of Labor, 2005b). The tremendous growth potential of GST is limited only by the educational system's ability to provide future workers with the conceptual and technical expertise and the GST awareness needed by government and industry.

Many environmental events over the past three years—the Asian Tsunami, Hurricanes Katrina and Rita, and southern California wildfires—have heightened public awareness of GIS (Tsou, 2005). Millions of people learned about these disasters by using GIS-based maps and visualizations. In addition, the explosion of web-based GIS sites such as Google Earth, MapQuest, ESRI ArcGIS Explorer, NASA's World Wind, and MSN Virtual Earth demonstrates that web-based GIS is a substantial and growing medium for communicating science and geography to the general public (Butler, 2006). Web-based GIS has the potential to increase the general population's awareness and understanding of geospatial information as never before (Peng and Tsou, 2003).

Community College Education

American community colleges have been around since the early 20th century (American Association of Community Colleges, 2005). Among the factors that contributed to their rise were the need for workers trained to operate the nation's expanding industries and the drive for social equality, the potential result of providing more people with access to higher education (Cohen and Brawer, 2002). Community colleges continued to increase in importance throughout the 20th century as more and more students graduated from high school and the demand for further education increased. In 1947, the President's Commission on Higher Education articulated the value of a population with free access to two years of study beyond high school and asserted that half of the young people could benefit from formal studies through grade 14 (Cohen and Brawer, 2003). More than fifty years later, President Bill Clinton underscored the importance of making education through grade 14 as universal as a high school diploma (Clinton, 1998).

In total, more students, including those taking credit and non-credit courses, attend community

colleges than four-year universities (Community College Research Center, 2005). The composition of community college students is more varied than many realize. Community college students include:

- High school graduates continuing with grades 13 and 14 who plan to transfer to a four-year institution

- Students pursuing a two-year vocational degree or certificate

- Adults working towards a General Equivalency Diploma (GED)[3] or entry-level workplace competencies, such as those participating in programs similar to Welfare-to-Work[4]

- Middle and high school students that are co-enrolling at a community college or attending in lieu of traditional school

- Re-entry students that have been in the workforce for some time and are looking for a new career or skills

- Students of all ages pursuing personal interests

- "Reverse transfer" students, who have already earned a bachelor's degree and are seeking new skills and skill upgrades, especially technical knowledge and skills. In fact, the growing trend of reverse transfer students has led some to refer to community colleges as the new form of graduate school (Arnone, 2001).

Community colleges serve the needs of the local community, providing convenient, cost-effective training and education to students of vast age, ethnic, and socio-economic diversity. Because of their enormous potential to impact the nation's workforce and enhance social equality, the National Science Foundation (NSF) and other agencies, such as the DOL, are increasingly devoting more resources to improving community college education (Community College Research Center, 2005).

Geospatial Technology Education

GIS programs[5] in higher education have experienced tremendous growth over the past 20 years. Currently more than 2,000 of the 4,165 public and private two- and four-year colleges and universities in the country use Environmental Systems Research Institute (ESRI) GIS software (ESRI, 2002; National Center for Education Statistics, 2006). Of these, approximately 400 of the nation's 1,157 two-year colleges offer some instruction in GIS; about 60 offer a GIS certificate or degree (Allen et al., 2006).

GIS is a bit of an oddity within the educational system because it is offered as both an academic and an occupational program. The curricula of community college occupational programs are generally more responsive to local workforce needs, as mandated by community college missions and their requirements for advisory committees from business and industry to guide occupational program development and implementation. Many community college GIS courses are taught by occupational faculty who work full-time as GIS professionals. These programs range from those simply offering courses in GIS and using GIS as a tool in other disciplines to those offering GIS certificates and associate's degrees for GIS technicians. Since many students enrolled in community college GIS courses are incumbent workers that need GIS skills for their jobs, some community colleges (such as Central Oregon Community College) offer GIS certificates only to those who already have a previous academic degree (Central Oregon Community College, 2007).

Four-year college and university missions and funding sources tend to be different, which is reflected in how they integrate GIS into the curriculum. In general universities tend to view GIS as a science, rather than a tool, as reflected in the use of the term GIScience, which is gaining in popularity at universities but not commonly found at community colleges (Wright et al., 1997; Kemp, 2003). Universities offer minors or certificates in GIS at the bachelor's, master's and doctoral level, with some of these courses available via distance education (ESRI, 2002; Wright and DiBiase, 2005).

The different philosophies of community colleges and universities often contributes to the difficulty articulating GIS courses between two- and four-year institutions. Another obstacle is that community colleges offer GIS courses as 100- and 200- level courses; most four-year institutions offer them as 300- and 400-level courses (Allen, 2005). As a result, community college students who plan to continue their studies at four-year institutions may have difficulty transferring GIS/GST courses. A recent trend at universities is to offer introductory geospatial or GIS courses as lower division courses, which may help facilitate increased

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[3]The GED is an exam developed in the United States for all adults who want an equivalent of a high school diploma. It tests general academic skills and core content that are covered in four years of high school.

[4]A former social program of the U.S. government, Welfare-to-Work focused on weaning single parents and the disabled from their reliance on federal and state income support and encouraging them back into the work force. For more information see www.opm.gov/wtw/index.htm.

[5]In most cases GIS and GST can be used interchangeably within the context of higher education. Most GIS courses and programs include some type of remote sensing and/or GPS.

articulation opportunities (DiBiase, 2007).

GIS is also becoming more commonplace in K-12 education, as evidenced by a variety of national GIS programs (GIS for 4-H, The EAST Initiative, Community Mapping Project), as well as countless local and regional efforts that are the result of motivated educators and linkages to higher education programs. The presence of GIS in the K-12 community will continue to grow as the importance of GST to the economy increases and the value of spatial thinking is recognized, as clearly articulated in a recent National Research Council report (National Research Council, 2005):

> *Spatial thinking must be recognized as a fundamental part of K-12 education and as an integrator and a facilitator for problem-solving across the curriculum. With advances in computing technologies and the increasing availability of geospatial data, spatial thinking will play a significant role in the information-based economy of the 21st century.*

This report describes spatial thinking as:

> *A constructive combination of concepts of space, tools of representation, and processes of reasoning that uses space to structure problems, find answers, and express solutions. It is powerful and pervasive in science, the workplace, and everyday life. By visualizing relationships within spatial structures, we can perceive, remember, and analyze the static and dynamic properties of objects and the relationships between objects. Despite its crucial role underpinning the National Standards for Science and Mathematics, spatial thinking is currently not systematically incorporated into the K-12 curriculum.*

Spatial thinking has gone beyond being a specialized skill set or body of knowledge; it is entering a new age of expected general literacy. This shift is only now evident as colleges and universities begin to accept GIS courses to meet general education requirements in areas such as science, quantitative reasoning, communications, and analytical thinking.

However, a barrier to accepting GIS as a general education course is that many educators do not understand where to place it within the curriculum. This is because it can be either an academic or occupational program, and is found within a multitude of disciplines ranging from agriculture to anthropology to archeology (and that only covers the first letter of the alphabet).

GIS/GST education is complex because of two factors: 1) the steep learning curve, and 2) the increase in the number of people that will need to be educated to meet workforce demands. First, though many technologies have a long and steep learning curve, GST is unique because of the variety of integrated technologies; the speed at which adaptation is occurring; and the rate at which equipment and software are being modified and updated, which precludes many businesses and the educational system from keeping up-to-date (Marble, 2006). Second, geospatial technologies are not just being used by a cadre of specialists and technicians; they are part of a system-wide integration that includes professionals and managers in all sectors of the economy. In addition to the GIS, GPS, and RS technicians who will need advanced and specialized education, peripheral support people–those who work with and supervise the technicians and use geospatial products for decision making–will all need additional education. The number of these workers is growing at an unprecedented rate (U.S. Department of Labor, 2005c).

A variety of national and state organizations, collegiate and secondary programs, and NSF and DOL grant projects are working to improve curricula, provide resources, and document workforce needs for geospatial technologies. As these diverse groups develop the necessary instructional materials, offer professional development, and publish workforce information, there is a concern over duplicating efforts where there is no structure for nationally coordinating or disseminating these resources. This is especially true at the community college level. For example, several community college-based projects have developed geospatial-related task analysis summaries or reports, known as DACUMs[6]. In many cases these reports are duplicated for a specific career, while other geospatial careers have had no task analysis at all. Coordinating efforts through an NGTC reduces the duplication of activities and frees up resources to address neglected and emerging areas in GST.

A Review of National Geospatial Technology Education and Workforce Efforts

GIS/GST education has grown and matured over the past 20 years. Several factors have contributed to a tremendous demand for GIS education: its growing use in a broad array of applications along with plentiful and easily accessible data; user-friendly software; increased computing power; and a more computer-literate public (Brown et. al., 2004; DiBiase et al., 2006). Many

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[6]DACUM is an acronym for developing a curriculum. It is a one or two day process that provides a picture of what the worker does in terms of duties, tasks, knowledge, skills, traits and in some cases the tools the worker uses (DACUM, 2007).

significant national efforts have added cohesion and continuity to GIS education.

One of the earliest national GIS education efforts was conducted by the National Center for Geographic Information and Analysis (NCGIA)[7]. Published in 1990, the *NCGIA Core Curriculum in GIS* consists of a detailed outline for a three-course sequence of 75 one-hour units (Goodchild and Kemp, 1992). In 1995, NCGIA began developing a revised and expanded *Core Curriculum in GIScience* (last updated in 2000) and a *Core Curriculum for Technical Programs* (last updated in 1999). Both of these projects were never completed to the level envisioned (DiBiase et al., 2006). However, in a 2006 survey of 170 GIS educators (Phase One of this project, available online at www.marinetech.org/workforce/geospatial), the NCGIA *Core Curriculum* was still the most referenced GIS curriculum to date. In 1992, the NCGIA began a *Remote Sensing Curriculum* project that is still supported and continues to be updated and expanded under the auspices of the American Society for Photogrammetry and Remote Sensing (ASPRS, 2007).

In 1994, the University Consortium for Geographic Information Science (UCGIS) was formed to provide a "unified voice for the geographic information science research community" (University Consortium of Geographic Information Science, 2002). Currently more than 80 universities and three professional societies are members with several industry and government affiliate members. The leading education-focused effort by the UCGIS is the *Model Curricula* project, which began in 1999. The first portion of this on-going project, the *Body of Knowledge* (BoK) *for GIScience and Technology* (GIS&T), was published in 2006 (DiBiase et al., 2006). The BoK is not a curriculum, but purports to include all pertinent GIS&T knowledge broken down into 10 knowledge areas (KAs). Each KA is further broken down into units, with topics for each unit. The topics are defined in terms of one or more formal educational learning objectives. In theory, by selecting different KAs, pathways through the BoK that lead to different degree outcomes could be defined. Thus, the BoK could be used to develop the curriculum content for different levels of education and disciplines.

Other recent national GIS education efforts have focused on defining core competencies instead of a national curriculum. Core competencies define the knowledge and skills required to carry out specific tasks common to a particular profession or occupation. They are critical links between the workplace and the classroom, since they connect job requirements to educational subject areas (Sullivan et al., 2004). Core competencies are the basis for the development of instructional materials, starting with assessments based on the competencies, and instructional modules based on the assessments. There are many benefits to establishing core competencies for a subject area or profession. They can provide a framework to (Sullivan et al., 2004; DiBiase et al., 2006):

- Help employers better understand and evaluate the education of potential employees
- Develop benchmarks for program accreditation
- Facilitate articulation agreements
- Make it easier to share curriculum among institutions
- Develop exam-based professional certification
- Facilitate the placement of students in internships and jobs

Establishing core competencies helps students understand what they know, and more importantly, what they don't know. This enables them to guide their education in a more efficient and productive manner.

Although UCGIS refers to the BoK as an "inventory of the domain" of GIS&T (DiBiase et al., 2006), rather than core competencies, the BoK is nevertheless an attempt to define parameters for the field of GIS&T, albeit from an academic rather than an industry-driven perspective. In contrast to the BoK, the GeoSpatial Workforce Development Center (GeoWDC)[8] at the University of Southern Mississippi used industry focus groups to develop a *Geospatial Technology Competency Model* (Gaudet et al., 2003; see Appendix A). *The Geospatial Technology Competency Model* attempts to identify the full range of competencies needed by a working geospatial technology professional and includes areas of business, technical, analytical, and interpersonal competencies that are independent of the GIS domain. Although the BoK provides much more depth and breadth in the GIS domain, the GeoWDC provides the framework for producing a well-rounded employee.

Many other grassroots efforts to define the core competencies for specific GST occupations have been

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[7]The NCGIA is a consortium of three universities (University of California at Santa Barbara, State University of New York at Buffalo, and University of Maine) founded in 1988 with funding from the National Science Foundation.

[8] The GeoSpatial Workforce Development Center (GeoWDC) is part of the National Workforce Development Education and Training Initiative (NWDETI) sponsored by the National Aeronautics and Space Administration (NASA).

undertaken, largely at community colleges across the country using the DACUM process to provide the foundation for developing a GIS curriculum and/or program that is aligned with local or regional workforce needs (Johnson, 2006). Using a DACUM carried out at California's San Diego Mesa College as part of an NSF-funded project, *A Scalable Skills Certification Program in Geographic Information Systems* (NSF/DUE 0401990), Del Mar College in Texas defined skills standards for GIS technicians for the state of Texas (Texas Skill Standards Board, 2007). The Texas Skill Standards for GIS Technician process extends the outcome of a DACUM to include the performance criteria necessary to assess whether a skill or competency has been met.

Although the GeoWDC *Geospatial Technology Competency Model* is the most extensive "workforce" competency model to date (GITA, 2006), it is not being referenced to the same degree as the UCGIS BoK. For example, the United States Geospatial Intelligence Foundation (USGIF)[9] was tasked with creating an Academy to accredit certificate programs qualified to educate Geospatial Intelligence Analysts. The Academy used portions of the BoK to define the GIS-related topics required to qualify programs for accreditation (USGIF, 2007).

The BoK is also being used by the GIS Certification Institute (GISCI)[10] to identify courses that qualify for educational points under the certification process. This current process does not include an exam for certification, which has been a point of criticism by some professionals (Gram, 2007). The GISCI is currently reviewing the BoK and its relevance to certification of GIS professionals (GISPs) to determine if the BoK "may serve as the backbone for an exam-based certification program" (Gram, 2007). In 2007, GISCI surveyed their certified GISPs on the need for a certification exam and the value of using the UCGIS BoK to determine certification status. Of approximately 560 survey respondents, more than 70 percent felt that "a percentage of the core knowledge areas of the BoK [should be used] to determine certification;" less than 10 percent felt that the core knowledge [BoK] areas should not be used to determine certification (Gram, 2007). However, a number of the GISPs raised

concerns about the academic nature of the BoK, illustrated by the following quotes (Gram, 2007):

> *I don't mind using a few items from the core knowledge areas for GIS from the GIS&T Body of Knowledge, but I found that document to be loaded with doctoral thesis topics rather than everyday applications of GIS technology.*

> *I'm all for the academic nature of these core areas and the associated questions, but they're not reflective of the average GISP that's been utilizing geospatial systems for over a decade. Many of these areas should be common knowledge for practically all GISPs (e.g., principles of map design), but others are simply questions of a purely academic nature that many of us have not encountered since our undergrad days.*

The U.S. Department of Labor and Education Training Administration funded another significant GST workforce study that was led by GITA[11]. In partnership with the Association of American Geographers (AAG) and the Wharton School of the University of Pennsylvania (GITA, 2006), GITA recommended:

- Standard definitions of the geospatial industry sector that have been vetted by industry leaders

- A rationale for market segmentation

- New occupational titles for the industry

- Methodology for estimating geospatial workforce demand

- Modifications to the GeoWDC Geospatial Technologies Competency Model

- Actions to close the "gap between geospatial workforce supply and demand"

Two recommendations, are particularly relevant to this study (GITA, 2006):

> 1. *Employers and educators must work together to develop effective strategies to close the gap between geospatial workforce demand and supply. The geospatial industry must articulate its workforce needs to ensure that educators respond with curricula that results in appropriately educated and trained individuals.*

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[9] The purpose of the USGIF is to promote the geospatial-intelligence tradecraft, and to develop a stronger community of interest between government, industry, academic, and professional organizations and individuals who share a mission focus around the development and application of geospatial intelligence data and geo-processing resources to address national security objectives.

[10] The GIS Certification Institute (GISCI) is a 501(c) organization founded in 2004 to certify GIS professionals (GISP). See p. 36-37 for more information on the GISCI.

[11] In 2004, the U.S. Department of Labor and Education Training Administration (DOL-ETA) awarded $6.4 million to support six projects related to the geospatial technology industry as part of the DOL-administered program, the President's High-Growth Job Training Initiative. The grant to GITA was originally awarded to the Spatial Technologies Industry Association and transferred to GITA in 2005.

2. Two year (community-based) colleges should assume a strong role in training new geospatial technologists and meeting on-the-job training needs of local professionals.

See Appendix B for a list of all the recommendations.

The GITA study has put forward constructive recommendations for work needed to define, quantify, and prepare workers for the geospatial industry. Still, much of this work has not yet been completed. More than ever, it is essential that stakeholders in the geospatial industry (private industry, government, education, and others) agree on industry definitions and requirements, including occupational titles, market segmentation, and the knowledge and skills required, especially for entry-level positions requiring two- and four-year degrees. It is vital that the work be effectively coordinated to ensure its completion in a timely and productive manner.

Table 1 summarizes many of the significant national efforts that have added continuity and cohesion to GST education.

Table 1. National efforts focused on GST education and workforce development

YEAR	ACTIVITY [Funding agency/source]
1988	NCGIA is formed. [NSF]
1990-1995	NCGIA Core Curriculum is developed. [NSF]
1992 - present	Remote Sensing Core Curriculum is developed and updated. [NSF/NASA/ASPRS]
1994	UCGIS is formed.
1995-1999	NCGIA Core Curriculum for Technical Programs is developed. [NSF]
1995 - 2000	NCGIA Core Curriculum for GIScience is developed. [NSF]
1998-2006	UCGIS Model Curricula Project is partially developed. [Multiple sources/industry]
2003	GeoWDC Geospatial Technologies Competency Model is published. [NASA]
2004	GIS Certification Institute is formed. [Urban and Regional Information Systems Association (URISA)]
2006	UCGIS Body of Knowledge (BoK) in GIS&T is published. [AAG]
2006	GITA/AAG study, Defining and Communicating Geospatial Industry Workforce Demand, Phase I report is released. [DOL-ETA]
2007	USGIF Program Accreditation Criteria is released.
2007	National Forum on Geospatial Technology Education for Community Colleges (this study) is conducted. [NSF]
2007	Texas Skill Standards for GIS Technicians is completed.

Project Background and Methodology

Project Background

At the 2005 ESRI User Conference,[12] many community college faculty and industry representatives attended a workshop that focused on the national coordination of educational GIS/GST activities at community colleges. A subsequent roundtable discussion at the Advanced Technological Education[13] (ATE) conference was held in October 2005. Some of the issues discussed were germane to most technology education fields, while others were unique to GST (Sullivan et. al., 2005). The consensus of these two meetings was that community college GST education desperately needed national coordination. Ten issues were selected as critical to the national coordination of GST education and the development of a National Geospatial Technology Center (NGTC). These issues are:

1. Workforce needs
2. Core competencies
3. Certification
4. Curriculum and pedagogy
5. Educational pathways/articulation
6. Professional development
7. Geospatial community communication
8. Awareness and reaching diverse audiences
9. Role of GST education in supporting college administrative tasks and entrepreneurialism[14]
10. Future trends

A proposal to support research on these ten issues and to create a plan to develop an NGTC was submitted to the NSF in October 2005 (*Developing a Vision and a Plan for a National Geospatial Technology Center*). It was subsequently funded in June 2006 (NSF/DUE 0603424).

Project Methodology

Conducted between July 2006 and November 2007, the study consisted of the following five phases.

1. *Online survey.* In October 2006, the project team invited several hundred faculty, primarily community college GST instructors, to participate in an online survey that gathered information on their practices, views, and challenges in GST education. Their contact information was collected from ESRI, ATE Program, MATE Center[15], and the AgrowKnowledge Center[16] mailing lists. The complete survey results are available online at www.marinetech.org/workforce/geospatial.

2. *Review and analysis.* The project team of 12 GST professionals from community colleges, universities, industry, and professional societies researched the literature, reviewed survey responses, and produced a written summary of the current state of each of the ten GST education issues. The team also created a list of questions that remained after their review and analysis. A written synopsis for each issue is available at www.marinetech.org/workforce/geospatial.

3. *National forum.* Forty leaders in GST education (primarily community college educators and a few university educators), industry, and workforce development participated in a national forum on GST education that was held January 5-7, 2007 in Monterey, California. During the forum, participants shared and discussed the results of the background research and remaining questions, and produced a set of draft recommendations for an NGTC. See Appendix C and D for the list of participants and forum agenda; the complete forum results are available at www.marinetech.org/workforce/geospatial.

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[12]The world's largest GIS conference is held annually, with attendance exceeding 13,000 (www.esri.com/events/uc).

[13]A Division of Undergraduate Education program at NSF, the Advanced Technological Education (ATE) program focuses on the education of technicians for high-technology fields that drive the nation's economy.

[14]Issue 9 was added later and another issue, qualities of a successful national center, was subsequently removed.

[15]National ATE Center for marine technologies.

[16]National ATE Center for agriscience and technology.

4. *Validate recommendations.* Five weeks after the forum, participants validated and prioritized draft recommendations, which were sent out in survey format. The complete recommendations are available online at www.marinetech.org/workforce/geospatial.

5. *Final report.* The project team developed a final document (this report) that provides a blueprint for the national coordination of geospatial activities at the community college level and a prioritized list of work for an NGTC. In addition, eight selected issue reports are included at the end of this document.

Results

Results

Summaries of each of the ten GST education issues discussed at the national forum follow, along with highlights of the survey and the recommendations from the forum. The complete forum results are available online at www.marinetech.org/workforce/geospatial. Forum participants prioritized their recommendations as:

High Priorities: an NGTC must do this

Medium Priorities: an NGTC should do this as time and resources allow

Low Priorities: an NGTC should do this only if time and resources are available

Not Recommended: an NGTC should not do this

A. Workforce Needs

Workforce studies can be complex and expensive, but are essential to developing GST programs that prepare students for current and future workforce needs. The numerous workforce studies and curriculum models outlined in the above review of national GST education and workforce efforts provide educators with a plethora of choices. Indeed, Phase One of this study (See www.marinetech.org/workforce/geospatial), the online survey of 170 GST professionals, showed that there is no strong consensus on their use.

For this reason, an NGTC will need to devote considerable resources to assessing the workforce, making best use of existing studies, and making this information readily available to community college educators in a user-friendly format. Other priorities include compiling and evaluating available GST workforce studies to prevent duplication of efforts, addressing sectors of the GST workforce that have been neglected, providing a structure for disseminating these resources, and developing strategic partnerships with other workforce-related organizations.

High Priorities

A1. Thoroughly research former workforce assessment efforts and practices before starting or recommending new studies.

A2. Organize, compile, and compare past and future DACUMs and make the results available on the center website. *A repository of DACUMs will enable the center to recommend future DACUMs, including those for occupations using GIS as ancillary knowledge, such as resource management or crime analysis.*

A3. Complement the DACUM process with other techniques, such as "environmental scans" that identify regional economic trends and assist practitioners in defining current and future workforce needs.

A4. Establish a partnership with the U.S. Department of Labor to develop mutual goals and projects to increase the efficiency and coordination of both organizations.

A5. Develop a mechanism to track student internships, jobs, and earnings at the local and national level. *Tracking students as they move through the educational system and into the GST workforce is complicated, but vital in demonstrating the impact of an NGTC. The majority of forum participants believe that an NGTC must track student internships, jobs, and earnings, possibly using online tools such as static and interactive MySpace or "My GeoSpace" web pages for student portfolios and information exchange. A creative and professional presentation will entice students to participate and continally update their electronic portfolios as they move through the educational system and into the workforce.*

A6. Establish a clearinghouse for internship, work experience, and service learning programs to remove geographic barriers to job placement (internship process materials should be made available on the NGTC website).

A7. Build partnerships with new and emerging sectors that utilize geospatial technology (e.g., graphic artists associated with the gaming industry).

A8. Operate with a spirit of social and environmental responsibility.

Medium Priorities

A9. Encourage new DACUMs to be conducted by partner institutions and others across the country.

A10. Link DACUM tasks to the BoK.

A11. Use the content of the BoK to construct a workforce survey where the incumbent geospatial workforce can validate and prioritize the content of the BoK.

B.   Core Competencies

If widely adopted by the educational community and clearly identified within a particular academic program, core competencies can provide the foundation for the standardization of GST education. Those surveyed in Phase One of this study underscore the value of core competencies to GST education; 63 percent of 170 surveyed feel that core competencies are needed for the national coordination of GST activities. Thirty-three percent are unsure, while only four percent feel that core competencies are not needed.

The UCGIS BoK is the most extensive document produced to date on the breadth of GI science and technology. A key question remains – how well does the BoK embody two-year community college GST programs that are responding to local and regional workforce needs? At the national forum, many community college educators felt that the BoK needs to be evaluated by working GIS/GST professionals as to the applicability of the Knowledge Areas (KAs) to the work GIS/GST professionals perform.

To successfully make the BoK more applicable to the needs of community colleges, an NGTC will need to develop and maintain organizational partnerships with relevant organizations. One hundred percent of the forum participants say that an NGTC should assist the UCGIS and AAG in furthering work on the BoK, and that the center should specifically set aside funds to do this (54 percent consider this a top priority).

High Priorities

B1. Determine if the BoK KAs encompass the breadth of the GIS&T field from a community college perspective.

B2. Assist UCGIS and AAG in continuing and expanding the BoK and making it more user friendly for undergraduate teaching and educating the incumbent workforce (identifying and filling gaps, etc.).

B3. Establish partnerships with other academic centers and industries to align KAs with sector-specific applications of GIS (e.g. agriculture, forestry).

B4. Take identified core competencies in the BoK and state them as learning outcomes consistent with accreditation language.

Medium Priorities

B5. Help to broaden the scope of the competencies and learning outcomes to all of geospatial technology (remote sensing, GPS) realizing that the BoK emphasizes GIS.

B6. Establish a method for selecting core competencies for the mission statement of a particular (college's) program: discipline-specific or workforce. This would be made available on the center website.

B7. Create additional units under existing KAs and/or create additional KAs related to workforce-driven applications of GIS (e.g. emergency response, crime mapping).

B8. Help create a glossary of terms for the BoK KAs specific to two-year programs.

B9. Determine if community college educators can create exemplary pathways (core courses with specific content and electives) for two-year programs that are cross referenced to the BoK.

B10. Using *Geography for Life* and other models as templates, create concrete examples for each level of mastery for the BoK topics that pertain to two-year community college education, and tie these to

assessments for each mastery level. *Geography for Life is a manual for U.S. geography education standards. It provides benchmarks against which the content of geography courses can be measured (Boehm and Bednarz, 1994). Mastery levels are performance standards related to the Categories of Educational Objectives (see BoK, p. 42). Six different mastery levels correspond to a student's ability to remember, understand, apply, analyze, evaluate, and create.*

C. Professional Certification

Certification is recognition by one's colleagues and peers that an individual has demonstrated professional integrity and competence in their field (ASPRS, 2007). Several existing certification efforts are relevant to community college GST education, including:

- GISCI Professional Certification, a voluntary, self-documented program. No exam is given.

- ASPRS Certification, a voluntary, exam-based process with levels of certification for technologists and scientists.

- Spatial Technology and Remote Sensing (STARS) Certification, a commercial process overseen by Digital Quest, a GST training and development company. It includes a program of study and a competency exam.

These three certification efforts are reviewed and summarized in the issue report on certification on page 35. In Phase One of this study, nearly 60 percent of the respondents believed that higher education should try to align its curriculum with professional certification efforts underway. However, very few faculty are currently doing this, presumably because of limited knowledge of available certification options.

High Priorities

C1. Serve as a repository of certification, accreditation, and licensing program information and help facilitate the dissemination of information to faculty and students.

C2. Evaluate certification options and provide recommendations to students, faculty, and industry about the advantages of each option.

C3. Join organizations that offer GIS/GST certifications in order to provide a unifying voice that represents community college views and interests in existing certification efforts.

Medium Priorities

C4. Form a partnership with geospatial professional organizations (i.e., GITA, URISA, ASPRS) and be the governing organization that works through ABET (Accreditation Board for Engineering and Technology) to create "GIS/geospatial" accreditation criteria.

C5. Work with industry to evaluate certificate programs offered by colleges and disseminate minimum standards for core competencies (those skills that a person performing a task should have) for different certificate unit (semester credit hours) loads (e.g., nine units, 10 to 20 units, etc.).

C6. Provide support for a new overarching national professional organization for spatial sciences practitioners.

Low Priorities

C7. Work with USGIF to create a two-year level accredited geospatial intelligence analyst model course or program.

C8. As new initiatives surface regarding certification or other licensing, provide administrative support for such testing such as proctoring, building tests or setting standards.

Not Recommended

- Become a geospatial technology certification granting organization.

- Be an organization that can provide educators with evidence (certification, certificates or licenses) that they have satisfied the minimum qualifications specific to teaching geospatial technology.

- Serve as an accreditation body for geospatial programs.

D. Curriculum and Pedagogy

A plethora of workforce-aligned GST curriculum has been produced by GST educators, independently and via grant-funded GIS/GST curriculum development projects. However, most community college GST educators are not aware that this curriculum exists, which can lead to a duplication of effort in some subject areas, while emerging subject areas may be overlooked because of time constraints. This concern led participants in the national forum to develop a list of high priority tasks related to management and dissemination of GST curriculum materials, such as compiling and reviewing curriculum materials, helping to identify missing curriculum components, and developing a clearinghouse of curricular components and instructional materials.

High Priorities

D1. Create an online clearinghouse and component management system that optimizes submission, review, and search capabilities of geospatial curriculum materials. *A website based on a component management system allows any registered user to submit materials by uploading files or documents to the web server. These materials would undergo a peer review process before becoming available to other registered users. It should be recognized that in the first three years of the center's existence, the majority of the materials will be submitted by center staff. As the center matures and the clearinghouse becomes more robust, it is expected that more of the materials will be submitted by partners.*

D2. Compile curricular components to post to the clearinghouse such as: a) workforce studies/needs assessments, b) core competencies in the form of learning objectives, and c) instructional materials to support teaching.

D3. Provide the processes and best practices by which a curriculum framework is used to develop a program that meets the local industry needs.

D4. Conduct a gap analysis on curriculum materials to determine missing components.

D5. Provide FAQ (Frequently Asked Questions) on the center web site pertaining to geospatial technical education and the development of curriculum programs.

D6. Create educational experiences that mimic high-performance work environments.

D7. Develop model programs of study that provide guidelines for geospatial associate degree programs.

Medium Priorities

D8. Develop/adapt an introductory course or modules that provide the fundamental (core) geospatial skills as outlined in the BoK (or subsequent improved version of it) that are needed by the mainstream GST workforce.

D9. Compile and make available, as part of the clearinghouse activities, instructional materials that use geospatial technologies to teach concepts of science, math and technology.

D10. Compile and support the development of curricula in technology based applications such as, but not limited to, archeology, agriculture, criminal justice, marine technology, and natural resources.

D11. Support the concept of good teaching and student learning by providing pedagogical standards.

D12. Support the use of pedagogical standards by referencing one of five Standards for Effective Pedagogy for all appropriate instructional materials.[17]

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[17]The Center for Research on Education, Diversity and Excellence (CREDE) lists five Standards for Effective Pedagogy that can serve as good guidelines for enhancing geospatial education:

1. Teachers and students working together—Facilitate learning through joint productive activity among teacher and students.

2. Developing language across the curriculum—Develop competence in the language and literacy of instruction across the curriculum.

3. Connecting school to students' lives—Connect teaching and curriculum to students' experiences and skills of home and community (contextualization).

4. Teaching complex thinking—Maintain challenging standards for student performance; design activities to advance understanding to more complex levels. Challenge students toward cognitive complexity.

5. Emphasizing dialogue over lectures—Instruct through teacher-student dialogue, especially academic, goal-directed, small-group conversations (known as instructional conversations), rather than lecture.
(Center for Research on Education, Diversity and Excellence, 2006)

E. Educational Pathways/Articulation

The need for better articulation and coordination between colleges and universities in geospatial technology education is paramount for building today's global workforce. During the past several years numerous models have been developed to bridge the gap between two-year community college curricula and four-year university curricula.

The main stumbling block to seamless articulation is ensuring that the education received at the sending institution is equal in content, scope, and rigor to that of the accepting institution. Because the schools' respective accrediting agencies will not be satisfied without this, doubt and inaction continue to inhibit the easy transfer of credits from one level to the next. This was shown to be true in this study's Phase One survey, where 72 percent of faculty indicated that they do not have any course-to-course articulation agreements, and supported by recommendations from national forum participants, who prioritized multiple recommendations to clear roadblocks from the articulation process.

High Priorities

E1. Develop an online forum and white paper that discusses strategies for achieving articulation.

E2. Organize, compile, and compare past and future articulation agreements, Memorandums of Understanding (MOU) and other documents nationwide and make the results available on searchable database on the center website.

E3. Develop career pathways that provide guidelines for a seamless education in geospatial technology from secondary to community college to university.

E4. A problem of K-12-community college articulation involves faculty credentials. An NGTC should develop standards to integrate GIS into geography advanced placement (AP) courses and/or College-Level Examination Program (CLEP) courses to overcome the credential issue.

Medium Priorities

E5. Promote articulation through standardized learning outcomes tied to the BoK.

E6. Develop a rubric of geospatial skills tied to the BoK that is linked to each education level. A possible template is *Geography for Life* (Boehm and Bednarz, 1994); see www.hawaii.edu/hga/Standard/Standard.html for an example.

E7. Use the BoK to create equivalencies between freshman and sophomore level courses at community colleges and junior and senior level courses at four-year institutions.

E8. Seek to secure a baseline database of existing geospatial education (programs, faculty/staff, number of students) nationwide. This may be achieved through collaboration with AAG or a similar nationally-recognized effort.

E9. Develop curriculum pathways (core courses and additional course content for specific disciplines) based on the BoK.

Low Priorities

E10. Review and summarize policies of state and regional accrediting agencies to facilitate articulation.

E11. Perform a cost/benefit analysis that would indicate the cost if there were no articulation agreement (credit hours lost and dollar costs) between schools and colleges and universities.

F. Professional Development

The dynamic and evolving nature of geospatial technology dictates a critical need for faculty development. Most community college faculty were educated at a time when GIS was virtually absent from the university curriculum. In the Phase One survey, 84 percent of respondents indicate that their primary means of professional development was self-teaching by reading literature. More than 67 percent do not have membership in a professional GST organization, such as UCGIS, AAG, ASPRS, GITA, NSGIC, Cartography and Geographic Information Society (CaGIS), or Urban and Regional Information Systems Association (URISA). Results of the Phase One survey clearly indicate a high level of interest in and awareness of the need for GST professional

development, but an overwhelming majority cited barriers such as lack of funding, time, available opportunities, administrative support, and the inability to travel long distances.

These barriers are reflected in the recommendations of national forum participants, which focus on an NGTC that helps to organize and disseminate professional development information. For example, 100 percent want an NGTC to maintain an online clearinghouse of information on professional development opportunities, training materials, and other resources.

High Priorities

F1. Organize, compile, and disseminate up-to-date information on professional development opportunities, training materials, tutorials and links to online resources on an NGTC website.

F2. Offer professional development training courses, workshops, and seminars.

F3. Offer geospatial technology professional development in other formats (not face-to-face) such as online tutorials, instructions and data, and podcasts, via its website.

F4. Identify major barriers to professional development through surveys and feedback from community college faculty (e.g. limited funds, inflexible schedules and unappreciative administration), and work to minimize these barriers to increase professional development availability and accessibility.

F5. Keep abreast of GST and make recommendations on the type of professional development faculty should pursue to keep current in their field.

F6. Build partnerships with four-year universities, professional societies, government agencies, industry and NGOs to promote, encourage, and expand professional development opportunities.

G.   Geospatial Community Communication

National coordination of workforce information and educational resources within the community college network is limited because of the lack of an effective communication structure. Without effective communication, GST education is less responsive to workforce needs because it relies on the work of individuals rather than networks to assess workforce needs, modify curriculum, and seek professional development. In many national GST education efforts, the interests of community colleges are under- or unrepresented because of the lack of coordination and communication among community colleges.

In the absence of effective communication networks, the majority of educators attending the national forum say that an NGTC must help with information flow among community colleges and professional societies, regional user groups, government agencies such as DOL and NSF, and other relevant organizations, and thereby serve as a collective voice for community college interests.

High Priorities

G1. Act as the representative body for two-year colleges, faculty, and students in the field of geospatial technology.

G2. Act as a collective voice to promote community college interests in professional societies, workforce-related studies, core curriculum projects, certification and accreditation efforts, and other activities of importance to community college audiences.

G3. Develop a new communication infrastructure to facilitate geospatial information exchange, such as a comprehensive website and e-mail list to facilitate communication.

G4. Provide up-to-date information on current and past geospatial-related NSF ATE projects, ATE Centers, and other NSF Division of Undergraduate Education projects via website and listserv.

G5. Provide latest information on current and past Department of Labor projects via website and listserv.

G6. Seek out the best existing communication network(s) that can be used to improve the flow of information.

G7. Work closely with existing regional hubs to improve communication on a regional level.

H.   GST Awareness and Reaching Underserved Audiences

The time to focus on increasing the diversity of the talent pool is now—the demand for highly-qualified workers in science, technology, engineering, and math (STEM) fields continues to increase, and a large portion of the current STEM workforce is approaching retirement. Recruiting diverse students can be challenging; raising awareness of geospatial technologies is the first step. With the increasing popularity of web-based mapping software, raising the general public's awareness of GST will become easier.

High Priorities

H1.   Promote GST as a mainstream scientific tool for community college education so that GST awareness and education is extended to other academic programs (e.g. economics, history, and biology).

H2.   Disseminate stories of successful geospatial awareness events and identify effective GST education tools, such as Google Earth and the National Atlas web mapping services, for community college GST teachers.

H3.   Provide a comprehensive list of outreach events and marketing materials and make them available online so that community college GST teachers can utilize these resources to promote GST career and technology awareness.

H4.   Identify effective student recruitment approaches for GIS programs in community colleges and disseminate available resources and recruitment tools to community college educators.

H5.   Provide comprehensive information about internship and mentorship opportunities to underserved audiences in community colleges.

H6.   Identify existing successful programs that reach diverse audiences.

Medium Priorities

H7.   Identify effective methods to facilitate the information exchanges and resource sharing for geospatial technology awareness among community college teachers and students. An NGTC can introduce new tools and use new media formats, such as on-line podcasting, multimedia movies, and blogs for GIS awareness.

H8.   Participate in and help coordinate GIS awareness events, such as GIS day and GIS education conferences. An NGTC will encourage GIS teachers in community colleges to coordinate with other agencies for their local GIS awareness event.

H9.   Keep abreast of the social and culture trends in an effort to help bridge inequity gaps in the geospatial technology workforce. The NGTC will post a document of relevant trends on the center web site and update it annually.

H10. Develop a system to evaluate the progress of increasing the number of underserved students in the GIS programs at community colleges.

I.   Role of GST Education in Supporting College Administrative Tasks and Entrepreneurialism

External forces such as decreased state support and declining local tax bases have driven many community colleges to look for new revenue sources (Evelyn, 2004). As a result, community college missions have become more complex as they evolve from reactive organizations to proactive institutions that promote local economic expansion (Grubb, 1997). For the latter, the demand for institutional research—specifically the ability to acquire, manage, analyze, and communicate marketplace data—has never been greater. Because this new way of thinking about college entrepreneurial activity is heavily laden in the demographics and economics of the region, GST can be a useful tool for supporting college administrative tasks such as workforce and economic development, institutional research, grant writing, student marketing, and facilities management. Participants in the national forum made several recommendations related to the growing role of GST in supporting college administrative functions.

High Priorities

I1. Develop a searchable clearinghouse with how-to templates, standard data models, and best practices to duplicate curriculum-driven entrepreneurial activities and experiences linking GST to community college administrative issues. *Many community colleges are working on or planning projects linking community college GST programs with institutional needs relating to data analysis and acquisition. By serving as a single repository for these projects, the NGTC can serve as a valuable dissemination arm for linking community college policy leaders to the potential benefits of the technology. As a result, the NGTC could assist in linking GST to the growing entrepreneurial mission of community colleges and elevate GST as critical decision support tools in managing modern community colleges.*

I2. Coordinate MOUs with government and industry about what community college GST programs can and cannot do to generate income under state law. *Using students to address local or institutional GST needs could cause conflict with regional private sector vendors. To help community colleges ethically and legally leverage project-based learning opportunities within existing and future GST programs, the NGTC will need to coordinate legal and regulatory issues to enable community colleges to elevate their entrepreneurial mission through GST programs.*

I3. Serve as a clearinghouse for geospatial data as it applies to community college demographics, enrollments, economics, etc. *Through a web-based portal, the NGTC will coordinate and develop a one-stop shop for community college data. The portal will allow community college administrators, board members, faculty, local community members and students to visualize and access local and regional information around any community college. The data included should be based upon extensive input from community college policy leaders, allowing the NGTC to design a clearinghouse that best serves the community college system in addressing current and future issues like documenting access, student diversity, grant writing, economic development, and marketing. Services such as this will enable GST to achieve the community college mission and develop a unique niche for the NGTC in promoting long-term sustainability.*

J. Future Trends

As we have seen, the GST industry is rapidly growing and evolving. Two recurring themes emerged in reviewing the various source documents for GST trends. First, because of the evolution of GIS to enterprise GIS[18], it is becoming more important to include information technology instruction within the geospatial curriculum. Second, the need for web-based instruction and data delivery is growing rapidly and cannot be ignored. The issue report on future trends in GST includes in-depth information on these and other upcoming industry changes, such as emerging applications in GIS, remote sensing, GPS, and multi-user GIS servers; the evolution of community college GST education to address these changes; and a discussion of the economic sectors, industries, businesses, government agencies, and research/educational institutions that are driving the tremendous increase in use of GST.

National forum participants were tasked with determining whether an NGTC should serve as a resource on GST trends. They determined that an NGTC can play a valuable role in helping them find, understand, and incorporate information on GST trends.

High Priorities

J1. Assess trends in the geospatial industry in order to project changes in the industry and workforce that impact GST curricula and programs at two-year colleges.

J2. Disseminate the information on trends to two-year colleges via the NGTC website.

J3. Assist community colleges with adapting their curricula to future trends.

Discussion

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[18]Enterprise GIS is an integrated, multidepartmental system composed of interoperable components. It provides broad access to geospatial data, a common infrastructure upon which to build and deploy GIS applications, and significant economies of scale (ESRI, 2007).

Discussion and Conclusion

With nanotechnology and biotechnology, geospatial technology is one of the three most important emerging and evolving fields in this country (Gewin, 2004). The GST workforce is annually growing at a total rate of 35 percent, and 100 percent in the commercial subsection of this market (U.S. Department of Labor, 2005c). This explosive growth is driven by dramatic increases in the capabilities of geospatial tools and the increased availability of high quality geospatial data (Marble, 2006).

However, this high growth rate is not without challenges. The DOL has not been able to keep up with standard industry definitions and occupational titles for the geospatial industry. As a result, GST labor market data is largely aggregated with other fields, making it difficult to define and monitor trends. This also creates problems when trying to prepare a workforce for employment: for which jobs should future workers be educated?

Community colleges and universities traditionally have approached this problem from different perspectives. Community colleges typically take into account the local workforce needs, while universities take a broader view of the science and theory that build the foundation for the discipline. Both approaches have distinct advantages and disadvantages. If not careful, community colleges can train students for a particular job at a particular moment in time; as the field and technology evolve, workers may find themselves "out of a job" unless they have a broad foundation that allows them to learn new knowledge and skills. On the other hand, university students may have a better scientific and theoretical foundation but lack the ability to practically apply this knowledge and the ancillary skill sets that make them employable.

Regardless of their different approaches, both community colleges and universities are hindered by the lack of reliable workforce information identifying knowledge, skills, and aptitudes required for entry-level positions. Furthermore, because of their differing approaches to GST education, the ability of community colleges and universities to communicate with one another is severely hampered without the framework of a common language.

Probably no issue plays a more critical role in creating this framework than the identification of GST core competencies. Core competencies connect job requirements to educational subject areas, making them a critical link between the classroom and the workplace.

Of the ten issues examined in this study, the identification of core competencies is essential to addressing many of the other issues, including workforce needs, certification, curriculum development, educational pathways and articulation, and professional development.

The quest to define core competencies has made substantial progress but is far from complete. The national adoption of core competencies has the potential to yield a multitude of benefits: efficient curriculum sharing, benchmarks for program accreditation, widespread articulation, exam-based professional certification, and effective screening and placement of new workers. However, to realize these benefits, core competencies must be accepted by two- and four-year institutions and validated by working professionals.

Three efforts have made progress in this area—the UCGIS BoK; the GeoWDC Geospatial Technology Competency Model; and a series of DACUMs, including the Texas GIS Technician Skill Standards, which were derived from the DACUM process. In addition, many activities that meld workforce and educational efforts are in progress. For example, a GISCI survey of certified GIS professionals assesses their views on the BoK; a USGIF program accreditation uses portions of the BoK; a GITA study made recommendations for improving the GeoWDC Geospatial Technology Competency Model; and efforts associated with this study examined four DACUMs for common tasks and to determine how they align with the BoK. (See the issue report comparing four DACUMs on page 31).

However, any efforts to tie together workforce and educational information must be done in a framework that sits within a clearly defined geospatial industry sector. For example, many of the GITA's recommendations highlight the need for defining the geospatial industry sector, including standard definitions for the geospatial industry sector, new occupational titles, and a rational for market segmentation. Indeed, many organizations have developed new competency-related frameworks and many agencies have funded these efforts (NSF, DOL, NASA, etc.). An NGTC must work with and connect existing competency-related efforts so that core competencies, and in turn a core curriculum that supports multiple entry-level positions, can be established and agreed upon by a wide range of stakeholders. Because community colleges and universities traditionally approach the content of a curriculum from different perspectives, understanding and compromise are needed to move forward. The consequences of not

coming to an agreement will only contribute to greater gaps between what the workforce needs and what the educational system is producing.

This study has made every effort to reach broadly and be inclusive across disciplines—including new and experienced GST faculty in rural and metropolitan regions across the country—to best represent the collective view on the potential role of an NGTC in coordinating GST education at the community college level and facilitating dialogues with industry, professional societies, and four-year universities. More than 92 percent of the community college educators who responded to the Phase One survey felt there should be a national organization that represents community college interests relating to geospatial technologies. As to what an NGTC should accomplish, the following three recommendations received the highest rating, with more than 75 percent of the survey respondents rating them as high priorities:

- An NGTC should provide a means by which geospatial educators can search and retrieve curriculum, instructional materials, and workforce information online.

- An NGTC should organize, compile, and disseminate up-to-date information on professional development opportunities, training materials, tutorials, and links to online resources on an NGTC website.

- An NGTC should act as the representative body for two-year colleges, faculty, and students in the field of geospatial technology and act as a collective voice to promote community college interests with professional societies, higher education, the DOL, and other organizations concerned with GST education.

As important as what it should do is what an NGTC should not do. National forum participants felt strongly that an NGTC should not be:

- A geospatial technology certification granting organization.

- An organization that provides educators with evidence (certification, certificates or licenses) that they have satisfied the minimum qualifications specific to teaching geospatial technology.

- An accreditation body for geospatial programs.

These recommendations make clear that community college educators want an NGTC that will represent them at national venues; act as a clearinghouse for easily accessible information on current curriculum and workforce information; and provide access to professional development opportunities.

The NSF funded one of multiple collaborative proposals submitted to develop an NGTC. The proposed National Geospatial Technology Center of Excellence (NGTCe) will be housed at Del Mar College in Corpus Christi, TX. The NGTC collaborative consists of: Lake Land College (Matoon, IL), San Diego State University, Kentucky Technical and Community College System, Southwestern Community College (Chula Vista, CA), Gainesville State College (Gainesville, GA), Central Piedmont Community College (Charlotte, NC), Century College (White Bear Lake, MN), and Niagara County Community College (Sanborn, NY). Industry partners include ESRI, Inc. The center's future website will be located at www.geotechcenter.org.

In addition, the State of California funded an 18-month grant titled California Community College Geospatial Information Support (C3GIS, www.c3gis.net), that drew on this study and incorporated a number of the recommendations found in this report. The C3GIS effort, while not as comprehensive as an NGTC, will test some methods for addressing the recommendations made by this study.

Conclusion

GST is a rapidly growing and changing industry that is transforming many sectors of the economy. The speed at which new fields are adopting GST and the rate at which equipment and software are modified and updated make it difficult for many industries, much less the educational system, to keep up to date. To further complicate the issue, national coordination of workforce information and educational resources within the community college network is fairly poor. For the U.S. to remain economically competitive, achieve greater understanding in protecting our resources, and reduce the chaos and loss of life associated with manmade and natural disasters, we need an efficient, responsive, and well-coordinated GST educational system with good communication among all levels and a better understanding of the knowledge and skills workers need to be successful in the workplace.

A Plan for the National Coordination of Geospatial Technology Education from a Community College Perspective is an effort to document the issues, needs, and concerns of community college educators and produce recommendations for an NGTC that best reflect their needs, while placing the recommendations within the context of the work that has been accomplished by the DOL, higher education, and other organizations relating to professional certification and accreditation. It is essential that some organization, presumably an NGTC, end the community college silence and act as a collective voice on behalf of community college interests in GST issues and activities of national importance. An NGTC will play an indispensable role in furthering the advancement of GST education.

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Systematic Curriculum and Instructional Development (SCID) Model for GIS

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Overview

In 2005, San Diego Mesa College was awarded a National Science Foundation (NSF)-Advanced Technology Education (ATE) grant to develop a Scalable Skills GIS Certificate Program. The goal of this project was to update the College's GIS curriculum to address the workforce needs of the GIS industry in San Diego County. The Systematic Curriculum & Instructional Development

Model, or SCID was used as a framework for this project. The model provides a detailed structure for designing, developing, implementing, and evaluating a skills-based curriculum. This methodology was developed by Dr. Robert Norton, from the Center on Education and Training for Employment at Ohio State University (www. dacumohiostate.com) and is outlined in the following illustration:

Figure 1. Major Components of the Systematic Curriculum and Design Model
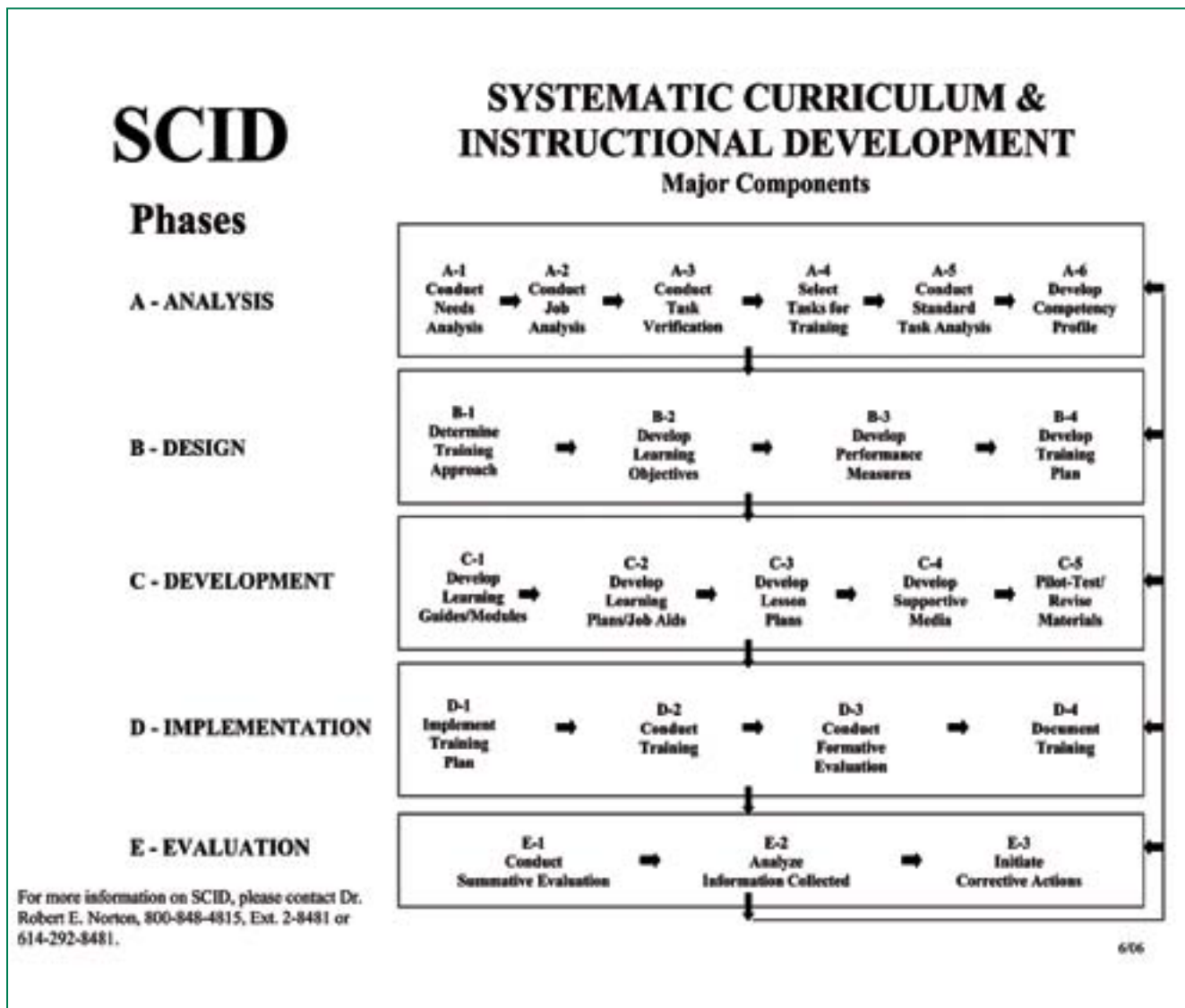
DACUM Job Analysis. This SCID model begins with a needs assessment, which at San Diego Mesa College was completed in 1999, prior to the creation of the GIS program. This was followed in 2005 by a DACUM Job Analysis. DACUM, an acronym for Developing a Curriculum, is an effective and widely used method of job or occupational analysis. The job analysis involved a two-day brainstorming workshop in which a focus group of 11 GIS technicians and a trained DACUM facilitator produced a chart that summarized the core duties, tasks and related competencies of an entry-level GIS technician in San Diego County (see sample below). This document forms the basis of Mesa College's "skills-based" curriculum.

Figure 2. Results of DACUM Job Analysis for a GIS Technician

DACUM Research Chart for GIS Technician

Duties	Tasks									
A Create / Acquire GIS Data* (3)	A-1 Define data requirements (C)	A-2 Research available data (C)	A-3 Purchase new data	A-4 Develop databases (e.g. define geometry, attributes) (C)	A-5 Define feature relationships/ behaviors (e.g. relate tables, relationship classes) (C)		A-6 Define feature behaviors (e.g. sub-types & domains) (C)	A-7 COGO legal descriptions (E)	A-8 Perform tablet digitization (E,C)	A-9 Perform "heads-up" (on-screen) digitization (E,C)	A-10 Geocode data (E,C)
A Create / Acquire GIS Data* (3) continued	A-11 Determine data compatibility (e.g. projections) (E,C)	A-12 Perform data conversions (e.g. between formats) (E,C)	A-13 Populate GIS feature attributes (E,C)	A-14 QA/QC data (E,C)	A-15 Create metadata (E,C)	A-16 Collect field location data via GPS (E,C)	A-17 Collect field attribute data (E,C)			
B Create Image Data	B-1 Scan hard copy images (E,C)	B-2 Georeference digital imagery (C)	B-3 Rectify images (C)	B-4 Perform image analysis (e.g. classification) (C)						
C Maintain GIS Data* (1)	C-1 Develop a data maintenance schedules	C-2 Develop GIS procedures (e.g. to update data)	C-3 Edit GIS data (e.g. add, delete, update) (E,C)	C-4 QA/QC data (E,C)	C-5 Refresh/ replace layers (e.g. imagery, thematic layers) (C)	C-6 Convert between data formats (C)	C-7 Conduct database performance tuning (e.g. compress, build stats, index)	C-8 Update metadata (E,C)		
D Conduct Spatial/ Non-spatial Analysis (4) (Vector, Raster)	D-1 Create Models (e.g. process & scientific models, flow charts) (C)	D-2 Create scripts (C)	D-3 Pre-process Data (e.g. generalize, subset) (C)	D-4 Conduct Geoprocessing (e.g. clip, buffering, overlay, run models) (C)		D-5 Generate statistics (e.g. descriptive, spatial) (C)	D-6 QA/QC Data (C)	D-7 Interpret Results (C)		
E Generate GIS Products* (2) (hard copy, electronic)	E-1 Create maps (E,C)	E-2 Create analysis reports (E,C)	E-3 Create charts (E,C)	E-4 Create tables (E,C)	E-5 Generate mailing labels (E,C)	E-6 Create graphic items (e.g. logos, headers, posters, exhibits) (E,C)	E-7 Distribute digital products (E,C)	E-7 Distribute hard copy products (E,C)		
F Develop Software Applications	F-1 Define user software needs (C)	F-2 Determine application design format (e.g. platform, language)	F-3 Develop software applications	F-4 Customize commercial software (C)	F-5 Create map templates (C)	F-6 QA/QC software applications (e.g. beta test) (C)	F-7 Build help files	F-8 Enhance existing custom applications		
G Manage GIS Data	G-1 Establish data custodianship (C)	G-2 Organize file structure (e.g. create directories, perform data and directory housekeeping) (C)	G-3 Archive / retrieve data (E,C)	G-4 Back-up / restore data (E,C)	G-5 Distribute data according to organizational policy (E,C)	G-6 Assign data/database permissions				
H Provide Technical Support*	H-1 Resolve user technical problems (C)	H-2 Install Software (e.g. enhancements, service packs) (C)	H-3 Write Technical Guides (C)	H-4 Train GIS end-user(s) (C)						
I Perform Administrative Tasks*	I-1 Correspond with others (e.g. email, mail, phone) (C)	I-2 Write informational reports (e.g. progress, technical, procedural, recommendations) (C)	I-3 Prepare cost estimates (e.g. time, equipment) (C)	I-4 Coordinate GIS projects (C)	I-5 Represent GIS at meetings (e.g. committees, user groups, organizational conferences) (E,C)		I-6 Maintain equipment/ supplies) (E,C)	I-7 Maintain contracts (E)	I-8 Supervise Interns (C)	I-9 Participate in public relations activities (E,C)
J Pursue Professional Development	J-1 Participate in professional conferences (e.g. oral, poster submissions, publish/ submit articles) (E,C)	J-2 Participate in GIS user groups (E,C)	J-3 Take advanced training courses (e.g. technical training & education courses) (C)	J-4 Cross-train within organization (C)						

General Knowledge

GIS Principles, Word Processing, Office Applications, Geometry, Trigonometry, Mathematics, Statistics
Current GIS software: (MapInfo, SmallWorld, ArcGIS, ArcView, GeoMedia), Cartographic principles, Image processing (ERDAS),

Photogrammetry, Programming languages (VBA), Land surveying, GPS, Reading engineering-grade plans, Databases, Census data, Windows operating system, General Geography, Data exchange procedures

Skills

Multi-tasking, Resourcefulness, Oral Communication, Writing, Technical writing, Printing legibly, Presentation, Cartographic Design, Analytical, Organizational, Time Management, Team Player, Ability to work independently, Facilitation, Computer, Network configuration, Data entry, Keyboarding

Worker Behaviors

Initiative, Mentor, Sense of humor, Adaptability, Self-disciplined, Ethical, Willingness to learn, Self-motivated, Punctual, Organized, Detail-oriented, Open-minded

Tools, Equipment, Supplies and Materials

Plotters, Printers, Scanners, P.C.s, Calculators, Engineering/Architectural scales, Servers, GPS (Trimble-GeoXT, Sokkia-GR 1000, Static or RTK), Laptops, Tablet PCs, PDA, Pocket PC, Digitizer, Total Station,

GIS Software: (ArcGIS, ArcIMS, ArcSDE, ArcPad, ArcGIS Extensions, Workstation ArcInfo, SmallWorld, MapInfo), MS Access, Auto CAD, Micro Station, IRASC, ERDAS Imagine, MS Office, MS Frontpage, Dreamweaver, Adobe Illustrator

Future Trends and Concerns

Dominance of ESRI, lack of competition, Rapidly changing technology, Explosion of data, Public access to data, Security restrictions on data,) Trend toward licensing & certification,

Need for on-going training, Mobile computing (remote access), Data standardization, Integration of software, Decentralization of GIS, End user Web applications, Data integration tools (GeoMedia)

It is interesting to note that graduates of Mesa's GIS Certificate Program will be working in positions similar to those held by members of the DACUM panel of GIS technicians. As indicated in Table 1, all but one of these technicians have undergraduate degrees in geography or a related field and two have master's degrees. In addition, most have supplemented their formal education by completing related certificates and ESRI classes. This indicates that, for many panel members, a GIS certificate serves to complement their university degree in geography. A skills-based GIS certificate program can therefore enhance the more comprehensive and theoretical geographic education that many students receive at a university.

Task Validation. The next step was to validate the results generated by this panel by surveying an additional 150 GIS professionals, asking them to place themselves in the role of a GIS technician and rate each of 74 tasks according to the following criteria:

1. Do you perform this task?
2. How important is this task in the performance of your job as a GIS technician?
3. What is the learning difficulty of this task?
4. Is this required at entry level?

This process generated consensus on important, difficult-to-learn tasks that are performed by entry-level GIS technicians. These tasks were given a high ranking and subsequently included in the new curriculum. Tasks with a lower ranking on these four criteria were either left out of the curriculum or placed in classes that are not required for GIS certification.

Task Analysis. Once the core job tasks were identified they were evaluated through a process known as task analysis. This involved breaking each task into a series of steps. Each step was then defined according to measurable performance standards, necessary tools and equipment, as well as other related resources (e.g. books, websites, data).

Training Approach. Following task analysis, the next step was to determine a training approach. The San Diego Mesa College GIS Program chose to implement a "competency-based" training approach that requires:

- Competencies be made public
- Clear criteria for assessment
- Different learning styles and abilities are accommodated
- Task performance is primary method of assessment
- The ability for learners to progress at their own speed

Learning Objectives. With this approach in mind, the next step involved developing a series of learning objectives and activities that would help train students to perform specific tasks. There are two types of learning objectives:

Table 1. DACUM Focus Group Members

	Name	Title	Years in postion	Organization	Education	Additional Traning & Certificates
1	Nancy Ross	GIS Specialist – Mgmt Info. Services	12.5 yrs	City of Chula Vista	BA - Planning, UCSD	Multiple ESRI Courses
2	Drew Dowling	GIS Analyst	2 yrs	SanGIS	BS - Earth Science, USC	ESRI course in ArcObjects
3	Colleen Larsen	GIS/Mapping Specialist II	6 yrs	Padre Dam Water Dist.	BS - Geography	ESRI & Bentley Certificates in CAD & GIS
4	David Hulten	GIS Technician	1 yr	City of Encinitas	BA - Geography	None
5	Dennis Larson	Senior GIS Technician	1 yr	SANDAG	BA - Geography, SDSU MA - Economics	GIS Certificate, SDSU
6	Sue Carnevale	Senior Regional Planner/GIS Analyst	24 yrs	SANDAG	BA - Geography, SDSU	ESRI GIS courses
7	Jason McNeil	GIS Technician II	3 yrs	City of Escondido	BS - Geography/GIS	ESRI training
8	Melanie Casey	GIS Analyst	6.5 yrs	County Plan & Land Use	BA - Geography	GIS Certificate
9	Fred McCamic	GIS Analyst	5 yrs	County Public Works	BA - Math, MA – Plan.	GIS Certificate
10	Gina Durizzi	Principal Survey Aide/ GIS Coordinator	5 yrs	City of San Diego, Waste Water	BA - Geography	GIS Certificate, ESRI training, Microstation, Land Survey Training
11	Lisa Canning	Senior Engineering Aide, MWWD	2 yrs	City of San Diego, Waste Water	Student Landscape Architecture	UCSD Graphic Design Extension ¾ certificate, ESRI courses

Table 2. Task Validation Results

Results of Task Verification Survey
GIS Technician
San Diego Mesa College, Sept. 2005

	Perform	Importance	Learning Difficulty	Required	Overall	Include in Curriculum
Duty E: Generate GIS Products (hard copy, electronic)						
E-1 Create maps	98%	93%	64%	98%	88%	Y
E-4 Create tables	79%	77%	59%	89%	76%	Y
E-8 Distribute hard copy products	84%	76%	50%	80%	72%	Y
E-7 Distribute digital products	77%	73%	53%	66%	68%	Y
E-3 Create charts	65%	67%	57%	80%	67%	Y
E-2 Create analysis reports	68%	73%	70%	57%	67%	Y
E-6 Create graphic items (e.g. logos, headers, posters, exhibits)	73%	64%	57%	60%	64%	Y
E-5 Generate mailing labels	49%	52%	43%	63%	52%	Y
Summary; Duty E	**74%**	**72%**	**56%**	**74%**	**69%**	
Duty F: Develop Software Applications						
F-5 Create map templates	73%	69%	63%	78%	70%	Y
F-6 QA/QC software applications (e.g. beta test)	52%	51%	70%	43%	54%	Y
F-1 Define user software needs	43%	55%	71%	19%	47%	Y
F-4 Customize commercial software	34%	57%	78%	10%	45%	Y
F-7 Build Help files	31%	44%	64%	35%	44%	N
F-8 Enhance existing custom applications	33%	46%	79%	10%	42%	N
F-3 Develop software applications	23%	49%	80%	9%	40%	N
F-2 Determine application design format (e.g. platform, language)	29%	50%	75%	4%	39%	N
Summary: Duty F	**40%**	**53%**	**73%**	**26%**	**48%**	
Duty G: Manage GIS Data						
G-2 Organize file structure (eg create directories, perform data/directory housekee	82%	80%	55%	69%	71%	Y
G-3 Archive / retrieve data	79%	70%	50%	68%	67%	Y
G-4 Back up / restore data	61%	69%	51%	60%	60%	Y
G-5 Distribute data according to organizational policy	60%	64%	46%	62%	58%	Y
G-1 Establish data custodianship	37%	60%	63%	28%	47%	Y
G-6 Assign data/database permissions	34%	56%	60%	6%	39%	N

Table 3. Task Analysis Results

STANDARD TASK ANALYSIS FORM		5/11/08 Validation Rating 63%		Duty A: Create/Acquire G Task: A16 - Collect Field Loc
	STEPS (necessary for performing task)	**PERFORMANCE STANDARDS (Observable & Measurable Criteria)**	**TOOLS, EQUIPMENT, MATERIALS & SUPPLIES**	**RELATED RESOURCES (e.g. articles, books, websites, data, exercises**
	Observe demonstration of GPS setup, GPS menus, satellite constellation, scale, zoom, pan, compass direction functionality, and data collection	Complete questions on key points of GPS use	Garmin GPS Map 60, software and cables; Google Earth Plus or higher	Introduction to GPS Using ArcPad 6.0; http://www.ca.uky.edu/mueller/pls468g/gis/gps_module.pdf Student handout of relevant directions for activities performed in this exercise and/or Garmin instruction booklet and/or digital direction file (including menu navigation, preferred coordinate system, and data collection techniques)
	Receive GPS units and prepare GPS units for use according to GPS instructions	Demonstrate correct GPS setup according to instructions, including coordinate system 6/26/08		Reference online resources, books, articles
	Receive description of features for which data will be collected (eg: signs, plants, benches, etc.			
	Collect waypoints outside of classroom for these features, with minimum of 4 satellites distributed evenly (PDOP??)	Record satellite strength and positional accuracy from GPS		
	In classroom observe demonstration of Garmin software, displaying data in Google Earth and download and export of data to shapefile	Answer questions on key points concerning data downloading and exporting		
	Connect GPS to classroom computer using Garmin cable	Window display demonstrates that GPS is properly connected		
	Display GPS data in Google Earth and evaluate accuracy	Observe locational accuracy of waypoints		
	Use Garmin software to export data in shapefile format	Shapefile saved to drive		Imagery of Mesa Cllege campus
	In ArcGIS display shapefile with campus imagery and streets	Create ArcMap layout demonstrating principles of cartography		

performance and enabling. A performance objective specifies the final outcome sought by an instructional activity while an enabling objective is a smaller component that contributes to the achievement of a performance objective.

Examples are as follows:

Sample Performance Objective: Given a Garmin GPS Map 60 and ArcGIS, collect waypoints for on-campus drinking fountains and display these on a cartographically-

Figure 3. Sample Performance Objective

Sample Performance Objective: Given a Garmin GPS Map 60 and ArcGIS, collect waypoints for on-campus drinking fountains and display these on a cartography correct map along with buildings, parking lots and other relevant features.

Sample Enabling Objective: gain knowledge of: (1) Garmin GPS Map 60; (2) cartography; (3) data transfer to ArcGIS

Performance Measures: Performance measures were also developed. These serve as assessment instruments for evaluating the skill, knowledge, and attitudes of students.

III. Performance Test

LEARNER'S NAME:	DATE: / /

COMPETENCY: B-1: Join Tables	Test Attempt 1st 2nd 3rd

Directions: Your facilitator will provide you with the necessary tooling and equipment. You are to complete the join as required. Your facilitator will evaluate your performance using the criteria listed below.	**OVERALL EVALUATION**	
	Level Achieved	**PERFORMANCE LEVELS**
		4 – Can perform this skill without supervision and with initiative and adaptability to problem situations.
		3 – Can perform this skill satisfactorily without assistance or supervision
		2 – Can perform this skill satisfactorily but requires some assistance and/or supervision.
		1 – Can perform parts of this skill satisfactorily, but requires considerable assistance and/or supervision.
	Instructor will initial level achieved.	

Directions: Your facilitator will provide you with the necessary tooling and equipment. You are to complete the production run as required. Your facilitator will evaluate your performance using the criteria listed below.

PERFORMANCE STANDARDS For acceptable achievement, all tasks must be awarded a "Yes" or an "N/A" response.	Yes	No	N/A
While completing the table join, the learner…			
1. Saved spreadsheet as a database (.dbf) file			
2. Added Shape File & database file to data frame			
3. Joined tables based on a common field			
4. Displayed information from database file on map			

Training Plan: A training plan that outlined what needed to be done before the program could begin to move forward was developed. This included staffing requirements, facility needs, tools, equipment and supplies, budget and curriculum and instructional materials.

correct map along with buildings, parking lots and other relevant features.

Sample Enabling Objective: gain knowledge of Garmin GPS Map 60, cartography, and data transfer to ArcGIS.

Performance Measures. Performance measures were also developed. These serve as assessment instruments for evaluating the skills, knowledge, and attitudes of the students.

Training Plan. A training plan outlined what needed to be done before the program could move forward. This included staffing requirements, facility needs, tools, equipment and supplies, budget and curriculum, and instructional materials.

Competency Profile. A competency profile links the various training activities with tasks selected to be included in the training program. This ensures that all the critical tasks are addressed by one or more training activities.

Learning Guides. Competency-based education depends heavily on quality instructional materials. Learning guides should be developed for each task or group of tasks. These are short documents which provide a general overview of how the learner will gain competency with the subject task. They are not to be confused with learning modules, which are more comprehensive and contain all the information necessary for the learner to achieve competency with a task.

Learning Aids/Job Aids. In addition to learning guides and modules, learning aids and job aids should also be considered. These are short documents that briefly describe the steps necessary for achieving mastery of a job task.

Lesson Plans. Although most educators have their own interpretation of what constitutes a lesson plan, all will agree that it is a necessary part of conventional instruction. The lesson plan outlines where you're going, how you're going to get there and how you know when you've arrived.

Evaluation. After the training program has been launched, it will be important to continually evaluate its relevance and effectiveness over time. This can be done by monitoring student job placements, updating the DACUM chart and seeking regular feedback from industry advisors. Updates and modifications to the curriculum should continue throughout the life of the program to ensure that it adapts to changes in technology as well as workforce and employer needs.

Conclusion

San Diego Mesa College is relying upon the DACUM/SCID curriculum development process to upgrade the quality of its GIS Certificate program and develop a skills-based GIS curriculum. The DACUM/SCID curriculum development process proved to be an effective and logical way of identifying the critical skills required for students in the field of GIS and translating them into a curriculum. Core skills, based directly on input from industry representatives, were scientifically validated, ranked, and analyzed to create a DACUM chart that forms the foundation of the new curriculum.

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Comparison of DACUM Charts for GIS

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Overview

This paper reviews and compares four job analyses or DACUMs in terms of tasks related to the duties of a GIS technician/analyst/specialist. To our knowledge, no one has compared these DACUMs to assess their similarities and differences.

- Is there significant overlap among the DACUMs?
- Is there a core set of tasks that are common to all?
- Are more studies needed? Do the results simply need to be better synthesized and disseminated?
- Should workforce studies be conducted in a different way in the future to make the results more useable?

Based upon the results of these reviews and comparisons, a recommendation will be made on how an NGTC should proceed in attaining, evaluating, and disseminating workforce information.

Background Research

The four DACUMs used for comparison are listed in Table 1. While each is clearly focused on the tasks involved in training the geospatial worker, differences in worker categories targeted by these studies seem to outweigh the similarities. Two studies target the GIS technician, presumably a lower-level worker focusing more on data creation and manipulation than on analysis or project management. One targets both the GIS technician and analyst, combining jobs that are often quite different, and raising the question of exactly how a technician differs from an analyst. The GIS specialist is targeted by one study, and is defined as "A scientifically-trained, multi-disciplined individual who applies sophisticated computer hardware and software to collect, store, retrieve, process and present geographic information." Absent from this definition is the term "analysis," implying that the specialist is similar to the technician. Clearly, there is

Table 1. DACUM Charts for GIS

Producer	Title	Date	Source of Funding/Sponsor	Scope of Content	Participants
Mesa College; San Diego State University; San Diego City Schools	DACUM Research Chart: GIS Technician	9/05	NSF Advanced Technology Education (ATE)	Primarily City and County Government	1 Engineering Aide; 1 Regional Planner/GIS Analyst; 3 GIS Analysts; 1 Survey Aide/GIS Coordinator; 3 GIS Technicians; 1 GIS/Mapping Specialist; 1 GIS Specialist
Northwest Center for Sustainable Resources	DACUM Research Chart for GIS Specialist	4/97	NSF ATE; Grape Harbor College	Primarily County Government and Natural Resources	Unknown
Center on Education and Training for Employment, College of Education, The Ohio State University	DACUM Chart for GIS Technician/Analyst	11/02	NSF Division of Undergraduate Education (DUE); The National Center for Agriscience & Technology Education, Kirkwood Community College	Agriculture	1 VP of Operations; 1 GIS Lab Assistant; 1 GIS Mapping Specialist; 1 GPS/GIS Specialist/Analyst; 1 Lab Technician
Southern Maine Technical College	Geographic Information Systems Technician DACUM	8/96	The Advanced Technology Environmental Education Center, Iowa; NSF Northeast Partnership for Environmental Education	Assumed General	1 AM/FM/GIS Manager; 5 Unknown

room for more precise definitions of these worker categories.

The participants involved in these studies are also quite disparate. Two studies employed fairly diverse groups of workers, including GIS analysts, technicians, specialists, and aides—groups that are most likely directly involved in performing GIS tasks. Another employed a GIS administrator, coordinator, and manager—individuals who are likely to be somewhat removed from hands-on GIS work. One study did not reveal the positions of its participants.

The scope of content also varies considerably between these studies. Two studies appear to place an emphasis on county government, one specifically on agriculture, and one on the general application of GIS technology. Dates of the studies range from 1996 to 2005, and all were funded in part by the National Science Foundation (NSF).

In our opinion, the most comprehensive DACUM was produced by the Northwest Center for Sustainable Resources (NCSR) in 1997. This study identifies a total of 100 GIS-related tasks, organized into the following 11 duties:

1. Data acquisition and development
2. Maintain and update data
3. Paper mapping design and development
4. GIS and remote sensing analysis
5. Application development
6. Document data
7. Database design
8. Information sharing and data exchange
9. Training and education
10. Project management
11. System administration and hardware software integration

Because of its breadth and detail, the NCSR DACUM was selected as the benchmark for comparing the four DACUMs. For each NCSR task, a corresponding task was sought from each of the remaining three DACUMs, without regard for the duty that the tasks were categorized under. In some instances, two or more DACUMs shared identical tasks, such as "create metadata." More commonly, similar tasks from two or more DACUMs were described using differing terminology, such as "communicate with peers" and "correspond with others." Tasks were considered to be identical in such cases. Some liberty was taken when comparing a general task with a more specific task, such as "perform buffer analysis" and "conduct geoprocessing." Tasks were typically considered to be the same in such cases.

Various cardinalities were identified when comparing tasks in the NCSR DACUM and the remaining three. The most common cardinality was one-to-one, in which a single NCSR task matched a single task in one of the other three DACUMs. One-to-many cardinalities also occurred, in which a single NCSR task corresponded with several tasks in one of the other DACUMs. For example, the NCSR task "capture spatial and attribute data" matched up with five tasks in the San Diego study: "perform tablet digitization," "perform heads-up digitization," "collect field location via GPS," "collect field attribute data," and "populate GIS feature attributes." This is another example of a case in which a very general task was considered to be equivalent to a more specific task (several more specific tasks in this case). Differences between the generality/specificity of tasks were quite large at times. A cardinality of many-to-one also existed in some cases. In other words, several related NCSR tasks sometimes corresponded with a single task in one of the other DACUMs. For example, the NCSR tasks "define purpose and use of maps," "design layout," "determine appropriate scale," "determine appropriate fonts and colors," and "recognize cartographic conventions," equated to the single task of "create maps" in another DACUM.

Commonalities of tasks were tabulated and converted to percentages. A 100 percent commonality indicated that a particular task was identified in all four DACUMs. A 75 percent commonality indicated that a task was identified in the NCSR DACUM and two additional DACUMs; a 50 percent commonality indicated that a task was identified in the NCSR DACUM and one additional DACUM. If a task was identified only in the NCSR DACUM, a minimum task commonality of 25 percent resulted. The average commonality for all tasks combined was just 55.5 percent, indicating that the four DACUMs are only very slightly more similar than they are different. Only nine of the 100 tasks identified in the NCSR DACUM were common to all four DACUMs:

1. Capture spatial and attribute data
2. Design layout
3. Determine appropriate fonts and colors
4. Determine appropriate scale
5. Determine data needs/format
6. Evaluate sources
7. Integrate data from various sources into consistent format
8. Perform vector/raster overlay analysis
9. Verify content and spatial accuracies

The nine common tasks are associated primarily with the duties of data capture and integration, cartography, and spatial analysis.

Fully 26 of 100 tasks received a commonality of 25 percent, indicating that these tasks were common only to the NCSR DACUM and not identified elsewhere. Nine non-overlapping tasks were drawn from the "system administration and hardware software integration" duty, representing the largest number of non-overlapping tasks from a single duty category. The second largest number of non-overlapping tasks is directly related to remote sensing, as opposed to GIS (three tasks). These non-overlapping tasks are:

1. Adhere to policies for sharing and receiving data
2. Assess client needs
3. Classify remote sensing data
4. Comply with software licensing agreements
5. Determine appropriate projections

6. Determine programming tools required to develop applications
7. Develop orthophotography
8. Develop policy for sharing data
9. Disseminate information through a website
10. Evaluate user needs
11. Export data in transferable format
12. Gather data for updates
13. Georeference imagery
14. Import data into existing GIS
15. Let users and data custodians know that updates are completed
16. Maintain compatibility between system components
17. Maintain hardware maintenance agreements
18. Maintain peripheral compatibility
19. Maintain system security
20. Procure new technologies
21. Provide post-training support
22. Schedule multi-tasking of equipment
23. Select system design
24. Support application
25. Update and maintain application
26. Verify accuracy of imported data

It can be argued that system administration and remote sensing tasks should not be included in a GIS DACUM, and that the overall percentage of task commonality would increase in their absence. In fact, if all system administration and remote sensing tasks—even those few that were shared with other DACUMs—are removed from consideration, the overall percentage of commonality increases to just 59.8 percent. Again, similarities between these four DACUMs outweigh differences by a seemingly insignificant margin.

Is there significant overlap among the DACUMs? The answer appears to be no. Results would likely vary if a greater number of DACUMs was compared, but we suggest that there are simply too many variables that prevent the emergence of a large, coincident body of GIS tasks. These variables include the type of geospatial worker being targeted, definitions of worker types, make-up of participants, scope of content (general or focused on a particular field), and detail of the study.

Is there a core set of tasks that is common to all? Yes, but it is small— only nine tasks were common to all four DACUMs. These tasks are associated primarily with the duties of data capture and integration, cartography, and spatial analysis. While these tasks do seem to reflect com-

mon GIS activities, we suggest that other common tasks are conspicuously absent. Are tasks related to projections, data classification, and database management not core?

Are more studies needed? Do the results simply need to be better synthesized and disseminated? Should workforce studies be conducted in a different way in the future to make the results more useable? Surely, further studies will be needed, but we argue that the extreme breadth of the technology might prove the goal of a unified DACUM for all possible GIS applications to be unattainable. It is our hope that as more DACUMs are produced, a larger set of core tasks will emerge that might form the basis of all GIS DACUMs. It seems unlikely that tasks outside the core will become standardized, and directly applicable to all possible domains.

Conclusion

In our opinion, a new geospatial technology resource center should proceed in collecting and comparing GIS DACUMs in an attempt to identify and expand this core set of tasks. This core can act as a seed for future DACUMs, but non-core GIS tasks will likely remain unique to individual disciplines and applications.

We did not identify significant areas of overlap between the DACUMs we studied. Results would likely vary if a greater number of DACUMs would be compared, but we suggest that there are simply too many variables that prevent the emergence of a large, coincident body of GIS tasks. These variables include the type of geospatial worker being targeted, definitions of worker types, makeup of participants, scope of content (general or focused on a particular field), and detail of the study.

There is a small core set of tasks that are common to all the DACUMs we studied. These tasks are associated primarily with the duties of data capture and integration, cartography, and spatial analysis. While these tasks do seem to reflect common GIS activities, we suggest that other common tasks are conspicuously absent. It is our hope that as more DACUMs are produced, a larger set of core tasks will emerge that might form the basis of all GIS DACUMs. It seems unlikely that tasks outside the core will become standardized, and directly applicable to all possible domains.

We suggest that a key role of an NGTC should be to thoroughly research former DACUMs and to subsequently organize, compile, and compare them—a role that is supported by the majority of respondents to the validation survey. We also recommend that an NGTC encourage partner organizations to perform new DACUMs.

Geospatial Technology Certification and Accreditation

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Overview

Certification is the formal recognition by one's colleagues that an individual has demonstrated professional competence in their field (American Society of Photogrammetry and Remote Sensing, 2007). The benefits of certification include the designation of a professional body of knowledge that provides the foundation for the accepted standards for determining someone's qualification. This can aid in the evaluation of job applicants, employees, and peers; broaden career opportunities for the certified professionals; encourage professional development and advancement; establish standards of professional practice and ethical conduct; and increase awareness, understanding and confidence in the use of products and services of certified professionals.

There are several ongoing geospatial technology (GST) certification efforts: American Society for Photogrammetry and Remote Sensing (ASPRS) Certification, Spatial Technology and Remote Sensing (STARS) from Digital Quest, and the GIS Certification Institute (GISCI) GIS Professional Certification. Additionally, United States Geospatial Intelligence Foundation (USGIF) Academy is undertaking an accreditation project.

In the survey of 170 educators in the first phase of this study, nearly 60 percent believed that higher education should try to align its curriculum with professional certification efforts underway. However, very few faculty are doing this because of their lack of understanding of the available certifications and the appropriateness of GST-related certifications for community college audiences. This issue report is an attempt to raise the awareness of existing GST-related certifications and begin the discussion on their appropriateness and shortcomings for community college audiences. This report also examines how existing certification and accreditation efforts are relevant to community college GST education and the type of work a National Geospatial Technology Center (NGTC) should undertake with these organizations to improve GST education and increase opportunities for community college students.

Background Information

Many people are often confused by the terms certification, certificates, registration/licensure, and accreditation.

- *Certification* is the formal recognition by one's colleagues that an individual has demonstrated professional competence in their field (ASPRS, 2007). This may or may not include a test.

- *A certificate* is a document awarded by a college attesting to the completion of a course of study (generally vocational/occupational in nature) not leading to a degree (associate's, bachelor's, etc.). Certificate programs generally do not include a language arts, mathematics, or social science requirement (Wikipedia contributors, 2008).

    - Two-year college certificates usually consist of 12 to 43 units of study in a specialized area

    - No standards currently exist to evaluate these programs

- *Registration* or *Licensure* both refer to the process, which usually include an exam, overseen by a government agency generally to ensure the safety, health, or welfare of the public. Registration may be required by local, county or state agencies (ASPRS, 2007).

    - For example, surveyors, doctors, and lawyers must be registered or licensed

- *Accreditation* is the process of evaluating the academic qualifications or standards of an institution or a specific program of study in accordance with pre-established criteria (GISCI, 2008).

Note that an individual is certified, licensed, or registered or completes a certificate, while an institution or program of study is accredited.

GST Certifications

Current certification efforts reviewed include GISCI Professional Certification, ASPRS Certification, and STARS Certification.

- **GISCI Professional Certification** is a voluntary program overseen by an independent body advised by several GIS-related organizations, including Urban and Regional Information Systems Association (URISA), Association of American Geographers (AAG), University Consortium for Geographic Information Science (UCGIS), and others. It is a self-documented process in which an individual provides evidence of GIS education, work experience, and professional activities and acquires the needed points in the three categories required for certification. Currently there is no exam, but the individual must sign a code of ethics to complete the process. See Table 1.

- **ASPRS Certification** is also voluntary but includes an exam. There are levels of certification for GIS technologist and scientist. An individual seeking certification must provide evidence of experience (work and education) and references, and must sign a code of ethics. A new option is a provisional certification for students who successfully pass the exam, but do not have the required work experience. Once they meet the work experience requirement, they will receive full certification. See Table 2.

- **SPACESTARS Certification** is a commercial certification process overseen by Digital Quest, a GST development and training company. It includes a program of study (courses given by a school and completion of a project) and a competency exam. Students who successfully complete the study program, project and pass the exam are awarded GIS technician level certification. See Table 3.

In addition to these efforts, a new certification program is being proposed by ESRI that will focus on the use of specific ESRI software. While still in its development stage, this program will not compete with current certification programs, because it will focus on ESRI software, not the broader range of GIS concepts and fundamentals. The program will be announced in August 2008 at the ESRI International User Conference in San Diego, California, and is scheduled to begin the following summer. Preliminary plans include exam-based certification, administered by an outside agency, which will test the individual's knowledge of the use and application of specific ESRI software. There currently is no plan to specify what classes must be taken to qualify for the examination.

Certification Efforts and Community College GIS Programs

Educators should be aware of the different certification programs and their requirements, and the opportunities to market their programs to individuals seeking certification. Community colleges can align their curriculum or offer special courses to prepare students to take certification examinations

such as those included in the ASPRS or STARS programs.

The GISCI Professional Certification, while awarding points in education for courses taken at a college, does not currently include an exam. There is a study underway to see if an exam should be included in the future, and the UCGIS Body of Knowledge (BoK) is currently being evaluated by certified GISCI professionals as the basis for the exam. If an exam is adopted, colleges should consider aligning their curriculum to cover the core learning objectives in the BoK and include this information in the marketing of their programs.

If ESRI institutes a software certification program, colleges have the opportunity to offer training and education to prepare students to pass the ESRI software certification exams.

GST-related Accreditation

Currently there are no accreditation programs specifically addressing GST, although the USGIF Education Committee has developed an accreditation process with guidelines for course content for Geospatial Intelligence Analyst certificate programs. With input from industry and academia, it created course guidelines and developed procedures for institutions to offer accredited programs granting certificates from the USGIF and the school for Geospatial Intelligence Analysts (www.usgif.org/Education_Accreditation.aspx). Guidelines for course content are based on the UCGIS BoK. Three university-level certificate programs (University of Missouri at Columbia, Pennsylvania State University and George Mason University) were accredited in February 2008. Community college certification programs may also apply and be accepted if they meet the guidelines for the program.

GST-related Licenses

Although there have been efforts by some groups to limit the practice of GIS to only those who have specific licenses, this topic, although important, is beyond the scope of this report. There is, however, one example of a GIS License, the European Computer Driver's License (ECDL) for GIS. The ECDL for GIS is only offered in Italy, but should soon be expanding to other EU countries. It is an offshoot of the European Computer Driver's License program, which allows students to take an exam for specific Microsoft Office programs such as use of PowerPoint or Excel. If they pass an exam, they get a record of this in their EU Computer Driver's License. The ECDL for GIS includes an exam that tests fundamental GIS concepts and the specific use of either ESRI or Intergraph GIS software. This program may spread to other countries outside of the EU; there has been some interest within the U.S.

GIS Certification Institute (GISCI) Certification

GISCI was created as a federation of GIS professional associations representing the broad spectrum of the profession: URISA, AAG, and UCGIS.

GISCI certification ensures that geographic information

systems professionals (GISPs) meet minimum standards for ethical conduct and professional achievement. Achievement areas include knowledge; skills, and abilities acquired through education; and professional experience. In addition, GISCI acknowledges and supports individuals who contribute to the GIS profession through sharing their professional knowledge, skills, and experience. Thus GISCI certification signifies an individual's commitment to the profession.

GISCI balances the recertification application so that continuing education, further experience, and additional contributions to the profession are required. The minimum required points for the contributions to the profession increases after initial certification. This challenges GISPs to stay involved and continue to help their colleagues and the public.

American Society for Photogrammetry and Remote Sensing (ASPRS) Certification

A growing number of scientific and technical disciplines depend on photogrammetry and mapping sciences for reliable measurements and information. The purpose of the ASPRS Certification Program is the establishment and maintenance of high standards of ethical conduct and professional practice among photogrammetrists, mapping scientists, and technologists.

Table 1. GISCI Certification

Info as of	August 15, 2007
Sponsor	GISCI, a tax-exempt not-for-profit organization that provides the GIS community with a complete certification program.
Start year	2004
Recognizing organizations	Four member organizations appoint representatives to the GISCI Board of Directors: Association of American Geographers (AAG), National State Geographic Information Council (NSGIC), University Consortium for Geographic Information Science (UCGIS), and Urban and Regional Information Systems Association (URISA). North Carolina, Oregon, and the National Association of Counties have endorsed the program. A number of small groups and chapters have shown informal and formal support for the program.
Certifications	Certified GIS Professional (GISP)
Number certified	1,664 Certified GISPs as of July 25, 2007
Percent of applicants who fail	Each month GISCI has a handful of applications that fail. However, the GISCI application process is different from most certification programs in that applicants have a strong idea of whether they will pass when they submit their application. A small number of applications fail due to miscalculations, misrepresentations, and documentation errors.
Number of members in sponsor org	GISPs are not members of GISCI, although they are recognized by GISCI as professionals.
Fees	$250 certification fee; $115 recertification fee.
Administration	GISCI has a staff of three, including an executive director, certification coordinator, and an accountant.
Certification requirements	GISCI uses a point-based system for certification. Achievement (points) must fall into three categories. • Educational Achievement: Bachelor's degree with some GIS courses or equivalent (30 points) • Professional Experience: Four years in GIS application or data development or equivalent (60 points). Most applicants have between seven and eight years of experience. • Contributions to the Profession: Annual membership and modest participation in a GIS professional association or equivalent (8 points) • An additional 52 flex points can be awarded in any of the three categories. Minimum points = 150
Test requirements	None
Continuing requirements	Every five years the applicant must submit a recertification application demonstrating that they have earned 75 points • Educational Achievement: 3 points • Professional Experience: 37 points • Contributions to the Profession: 7 points • Additional "Flex" Points: 28 points
Web site	www.gisci.org

The primary objectives of the program are:

- To identify and recognize professionals who meet the requirements established by the Society for certification after being carefully and fairly appraised by their peers and passing a written examination.
- To provide a basis for weighing the validity of allegations and complaints that involve practicing professionals and taking appropriate action if needed.
- To encourage those not fully qualified to work towards certification as a professional goal.
- To encourage certified professionals to continue their professional achievements as the rapid change in technology occurs, through the recertification process.

The ASPRS Certification Program is voluntary and open to all qualified individuals; membership in ASPRS is not required.

STARS (Spatial Technology and Remote Sensing)

STARS is a competency-based, industry-recognized,

Table 2. ASPRS Certification

Info as of	June 6, 2007
Sponsor	American Society for Photogrammetry and Remote Sensing
Start year	1975 for photogrammetrist; 1991 for mapping scientist (remote sensing and GIS/ Land Information Science, or LIS) As of 2006 a provisional certification program allows students to take the test once they have completed the course work and they can become "provisionally certified" until they complete the on-job experience requirement.
Recognizing Organizations	ASPRS certified professionals are required for contract services by the U.S. Army Corps of Engineers, the U.S. Geological Survey, and state and local government agencies when procuring services. ASPRS Certification is recognized by employers seeking to fill positions. ASPRS Certified Professionals work closely with the National Council for Examination of Engineers and Surveyors on the development and maintenance of a national photogrammetry exam.
Certifications	• Certified Photogrammetrist • Certified Mapping Scientist, Remote Sensing • Certified Mapping Scientist, GIS/LIS • Certified Photogrammetric Technologist • Certified Remote Sensing Technologist • Certified GIS/LIS Technologist
Number certified	Active Certified: 860, including approximately 60 outside of the U.S.
Percent of applicants who fail	14 percent failed to be certified or recertified.
Number of members in sponsor org	6,150; membership in ASPRS is not required.
Fees	• Provisional Certification, Initial Application: $150 members, $200 non-members • Provisional Certification, Final Application: $150 members, $300 non-members • Recertification: $150 members, $275 non-members • Initial Certification, Technologist: $150 members, $275 non-members • Recertification, Technologist: $100 members, $150 non-members
Administration	ASPRS Board of Directors, Evaluation for Certification Committee, Professional Conduct Committee, Professional Practices Division
Certification requirements Certified Photogrammetrist	Certified Photogrammetrist—A professional who uses photogrammetric technology to extract measurements, make maps, and interpret data from images. The photogrammetrist is responsible for all phases of mapping and other mensuration requirements, including planning and supervising survey activities for control; specifying photography or other imagery requirements; and managing projects for mapping. • Six years of experience in photogrammetry, including three years years in a position of professional responsibility demonstrating professional knowledge and competence.

(Table 2 continued from privious page)

	• References from four persons who hold or who have held responsible positions in photogrammetry and have first-hand knowledge of the applicant's professional and personal qualifications. • Declaration of compliance with the code of ethics of the ASPRS. • Successful completion of a written examination.
Certification requirements Mapping Scientist, Remote Sensing	Certified Mapping Scientist, Remote Sensing--A professional that specializes in analysis of images acquired from aircraft, satellites or ground bases, or platforms using visual or computer-assisted technology. Professionals may develop analytical techniques and sensor systems. • Three years of experience in photogrammetric and/or cartographic applications in a position of responsibility that demonstrated knowledge and competence in planning and application. • Three years of specialized experience at a professional level in remote sensing and interpretation of data from various imaging systems and/or design of remote sensing systems. • References from four persons who hold or who have held responsible positions in the mapping sciences and remote sensing and have first-hand knowledge of the applicant's professional and personal qualifications. • Declaration of compliance with the Code of Ethics of the ASPRS. • Successful completion of a written examination.
Scientist, GIS/LIS	Certified Mapping Scientist, GIS/LIS—A professional involved in GIS/LIS systems design and/or systems application of database management and computer programs that allow for the use of spatially-referenced databases for solving user analysis requirements. They are responsible for the integration of data needs and the use and development of correspondence between various spatial systems that are used to solve requirements. • Three years experience in mapping sciences or photogrammetry in a position of responsibility demonstrating professional knowledge of and competence in mapping science and mapping procedures. • Three years of professional experience in GIS/LIS, during which professional knowledge and competence in those systems were demonstrated. • References from four persons who hold or have held responsible positions in the mapping sciences and in GIS/LIS and have first-hand knowledge of the applicant's professional and personal qualifications. • Declaration of compliance with the Code of Ethics of the ASPRS. • Successful completion of a written examination.
Other requirements for scientists	When computing the number of years of experience under basic requirements, a bachelor's or higher degree in engineering or the natural or physical sciences can be counted as one-half year towards total time, in lieu of actual job experience.
Certification Requirements Technologists	• Certified Photogrammetric Technologist—A technician who performs or supervises technical photogrammetric tasks to extract spatial data from photographic or digital imagery and other remotely-sensed data. • Certified Remote Sensing Technologist—A technician who performs or supervises tasks to interpret, manipulate, extract, process, and convert remotely sensed data from photographic or digital imagery and other remotely-sensed data. • Certified GIS/LIS Technologist—A technician who integrates a variety of spatial data sets into a GIS format designed for graphic output or analysis. **Requirements:** These requirements apply for all technologist categories: • A total of three years experience, of which two are in the specialty category. • Four references must be submitted from persons knowledgeable of the applicant's work experience and personal conduct. • Applicant must submit a non-refundable application fee. The application includes a declaration of compliance with the code of ethics of the ASPRS. • The successful completion of a written examination following peer review and approval. **Educational Credits:** An associate's or higher education degree can be counted as one-half year towards total time.

(Table 2 continued from privious page)

Continuing requirements, scientists and technologists	Professionals must be recertified every five years. Recertification applicants must complete the recertification application showing the type of activity that they have practiced and their professional involvement in the mapping sciences. They must also have four references with knowledge of their professional and personal involvement in the last five years. Each applicant must earn twenty-five points based on the following criteria that will be reviewed by the evaluation for Certification Committee. **Possible Points** / **Evaluation Criterion** up to 20 — Applicant has been active in providing services in the area to be recertified, or has been in the academic arena involved directly with those subjects. up to 8 — Applicant has participated in panels, and presented or published technical papers. up to 8 — Applicant has attended and taken workshops or classes in related subjects or Equal Industry Standards. up to 4 — Applicant has attended technical conferences sponsored by ASPRS, URISA, SPIE, or GITA, and other appropriate professional meetings. Applicant has actively served on ASPRS Standing Committees.
Website	www.asprs.org/membership/certification/certification_guidelines.html#GENERAL_INFORMATION

entry-level geospatial certification managed by Digital Quest, a GST development and training company. The four series of courses that make up the STARS certification are mapped directly to the Geospatial Workforce Development (GWD) model, which is recognized by NASA, the U.S. Department of Labor (DOL), and industry leaders as the basis for determining the skill set needed to make the best possible geospatial employee. The STARS curriculum is also the educational component of the DOL's STARS Geospatial Apprenticeship Program.

Digital Quest works with colleges and school districts to establish "geospatial hub sites," which use STARS materials to deliver instruction. Digital Quest gathers and delivers local and county-wide data and imagery and creates customized assessments for each geospatial hub site, and trains the instructor onsite or at the STARS teacher training laboratory located in Mississippi at NASA's John C. Stennis Space Center.

The STARS development team is working on a series of software, books, and materials designed for individuals that do not have access to geospatial hub sites. The target audiences for the program are entry-level geospatial technicians including those from high school, apprenticeship, continuing education, workforce education, and community college programs.

Table 3. STARS Certification

Info as of	November 25, 2007
Sponsor	Creator: Digital Quest Inc; Sponsored by Mississippi Enterprise for Technology (MsET) Located in the Center of Geospatial Excellence, NASA's John C. Stennis Space Center, Mississippi
Start year	2004
Recognizing Organizations	Mississippi Enterprise for Technology, DOL Office of Apprenticeship. By completing STARS courses, students receive educational achievement credit toward the GISCI certification.
Number certified	2003 - 8 2004 - 17 2005 - 26 2006 - 45 2007 - 60

(Table 2 continued from privious page)

Fees	• A STARS-certified geospatial hub site receives the first 50 STARS Certification Exams included in the curriculum price • $150 per student after the first 50 students • $500 for someone who doesn't take the courses at a STARS Certified geospatial hub site • Free to college students that compete in SkillsUSA
Administration	The STARS certification is administered, supported, and delivered by Digital Quest and its partners. At geospatial hub sites, the exam is proctored by STARS-certified instructors. Updates are requested, reviewed and/or monitored by geospatial hub sites and strategic partners.
Education requirements	Completion of four 90-hour series of curriculum (360 hours of materials), approximately 4 semesters
Experience requirements	To pass both components of the exam, a student must show working knowledge of geospatial project management (planning, implementation and presentation), hardware tools (computers, printers, GPS units), and software tools (ArcGIS with the following extensions: Spatial Analysis, 3D Analysis, Network Analysis, and Image Analysis)
Test requirements	Yes. Students must demonstrate the skills required of a GIS technician by completing a capstone project and are required to pass an online exam.
Continuing requirements	None, but STARS-certified technicians are recommended to earn GISCI certification.
Web site	www.digitalquest.com

Conclusion

Many community college educators believe it is in the best interest of their students to align their GST program with professional certification guidelines, yet most educators lack knowledge of current GST certification options.

It is recommended that an NGTC:

1. Serve as a repository of certification, accreditation, and licensing program information and help facilitate the dissemination of information to faculty and students.

2. Evaluate certification options and provide recommendations to students, faculty, and industry about the advantages of each option.

3. Join organizations that offer GIS/GST certifications to provide a unifying voice that represents community college views and interests in existing certification efforts.

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Articulation and Career Pathways

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Overview

Articulation and career pathways in geospatial technology (GST) education will be one of the major issues for the National Geospatial Technology Center (NGTC). With rapidly increasing tuition at all levels of higher education, the American public is demanding more flexibility in education and training. Colleges and universities are under tremendous pressure from students and stakeholders, such as employers and taxpayers, to produce a technically literate workforce in shorter time with less loss of class credit. This report will examine the issues that need to be addressed by the NGTC to improve articulation and create seamless career pathways from high school to college to university graduation.

Background Information

The need for better articulation and coordination between colleges and universities in GST education is paramount in the 21st century global workforce, where Americans find themselves competing with increasingly technologically sophisticated workers in countries such as China and India. Geospatial work, like software development and radiology, is easily outsourced in today's well-connected Internet era.

The GST field is one of the most dynamic and rapidly changing areas of technology. Few fields are expanding as rapidly into new areas of application. Advances in technology and data availability are driving the demand for new workers. Training 21st century technicians to meet this demand begins at the community college (Kincaid et al., 2006):

> *Community colleges play a major and increasing role in U.S. higher education. Although they sometimes struggle under the pressure of multiple missions, they have exceptional faculty who focus on teaching and maintain the quality of core transfer and occupational programs.*

During the past several years there have been numerous attempts to bridge the gap between the two-year community college certificate or associate's degree and the four- year university bachelor's degree. For example, Del Mar College in Corpus Christi, Texas, through its National Science Foundation (NSF)-funded *GIS Technical Implementation Project (GIS-TECH)*, has created a "GIS Academy." Based on the Cisco Network Academy model, GIS Academy attempts to address secondary to college and college to university articulation challenges.

The academy model requires secondary teachers to receive a year-long training program leading to a GIS certificate, which enables the teacher and school district to qualify for Tech-Prep articulation of one or two high school GIS courses into the college's GIS degree program. (Tech-Prep is a national program designed to prepare secondary school students for technical careers.) Extensive training is required to ensure the secondary teacher meets the accreditation requirements of the Southern Association of Colleges and Schools (SACS), and the college's own teacher qualification requirements.

While successful at qualifying teachers and articulating students in small numbers, this approach was not well-received when presented at a roundtable of community college educators in Washington, DC during the 2005 annual Advanced Technical Education (ATE) Principle Investigators conference. Participants at the roundtable expressed concern that the approach was too narrow and confined to technology workforce training and not interdisciplinary, like geography or environmental science.

Another NSF funded project, *A Scalable Skills Certification Program in Geographic Information Systems (GIS)*, by San Diego Mesa College and San Diego State University allows the community college student to transfer a GIS course from high school to college to the university. Specifically the project aimed to accomplish the following:

- To develop skill certificates that certify specific work-based competencies useful to industry

- To develop standards-based curriculum, aligned across the three educational levels (high school, community college, and four-year university), designed to meet identified industry needs and linked to job descriptions

- To create articulation agreements that ensure students are able to progress efficiently through the skills certificate and more traditional programs

- To prepare high school teachers and post-secondary faculty to provide the GIS skills training

While similar in concept to the *GIS-TECH* project, the *Scalable Skills* project aimed to provide teacher training at a more fundamental, less time-consuming level. San Diego State University secured approval from the California Higher Education Board to allow their GIS course to be offered at the freshmen level, making articulation with the community college more feasible. This unique feature addressed a major barrier to articulation nationwide: the propensity of universities to place their geospatial courses in the upper level undergraduate years (junior/senior), which effectively

prohibits the articulation of lower level (freshman/sopho-more) courses taken in a certificate or associate's degree program.

A third NSF-funded project, *MentorLinks*, was developed by Matoon, Illinois-based Lake Land College and the Kentucky State Community and Technical College System. *MentorLinks* works to promote cooperation among colleagues at colleges and universities through projects and professional development. This method of forming close relationships among peer professionals has been described as both necessary and effective for any articulation model to succeed (National Science Board, 1986):

> *…many two-year college faculty are prevented by geographical considerations from any significant interaction with faculty at research institutions. Relatively modest partnership support from NSF for faculty development could lead to genuine improvements in science and mathematics instruction [at two-year colleges]. … The two-year colleges are a part of higher education. Their transfer programs provide large numbers of upper division students to four-year institutions. Articulation at this transfer point is difficult and requires serious and permanent collaborative efforts between the source and acceptor colleges.*

Georgia's Gainesville State College, with support from the NSF, has worked to integrate geospatial technology into middle and high school classrooms. A major spin-off from the NSF grant was an agreement between Gainesville State College and the Forsyth County Board of Education that allows Forsyth County High School students who successfully pass the Gainesville State College final examination in Introduction to Geographic Information Science to exempt the course upon entry to Gainesville State College.

National Imperative for Articulation

State legislatures nationwide are demanding a more effective higher education system. As college costs rise faster than inflation, students, parents, and taxpayers all expect their elected officials to reign in expenses. In turn, state boards of education challenge educators to cooperate better to promote articulation. In Texas, the Higher Education Coordinating Board's Workforce Education Committee (WECM) recently stated (WECM Leadership Committee, 2007):

> *Seamless transfer of WECM courses to applied bachelor degrees still needs to be addressed. A practical statewide model needs to be developed where WECM courses and A.A.S. degrees will articulate to bachelor degrees. A subcommittee was formed to develop a proposal and model.*

Universities are also responding to the Texas legislature's call to improve transferability. For example, Dr. Elisabeth Mermann-Jozwiak, professor of English and associate dean at Texas A&M University—Corpus Christi announced a new and more flexible alterative to the traditional BS degree in May 2007 (Mermann-Jozwiak, 2007):

> *The purpose of the Bachelor of Applied Arts and Sciences (BAAS) is to offer students with formal training in a vocational-technical studies area the opportunity to obtain a baccalaureate degree without the significant loss of credits that normally occurs in pursuing a traditional degree. This program is especially appropriate for graduates of an Associate of Applied Science program. The degree is designed to afford both academic and professional depth to individuals who possess recognized competence in an occupational or technical field. It is not designed to prepare students who wish to pursue a graduate degree.*

However, the main stumbling block to any seamless articulation system is that to align curricula at disparate schools, faculty and students need to know that the training received at the sending institution is equivalent in content, scope, and rigor as that of the acceptor institution. Until these questions can be answered with a degree of certainty that will meet the schools respective accrediting agencies, doubt and therefore inaction will prevent the easy transfer of credits from one level to the next.

Approaches to Articulation

Research of the literature and discussions held with more than 50 geospatial educators from both colleges and universities nationwide reveals that there is no one single "correct" model for articulation. Discussions at the October 2005 ATE PI Conference, the August 2005 Roundtable on Integrating Remote Sensing, and the national forum in Monterey in January 2007, all reinforced the concept of the need for an **interdisciplinary approach** to articulation. While the GIS Academy model works well in Corpus Christi, it might not be feasible in many other locations. Educators noted that the Academy model focuses on workforce technician education, whereas many GIS programs at other colleges and universities are housed in other departments, such as geography, architectural, agricultural, drafting, environmental science, or surveying. The Academy model, while successful at promoting secondary to college articulation, does not meet the requirements for college to university articulation. For this task, a much broader approach that is **interdisciplinary** and provides for **multiple pathways** to specific careers is recommended.

Findings

Although GIS has its roots in cartography and geography, it now encompasses geographic information systems (GIS), remote sensing, internet mapping technology, computer programming, database management applications, global positioning systems (GPS), and 3D visualization. This multitude of fields and specializations makes it difficult to create a generic curriculum which will seamlessly articulate from one college to another college or university. The very specialization that qualifies a graduate enter into a marketplace may also prevent them from a smooth transition to another degree. Laura Rocchio, Landsat Support Scientist, NASA-Goddard Space Flight Center, noted that the wide range of jobs makes it difficult for most technologists to receive all the training they need in any given two-year program. In their Bachelor of

Applied GIS (BGIS) degree proposal, Selkirk College of British Columbia, Canada stated (Selkirk College, 2005):

Graduates of the BGIS will possess a highly desirable skill set that make them immediately employable in a diverse range of employment sectors.

In this complex and rapidly changing field, two major requirements for articulation are lacking: a definitive and accurate set of job descriptors and a comprehensive definition of skills required for each specific job. We must first define these two missing pieces before we can design curricula that can be properly aligned and compared for articulation evaluation.

The first task, defining precise job descriptions, has not yet been successfully accomplished. Several attempts to do this have been made, but no definitive terms have been nationally accepted. The Department of Labor (DOL) is the federal agency tasked with maintaining the national database of occupational codes and descriptors. Until recently, the DOL Bureau of Labor Statistics (www.bls.gov) utilized the antiquated Standard Industrial Classification (SIC), which was developed in the 1930s when manufacturing dominated the U.S. economic scene. Recent developments in information services, new forms of health care provision, expansion of services, and high tech manufacturing are examples of industrial changes that cannot be studied under the current SIC system. More recently, the North American Industry Classification System (NAICS) was created to replace the SIC system. Although NAICS was designed to be maintained, the system has failed to keep pace with the rapid changes in the geospatial technology field. Under NAICS, geospatial technology still only has one archaic category: 541370 Surveying and Mapping Services.

Job descriptions likewise suffer from a lack of agreement on what a term means exactly. The following examples are used by the Bureau of Labor Statistics (Bureau of Labor Statistics, 2008):

- GIS Analyst
- GIS Technician
- GIS Manager
- GIS Specialist
- Geospatial Analyst
- Geospatial Technician
- Geospatial Data Resource Manager
- GIS Coordinator
- Geospatial Software Developer
- GIS Developer
- GIS Programmer
- Project Managers
- Remote Sensing Specialist
- Remote Sensing Technician

What is lacking from this list of possible job titles, and respective curricula, is a precise definition of respective job skills. What level of training, certification, or education does each job require? Answers to these questions can provide a clear understanding of the training needs for each job, and therefore, the curriculum "pathway" that each would require of a graduate.
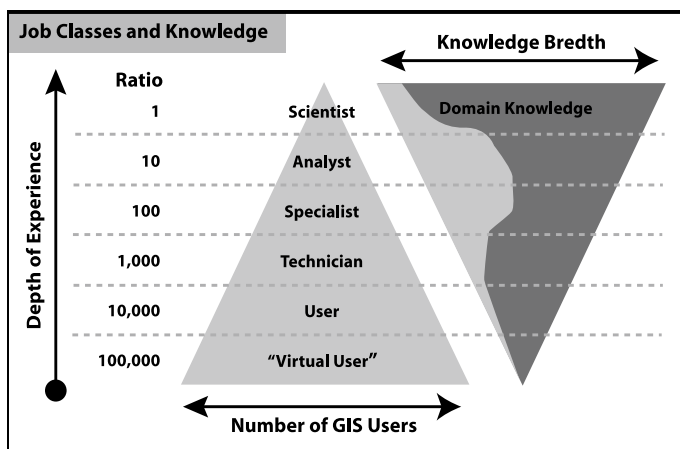
Source: *GIS Educator*, Summer 2004, p. 2

An illustration in *GIS Educator* depicts a proposed set of job descriptions, based upon their technical and engineering complexity and sophistication (Johnson, 2007):

On the right, this graphic depicts the Body of Knowledge for GIScience and Technology (BoK), an ongoing project that purports to include all relevant GST knowledge. The level of expertise (from top to bottom) is depicted on the left. One of the major goals of the proposed NGTC would be to find an agreeable set of job descriptors and then define the pathway through the BoK to achieve each level. The levels could then be seamlessly articulated from one to the next to enable a nearly lossless transfer of college credit from the certificate to associate's degree, associate's degree to bachelor's degree, and higher.

Recommendations

Moving forward, it is recommended that the NGTC consider the following to address articulation and career pathways:

1. A model of articulation that is interdisciplinary and inclusive in nature is recommended over a more narrowly-focused model.

2. A set of precise job descriptors acceptable to the NAICS should be created and widely disseminated.

3. A set of career pathways for each of the job descriptors should be developed in conjunction with the GIS&T Body of Knowledge document.

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Curriculum Development and Pedagogy

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Overview

As one of its highest priorities, the proposed National Geospatial Technology Center (NGTC) must address the management and dissemination of GST curriculum materials at a national level. To promote student learning, create a seamless education and provide industry with an adequate workforce, the NGTC must enhance GST pedagogy by consolidating the current collection of geospatial curriculum.

Currently, a large body of geospatial technology (GST) curricula exists, but most community college educators are not aware of what materials are available because of the lack of a central management structure. The national forum on GST education concluded that improving the management of curriculum materials would be of immense value to GST educators. An NGTC can do this by:

- Creating a useable framework for categorizing and organizing curriculum materials

- Developing a searchable clearinghouse to improve dissemination of curriculum materials

- Ensuring that appropriate pedagogical standards are applied to curriculum materials

Review of Current Materials

Currently there are many different sources of geospatial curriculum and instructional materials. Multiple organizations have created various levels of national curriculum and workforce studies. Many NSF projects and Advanced Technology Education (ATE) centers have developed instructional materials related to GST.

An NGTC should create a comprehensive list and index all educational geospatial projects and initiatives to determine existing gaps in available materials. Several existing GST curricula must be considered as an NGTC addresses the issue of coordination of GST curricula:

- **Geographic Information Science and Technology (GIS&T) Body of Knowledge (BoK)**. To prepare students for success in the variety of professions that rely upon geospatial technologies, the University Consortium for Geographic Information Science (UCGIS) developed a comprehensive GIS&T BoK that specifies what aspiring geospatial professionals need to know and do. Since 1998, scholars from many research universities have contributed to the BoK, which includes ten knowledge areas, dozens of units, and hundreds of topics, each defined as a formal educational objective.

- **Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum.** Published by the National Research Council of the National Academies, this curriculum promotes spatial thinking as a cognitive skill that can be used in everyday life, the workplace, and science to structure problems, find answers, and express solutions using the properties of space.

- **NCGIA Core Curriculum in GIScience.** Developed in 1990, the Core Curriculum in GIScience is a detailed outline for a three-course sequence of 75 one-hour units. Due to the ongoing demand for copies of its original curriculum, the NCGIA decided that a major revision is warranted. While it was initially felt that widespread diffusion of these lecture materials would eventually make the document redundant, the rapid development of the technology and the evolution of GIS continue to make the NCGIA's effort valuable.

- **NCGIA GIS Core Curriculum for Technical Programs Instructor Guide (CCTP).** The CCTP concentrates on course content assistance for instructors and is intended to support a full range of courses taught at two-year colleges. The materials are textbook- and course-independent, providing a generic task-oriented approach. While the NCGIA core curriculum in GIS focuses on geographic information science, the CCTP focuses on information that instructors need to present to students so they can perform the technical activities associated with GIS technology.

- **Kidz Online Geospatial Generalist Certificate of Completion Program.** Kidz Online worked directly with the global GST industry to design the curriculum, ensuring the delivery of valuable, industry-appropriate training products was ensured and establishing a connection between development of the future geospatial workforce and international prospective employers.

- **Denver Public Schools Geospatial Curriculum.** Developed by Robb Menzies of Denver Public Schools, this is an example of a local geospatial project with a national impact. It includes a variety of geospatial workshops, career exploratory materials and instructional activities.

Curriculum Framework

Developing a comprehensive curriculum structure is beyond the scope of an NGTC; however, a center should

compile examples of existing curricula and create a basic curriculum framework. A comprehensive framework can be used for issuing certificates, cross-referencing competencies, articulation, recruitment, good pedagogy, rigor in science and math, and gap analysis of instructional materials.

Each state relies on industry and educational sources to help them develop independent curriculum benchmarks. The use of state benchmarks to develop a national curriculum would be extremely difficult to complete and of limited value. An NGTC can provide value by developing a national framework based on workforce needs to assist states in developing or enhancing their own benchmarks. Because of state educational autonomy, these models should not be presented as requirements but as guidelines for colleges to adapt to state and local needs.

A national framework must consider all stakeholder needs and address all educational disciplines. Development of instructional materials should not necessarily be a primary focus, although a center should work to find gaps or missing concepts within current instructional resources. In identifying and working with various stakeholders and compiling current resources into an organized structure, an NGTC may need to develop curriculum materials to meet the needs of participating colleges.

Along with other projects and NSF ATE Center activities, these examples represent at least one of the three components that are necessary for a national curriculum framework: workforce needs; skills, competencies and knowledge; and instructional materials.

- **Workforce needs.** Workforce needs are defined through job task analysis techniques such as the DACUM (Developing a Curriculum) process and can be used to develop a comprehensive curriculum. A curriculum framework should provide faculty with access to DACUMs and be understandable and usable for specific local needs.

- **Knowledge, skills, and competencies**. Knowledge, skills, and competencies needed by graduates entering the workforce are the educational equivalent of workforce needs. Specific tasks needed by geospatial workers are put into educational terms that allow the instructor to have learning objectives for students to acquire the knowledge and skills necessary to enter the workforce. Resources currently available need to be compiled and made available to educators.

- **Instructional materials.** Geospatial instructional materials provide the means for teaching the skills and

competencies required by industry. This may include resources such as content, activities, projects, active learning, lesson plans, workshops, non-credit courses, on-line courses, credit courses, programs of study, and articulation agreements.

To show how an NGTC might usefully organize curriculum materials, graphic models were developed to illustrate possible structures that an NGTC could use to provide educators with access to the three components of a curriculum framework: workforce needs; knowledge, skills, and competencies; and instructional materials.

An NGTC is responsible for selecting and finalizing structure—either the Compilation Model or Categorization Model. This includes compiling DACUM, competencies, assessments, and programs of study and crosslinking all appropriate materials.

The key to a usable curriculum framework is crosslinking the components, which allows community colleges to connect with local industry needs. For example, an instructor using the curriculum framework should be able to select a specific job task used by a geospatial technician, identify required skills and competencies, and subsequently link relevant curriculum resources and delivery methods. Crosslinking shows the progression of development and document how a curriculum delivery item applies to a workforce need. Both models described below feature crosslinkages between curriculum components.

- **Compilation Model.** In the Compilation Model, DACUMs and job task analysis (representing workforce needs); knowledge, skills, and competencies; and instructional materials are compiled by an NGTC and offered in their current format. This requires minimal
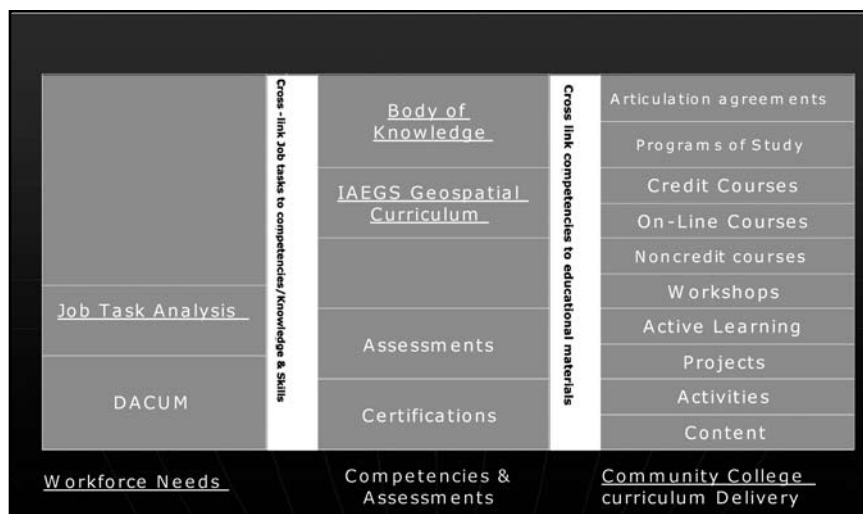

Figure 1. The Compilation Model illustrates the concept of an NGTC that provides "compiled" resources for educators to use in developing curriculum. These resources are considered compiled because they are developed by other entities and compiled for listing by the Center. The two white sections between the main three components represent crosslinking.

effort by an NGTC: a simple listing of compiled resources and the assumption that educators have the ability to apply the resource.

- **Categorization Model.** Instead of a simple listing of DACUMs and job task analysis, workforce needs are categorized by type of geospatial occupation, such as virtual user, user, ancillary user, technician, analyst, manager, and GIS scientist. Knowledge, skills, and competency resources are categorized by GIS skill areas, which have been identified as data collection; manipulation and editing; analysis; programming; and product generation. As in the Compilation Model, instructional materials are compiled and offered in their current format. This model requires more work on behalf of NGTC staff, but would be a more valuable aid to faculty in developing educational programs, courses, or curriculum materials.

Curriculum Clearinghouse

The multitude of geospatial educational curriculum and instructional materials has little value to educators if they cannot find what they need. The role of the national center should not be to create or recreate curriculum, but rather to organize and disseminate the materials that are already available. A clearinghouse is needed to collect, review, promote and disseminate resources such as workforce needs assessments, DACUMs, core competencies, resource websites, and sources for curriculum and instructional resources, can all become a part of this clearinghouse organized based on the geospatial framework.

Several ATE Centers use a content management system as the basis for an on-line clearinghouse. This system allows for the on-line submission of instructional materials by educators.

Both staff and partners can be part of this process. To assure a robust clearinghouse, partnership involvement with populating and maintaining clearinghouse data must increase over time. Processes must be developed to create an active submission of materials. Partners should be required to develop and submit materials, and incentives should be used as encouragement. Partners should also be required to evaluate and review submissions.

Both spatial and instructional material should be in a standard format and include metadata. Other ATE Centers have created a process for this so that materials can be shared among Centers. For example, the National Science Digital Library encourages contributions of educational resources from NSF grant awardees, library users, community members, resource developers, content providers, educators, learners of all ages, and other collection builders. Contributions can range from individual lesson plans or websites to collections of thousands of items, to technology-based tools and services that aid educational applications of digital resources. This enlarges and strengthens the library and encourages reuse and sharing of materials.
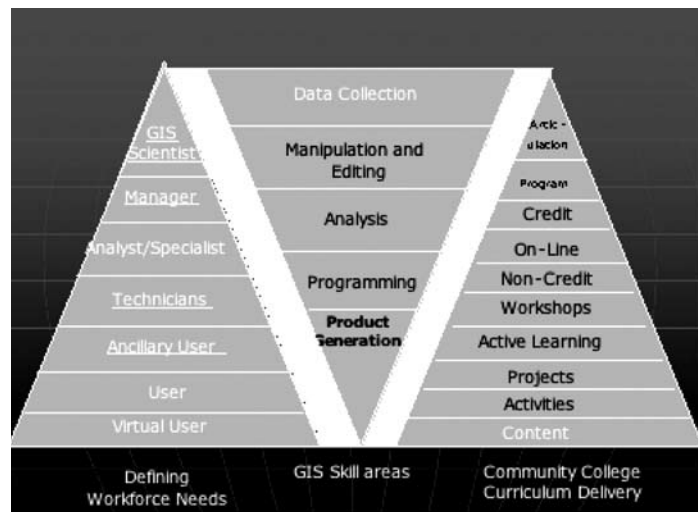

Figure 2. The Categorization Model illustrates the concept of an NGTC that categorizes existing resources for educators to use in developing curriculum. Though the materials used in this model may be the same as those used within the Compilation Model, they are restructured based on careers and skills for which curriculum is being developed. The two white sections between the main three components represent a cross-linking.

Additional ideas for components of the clearinghouse include Frequently Asked Question (FAQ) documents. Common questions should be compiled and answered in an FAQ, and a process for submitting additional questions should be made available.

Pedagogical Standards

Defined as the art and science of educating children, pedagogy is often used as a synonym for teaching. More accurately, pedagogy embodies teacher-focused eduction. Defined as the art and science of helping adults learn, andragogy is an alternative to pedagogy and refers to learner-focused education for people of all ages.

This is noted to maintain the difference between teacher based education and learner based education. The Center for Research on Education, Diversity and Excellence (CREDE) lists five Standards for Effective Pedagogy which can serve as good guidelines for enhancing geospatial education.

1. **Teachers and students working together.** Facilitate learning through joint productive activity among teachers and students.

2. **Developing language across the curriculum.** Develop competence in the language and literacy of instruction across the curriculum.

3. **Connecting school to students' lives.** Connect teaching and curriculum to students' experiences and skills of home and community (contextualization).

4. **Teaching complex thinking.** Maintain challenging standards for student performance; design activities to advance understanding to more complex levels. Challenge students toward cognitive complexity.

5. Emphasizing dialogue over lectures. Instruct through teacher-student dialogue, especially academic, goal-directed, small-group conversations (known as instructional conversations), rather than lecture.[1]

The process of referencing these five guidelines when disseminating curriculum materials is an objective of this visioning grant. Specific pedagogy-related activities for which an NGTC should take responsibility include:

- Review and identify specific pedagogical standards, to confirm the standards listed by CREDE are appropriate; and identify pedagogical standards that are not being met or have limited availability for development.

- Tie clearinghouse submissions to pedagogical standards. Each submission would be required to include appropriate pedagogical standards as part of the metadata. This would involve the selection of one or more of the standards from a list.

- Provide examples and a detailed description of how selected submissions are actually used in the classroom would be helpful to new teachers. Users of the materials should be listed as a resource.

- Create a specific section of the clearinghouse for instructional materials that use geospatial tools for teaching science and math concepts.

The appropriate use of pedagogical (and andragogical) standards must be promoted to enhance geospatial learning. GST instructors-in-training can be provided teacher- and student-based learning activities to aid the learning process. In addition, teachers can learn how to use GST as an instructional aid for teaching academic and general education knowledge and skills.

Summary

To enhance GST education, an NGCT must consolidate existing GST curricula to make it easier for community college educators to find appropriate curricular materials. Unless the process of finding and evaluating curriculum materials is simplified, GST educators will continue to duplicate curriculum development efforts and overlook emerging subject areas.

An NGTC will become a national outlet for managing and disseminating of GST curriculum materials at a national level, including:

- Creating a useable framework for categorizing and organizing curriculum materials

- Developing a searchable clearinghouse to improve dissemination of curriculum materials

- Ensuring that appropriate pedagogical standards are applied to curriculum materials

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[1]Center for Research on Education, Diversity and Excellence, 2002. The Five Standards for Effective Pedagogy, http://crede.berkley.edu/standarts/standards.html

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Geospatial Technology Awareness and Reaching Diverse Audiences

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Overview

The use of geospatial technologies (GST) continues to increase. Web-based maps, such as MapQuest, Google Earth, NASA's World Wind, MSN Virtual Earth, and a multitude of Google Map application hybrids are used by the general public to obtain spatial information at greater levels than ever before. Accordingly, business managers and policymakers need to become more aware of the benefits of geospatial technologies, while students in the K-12 school system and the general public need the ability to think spatially. Raising the awareness of GST is critical to expanding their use.

This report addresses three research questions:

1. What projects and organizations are helping to raise the awareness of geospatial technologies? How should a National Geospatial Technology Center (NGTC) work with these groups?

2. What type of events, initiatives, and technologies (for example, Google Earth, Asian Tsunami, Hurricane Katrina, and the National Mapping Program) provide opportunities to heighten geospatial awareness?

3. What venues reach out to diverse audiences and encourage them to become part of the GST workforce? What models in other fields could be adapted to reach these audiences?

Background Research

In recent years, GST has advanced significantly. Millions of people use popular web-based GIS applications, such as Google Earth, MapQuest, and Google Map application hybrids (known as mashups). Emergency responses to natural disasters and concerns over homeland security have created a strong need for the general public to understand and use geospatial technology. With the expanded use of Internet-based GIS and the World Wide Web, people can access geospatial information and maps in near real-time. Many major satellite imagery companies (such as Digital Globe and GeoEye) and GIS vendors (ESRI and Google) offer free satellite images and low-cost GIS data and maps. The general public can vividly see the changes caused by natural disasters or other unique events via remotely sensed imagery and maps caused by natural disasters or other unique events.

However, most users are not aware that satellite imagery and visualization maps are geospatial technologies (GST). Raising the awareness of GST could increase the enroll-

ment in community college GIS programs and encourage more students to choose the GST careers. Therefore, an NGTC should focus on promoting the concept of geospatial technology and identifying appropriate resources in the GIS community to raise GST awareness.

The following are suggested categories for identifying major resources related to elevating the awareness of geospatial technology. General resources include:

- Federal organizations and projects

- Local (state or city) government GIS projects

- Academic institutes and research projects

- Private industry

- Non-profit organizations (such as Geo-21 and GIS for 4-H) and NGOs

Specialized resources include education programs and industry organizations in the fields of:

- Civil engineering

- Marine biology

- Transportation

- Public health

- Homeland security

To catalog GST awareness resources, an NGTC should focus on collecting web portals for GST information instead of disparate GIS project websites. An NGTC should establish a thorough maintenance plan for the resource catalog update. The following is a representative record of a GIS awareness resource website, along with an example of how this information should be cataloged.

- Title: Career Voyages

- URL and Contact Info: www.careervoyages.gov/, www.careervoyages.gov/geospatialtechnology-main.cfm

- Contact Information: Toll-Free Help Line, 1-877-US-2JOBS (1-877-872-5627) or TTY 1-877-889-5627, Email: career.voyages@dol.gov

- Targeted Users: General GIS awareness. Community college and four-year university students and teachers.

- Brief summary: Created by the U.S. Department of Labor, this website emphasizes 12 high-growth industries and three emerging industries— geospatial technology, biotechnology, and nanotechnology. The

GST sub-pages contain very useful information related to geospatial technology; the website provides very useful information related to the GST awareness, including video presentations, industry overviews, and training in different levels of education institutes, etc.

Because of the human interest generated by natural disasters, the NGTC should consider identifying websites related to disaster incidents that use 3D visualization tools. Some GIS packages, such as Google Earth (http://earth.google.com) and NASA World Wind (http://worldwind.arc.nasa.gov/), include various data and links for the demonstration of disaster events in a 3D visualization environment.

An NGTC could also provide some tools to help potential educators utilize GIS tools to accomplish their education goals. The following is the partial list of related 3D visualization tools and websites for natural disaster monitoring and management:

- GeoEye Inc., a provider of satellite and aerial imagery and geospatial information, www.geoeye.com/

- Pacific Disaster Center, which provides applied information, research, and analysis for the disaster management and humanitarian assistance communities of the Asia Pacific region and beyond, www.pdc.org/iweb/pdchome.html

- Motherplanet, Inc., provider of high-resolution interactive 3D digital world map solutions combining aerial and satellite imagery, shaded relief topographic imagery, www.motherplanet.net/

- GeoFusion, Inc's GeoMatrix Gateways, which provides high-resultion 3D satellite and aerial visualization, including hurricane and tsunami images, www.geoplayer.com/gateways/

- Geospational Multi-agency Coordination (GeoMAC), and Internet-based mapping application that allows U.S. fire managers and the general public to access online maps of current fire locations, www.geomac.gov/

- NASA World Wind, software that uses satellite imagery and NASA shuttle mission topography data to let users experience the Earth in 3D, worldwind.arc.nasa.gov/

In an effort to reach broad audiences and multiple professional groups related to geospatial technology, the center could use national events, such as GIS Day and Geography Awareness Week, to raise GST awareness and reach diverse audiences. For example, the Department of Geography at San Diego State University created a series of GIS-related lectures and a career forum to introduce geospatial technology to non-geography majored students on campus during the 2005 GIS day (http://geoinfo.sdsu.edu/hightech/Kim/Page1c.htm). Instead of inventing new tools, an NGTC should integrate multiple resources and tools available for current GIS awareness—such as ESRI GIS Day, National Geographic, and the geocaching (GPS treasure hunting) community. The center should also try to reach broader audiences for geospatial career awareness, such as the GPS geocaching groups, Google Earth BBS (bulletin boards), or Google Map mashup users.

In spring 2006, an important article related to GST awareness, "The Web-Wide World," was published in the journal Nature. The article, which described the significant impacts of geospatial technology for the scientific community and the general public, demonstrates the great need to educate the general public and the scientific community on how to understand and utilize geospatial technology (Butler, 2006).

Results for the National Forum

To provide a comprehensive overview of the research topics addressing GST awareness and reaching diverse audiences, the national forum discussion focused on the following questions and provided some suggestions for each question.

1. **What is the vision for GST awareness over the next five years that will promote increased recruitment into community college GIS programs?**
   Forum participants agreed that geospatial technology should become a mainstream scientific tool, similar to the role of statistics in the late 1960s. Geospatial technology should be embedded into the core curriculum of all spatial serving programs, such as forestry, environmental management, and transportation. It is also very important that college administrative staff and student counselors recognize the importance of geospatial technology and provide information to their students about the GIS programs available in colleges. Within five or six years, high schools in U.S. may use GST as a tool in existing advanced placement (AP) courses or develop new AP courses with an emphasis on geospatial technology.

2. **How should the center reach out to diverse audiences and encourage them to become part of the GST workforce? What models in other fields could be adopted to reach these audiences?**
   In targeting underrepresented groups and colleges, an NGTC should establish measurable benchmarks for reaching its goals. For example, the number of underserved students needs to be increased to a certain percentage of the total students in the GIS programs. The center should also develop and promote student internship opportunities for underrepresented students. Strategies can be adopted from some successful programs targeting under-served students. The following are examples of successful programs:

   - Science, Technology, Engineering and Mathematics (STEM) programs funded by NSF, www.stemedcoalition.org

   - MIT MITES program, web.mit.edu/mites/www/ NOAA/NSF/AMS (American Meteorological Society) Diversity in Geosciences Education

- Oregon State University Science and Math Investigative Learning Experiences (SMILE) after-school at-risk program

- Science, Math, Articulation, Resource, Technology (SMART) Conference for science and math articulation in high schools

3. **What types of recruitment strategies should an NGTC promote for community college GIS programs? What kinds of resources are available?**

The national forum participants provided many innovative education approaches and recruitment methods. For example, a very effective and easy method is to collaborate with other teachers as a guest lecturer in a non-GIS class and promoting the concept of geospatial technology. Another effective strategy is to use new media technologies, such as podcasting and RSS feeds, to reach out to younger generations. Student recruitment efforts should be balanced between on- and off-campus students. Good communication and relationships with college student counselors and career advisors are also very important. Finally, the GIS courses should also provide flexible schedules for helping students to enroll in and complete the GIS programs.

4. **Identify effective methods (email lists or newsletter, or websites) to facilitate the information exchanges and sharing the resources for GST awareness among community college students.**

National forum participants suggested the following methods:

- Collaboration among teacher-formed geographic alliance groups, GST sub-groups within the American Association of Community Colleges (AACC), and 4-H groups.

- Development of video games or on-line interactive tools for GIS awareness.

- Use of modern media tools and examples in the class rooms, such as YouTube, reality TV shows, and TV dramas such as CSI and 24.

- Facilitation of high school teacher workshops to disseminate GIS exercise templates and modules.

- Creation of a mailing list to reach high school teachers

- Development of GIS education blogs

5. **Identify outreach events, organizations, portals, and tools (3D, visualization) related to GIS career and technology awareness.**

National forum participants identified the following events, tools, and resources:

- The GeoWall Consortium, which develops hardware and software for low-cost stereo visualization

- GIS career websites, including those from the Association of American Geographers (AAG), ESRI, and Geospatial Information and Technology Association (GITA)

- Optimize use of search engines such as Google to ensure top page rankings for college GIS program websites

- Online GIS marketing materials

- Collaboration with other agencies for GIS Day events; for example, coordination and resource sharing between urban and rural GIS Day events

- Participation in local science fair events, such as those at natural history museums and science centers using GIS demonstrations and/or booths

Conclusion

Many important suggestions to shape future work can be drawn from the national forum discussion and subsequent survey.

First, interdisciplinary collaboration is the key to a successful awareness and outreach program. An NGTC can play an essential role in educating community college teachers and students about the importance of geospatial technology and facilitating successful geospatial awareness events and activities. With help from the center, community college teachers can plan their own geospatial awareness events in their local schools and communities. The NGTC should also identify effective GIS education tools, such as Google Earth and the National Atlas web mapping services, for GIS teachers in community colleges.

Second, raising awareness of geospatial technology will be more effective with GIS application examples rather than the basic introduction of GIS technology. For example, teaching the concept of GIS databases will be less effective than teaching an example of crime mapping web services for raising awareness of geospatial technology. The "teach-with-GIS" approach is better than the "teach-about-GIS" approach for promoting GIS careers and GST awareness.

Third, an NGTC should integrate resources to provide internship and mentorship opportunities for underserved students and minority groups. The center can collaborate with the Department of Labor and other related organizations to increase the number of underrepresented students enrolled in GST training and academic programs. Although the final national forum survey might indicate a lower priority for this task, reaching out to diverse students and underserved students for geospatial training programs is a very important issue that will facilitate the long-term development of the national center and the GIS professional community.

Finally, it is very important for the new center to think beyond traditional GIS training approaches and adopt innovative methods for raising awareness of geospatial technology and reaching diverse audiences. The major task is to demonstrate that geospatial technology is entering the mainstream of information technology and scientific tools in the twenty-first century. The center should utilize new media, new ideas, and new materials to attract the young generation of students into the career of geospatial technology.

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Institutional Research, Entrepeneurialism and GIS

Mike Rudibaugh

Lake Land College / Mattoon, Illinois

Overview

External forces such as declining state support and declining local tax bases have driven many community colleges to look for new sources of revenue, such as government grants, private donations, and dynamic new entrepreneurial activities (Evelyn, 2004). Private sector, community, and government partnerships have emerged as the new social structure in which community colleges promote economic viability at institutional, local, and regional levels (Kisker & Carducci, 2003; Sheldon, 2003; Hall, 2002; Brumbach & Villadsen, 2002). These partnerships have focused on building both physical and social structures that assist communities in creating the environments needed to compete for capital investment. These new functions have created an entirely new landscape within the community college setting, reflecting a new entrepreneurial spirit that is market-oriented and increasingly responsive to external forces (Grubb, et al., 1997).

As a result, community college missions have become more complex and diverse relative to their relationships with internal and external players. The entrepreneurial mission shifts community colleges from reactionary organizations within communities to proactive ones in promoting local economic expansion. Entrepreneurial colleges actively create a demand for the institution's services and elevate community economic efforts. The demand for good institutional research, specifically the ability to acquire, manage, analyze, and communicate marketplace data has never been greater. This paradigm shift puts a geographical face, heavily laden in the demographics and economics of the region, on college entrepreneurial activity. Given the spatial nature of this undertaking, a key question becomes: what role can geospatial technologies (GST) play in assisting community colleges in making this transition? Furthermore, how can GST assist community colleges with other campus and administrative functions to improve the efficiency of a community college campus?

Results from the National Forum

What specific management and operational tasks can GST assist with to improve the efficiency of a community college campus?

National forum participants strongly agreed that a clear need exists for GST and geospatial technicians on community college campuses. Most of the participants had already demonstrated a variety of geospatial applications in addressing administrative tasks at their home campuses. The following list represents the participants' vision of the potential college activities that could be significantly enhanced by the use of GST:

- Student marketing and institutional research
- Documenting access
- Lobbying
- Grant writing
- Facilities management
- Local economic and partnership development

The evolving NGTC could provide valuable coordination and dissemination of GST products and services to the community college constituency. Over time, the NGTC will likely add and subtract new applications as the technology evolves. In addition, new community college situational challenges will arise and the NGTC will play a key role in elevating geospatial awareness among community college policy leaders. The NGTC should play an active role in elevating community college awareness of GST by engaging administrators and policy leaders through high visibility publications and conferences. These professional development pathways, as used by community college leaders, will demonstrate institutional applications of how geospatial technologies and methods can be leveraged to improve services to the students and communities they serve. A successful outcome will be to institutionalize geospatial technologies that support the community college mission of providing cost-effective education. This will be primarily accomplished by doing more with fewer resources, as GST will help target capital investment, services, and information needed for data-driven policy development.

How can GST assist in transitioning community colleges into entrepreneurial enterprises?

This question links specific recommendations on how GST could be used to address current and future administrative or management issues facing community colleges. Specifically, these recommendations serve as a potential guide in encouraging community colleges to think "spatially" about managing campus and student resources. Most of the participants were already engaged with linking GST to current administrative issues facing community colleges and provided

examples of such existing and potential applications. The examples will be categorized around the following community college programming topics or issues:

1. Student marketing
2. Documenting access
3. Lobbying
4. Grant writing
5. Facilities managements
6. Local economic development

The topics above serve as a potential blueprint for the NGTC in serving community colleges and supporting their evolving mission to serve student needs and communities.

Student Marketing

Knowing where students are from is a critical issue in developing efficient marketing strategies for community colleges and in assessing student needs. Using GST, community college admissions offices, recruiters, and counselors could engage and measure student marketing efforts in new dynamic ways and determine where new students could be targeted within a particular service area. This would contribute to enrollment growth. An example of this is demonstrated by an application developed at Lake Land College (LLC) to address marketing online curriculum within East-Central Illinois.

Geographic information analysis (through GIS) revealed that 632 out of 694 online students (91 percent) lived within the district. This information allowed administrators at LLC to measure the local, regional, or national student markets driving the institution's online program. Using a GST approach, LLC was able to demonstrate that its online students were primarily coming from in-district student markets and that the potential exists to expand regionally or nationally.

Documenting Access

Across the nation, community colleges are increasingly being asked to demonstrate how they are reaching groups that have historically been underserved in higher education. The *Achieving the Dream Project*, which is coordinated by American Association of Community Colleges (AACC), exemplifies this national movement. These underserved groups are typically students of low-income families, first generation students, or students of color (Lumina Foundation Report, 2004). Historically, students from these groups attend community colleges at a higher rate than the general population of students seeking higher education. GST could assist in this national discussion by visually demonstrating how community colleges serve these groups. Using GST to map regional economic, demographic and registered student trends could provide valuable insight to capture participation rates of these underserved groups. Integrating external data sets, like the U.S. Census Reports, with student enrollments could quantify new ways that

local community colleges are engaging these underserved populations. As a result, GST can assist in helping community colleges fulfill their mission relative to increasing and documenting access to higher education for all student populations locally, regionally, and nationally.

A recent study conducted by Community College Research Center at Columbia University demonstrated the potential of utilizing cluster analysis with GIS in linking the impact of local or regional socioeconomic status (SES) impacts community college programming. Researchers found that GIS was a natural tool for integrating the spatial relationships of student residential patterns in relation to U.S. Census Data profiling SES, and it could be useful in answering the following questions:

- Is the community college serving a population that reflects local, regional, or state trends relative to SES?

- Are the communities being served by a given community college changing over time, and if so, how will this impact programming?

- Could policy makers develop more data-driven strategies in developing tuition and financial aid policies around accurate SES information?

- Are certain neighborhoods or communities accessing higher education at different rates?

- Can marketing efforts be improved by linking student locations with communities and associated SES trends within regional frameworks?

Lobbying

A community college's ability to geographically demonstrate who they are and how they are similar to or different from other districts could assist them in making a case for increased funding. For example, LLC in Illinois receives less funding from property taxes than urban districts.

GST could assist state and local legislators in visualizing regional issues and serve to bring colleges together around a common strategic issue such as workforce development or funding issues. By using GST, community colleges can now demonstrate and quantify demographic or labor market trends within a given legislator's district. Overlaying the community college service area with a legislator's district will demonstrate how colleges can bring shared local or regional issues to key political figures for action.

Grant Writing

Some community colleges are beginning to integrate GIS technology into the grant development process. Jeri Beel, grant writer for LLC, states that many of the grants her office applies for stipulate conditions or criteria that must exist to meet grant guidelines. Applying for grants requires her office to generate data on district characteristics such as levels of educational attainment, income patterns, and high school student populations. LLC's grant office recently began utilizing GIS to support the college's Federal TRIO Talent Search grant. Beel describes how GIS assisted the college in
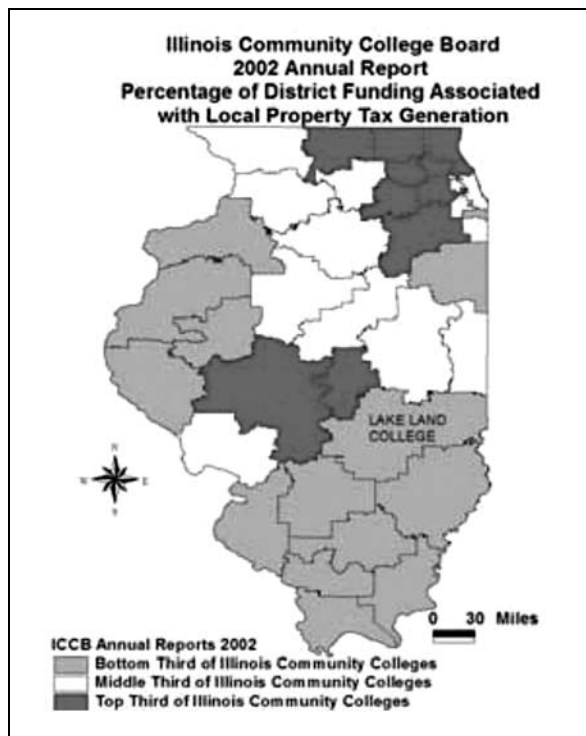
Figure 1. *Percentage of District Funding Associated with Local Property Taxes*

targeting regional patterns for low income, disabled, and first generation students enrolling in higher education and in analyzing other data to develop the grant proposal. Beel also suggests the ability to geographically integrate external data such as U.S. Census reports with local data on high school and community college student populations will be a powerful tool in speeding up the grant development process (Rudibaugh, Sullivan, and Gattrel, 2006). GST can assist community colleges with transitioning to a more entrepreneurial environment by positioning institutions as regional hubs for accessing, mapping, analyzing, and communicating federal, state, and local data and identifying critical local or regional issues shaping potential grant opportunities.

Facilities Management

The potential of GST to impact and improve community college facility management issues are numerous. First, the ability to use GST as support tools to assist students in navigating around campuses is one potential application. A community college in California is using GST to prepare the school to meet the American with Disabilities Act (ADA) design standards for an accessible community college.

Second, GST could be a powerful tool for community colleges to model facilities growth plans. As community colleges grow, their impact on adjacent and surrounding land uses becomes critical. Using GST and maps, community college leaders could demonstrate to local community leaders how this growth will impact the surrounding areas and potentially better serve students and economic development. Many community colleges are expanding their facilities to off-campus satellite locations. These decisions are often the

result of trying to better reach students in isolated areas of community college districts or service areas. Using GST, these decisions that are often made by community college policy leaders or college boards can be quantified and mapped to help visualize and justify the expansion based upon hard data.

Local and Regional Economic Development

Data integration with federal, state, regional, and local sources is one of the advantages of integrating GST with community college planning. From a national perspective, community colleges are adapting new approaches to obtain funding sources in meeting institutional needs. Utilizing GST, community colleges could position themselves as central repositories of data and information connecting regional and local economic development to broad national or global issues. As a result, GST could assist community colleges in developing regional and local partnerships and help them identify the issues that are shaping regional economic development opportunities.

The map below demonstrates how federal data from U.S. Census Bureau could be used to map a potential industry cluster for a given industry. McHenry Community College in Crystal Lake, Illinois can quantify and demonstrate that a robust occupational market for gaming technicians exists south of the campus. Documenting and quantifying existing industry clusters, like the one above, could assist community colleges in leading economic development discussions on how best to leverage local competitive advantages in developing or advancing a given industry. In addition, they could document and map the regional viability for supporting a new program. Using GST as a data validation engine, community colleges could regionally map the number of businesses and industries needing training in key occupational industries. This information and data could bridge,
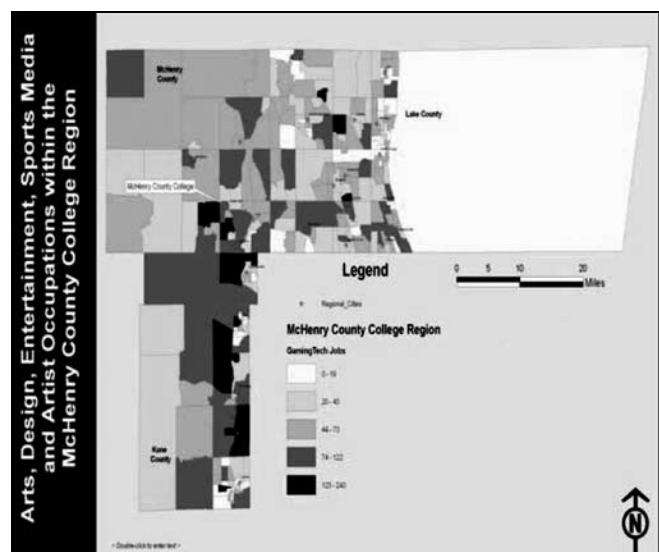

Figure 2. *Gaming Technology Jobs in McHenry County College (U.S. Census Data 2000)*

in a quantifiable way, new approaches in linking businesses, students, and community college programs together under the collective identity of local economic development.

Recommendations from the National Forum

Recommendations from the national forum panel group on institutional research, entrepreneurialism, and GIS indicate three primary goals for the NGTC to address within a five-year vision to promote geospatial education within community colleges.

Recommendation #1

The NGTC will develop a searchable clearinghouse with how-to templates, standard data models and best practices to duplicate curriculum-driven entrepreneurial activities/experiences linking GST to community college administrative issues. By maintaining a repository of case studies on administrative applications of GST, the NGTC will serve as a valuable dissemination arm for education community college policy leaders on the potential benefits of the technology. Clearly, many community colleges are currently engaged in, or planning, projects linking community college GST programs with institutional needs relating to data analysis and acquisition. The NGTC could serve as a single repository for these projects and raise awareness on the valuable role GST could play in effective data management of community college campuses. As a result, the NGTC could assist in linking GST to the growing entrepreneurial mission of community colleges and elevate GST as a critical decision support tool. The validation post-conference survey indicates strong support for this issue from the national forum participants

With a high priority response rate of 71.8 percent, this recommendation rates as one of the highest potential services listed on the entire validation survey. Clearly, national forum participants agree that demonstrating the value of GST by applying them towards local community college issues has value. Coordinating new methods, models, and applications of GST towards community college institutional issues will, over time, lead to increasing understanding of the value the technologies play in managing a modern digital institution. As community college policy leaders and administrators see these examples, key buy-in and support will grow for GST within the community college system. This buy-in from policy leaders within the community college system will be critical in developing other issues associated with the NGTC, such as elevating the need for professional development for faculty, curriculum integration with other disciplines, and long-term sustainability.

Recommendation #2

The NGTC will develop MOUs with government and industry to establish guidelines for what community college GST programs can and cannot do to generate money under state law. How can community colleges ethically and legally leverage project-based GST learning opportunities within existing and future GST programs at community colleges?

Using students to address local or institutional GST needs could cause conflict with regional private sector vendors. The NGTC will need to coordinate issues such as charges of unfair competition and regulatory state laws in maximizing how community colleges elevate their entrepreneurial mission through GST programs.

More than half of the national forum participants agreed that an NGTC should address the role of using community college GST programs for institutional purposes. Clearly, community colleges should leverage the resources of GST programs in addressing issues impacting the institution, such as facilities management, marketing, and data integration. However, the evolving NGTC should assist and model how community colleges leverage their GST programs in elevating the rising entrepreneurial mission of community colleges. Results from the validation survey indicate that the NGTC should provide guidance on how community colleges address these legal issues and how to best develop GST entrepreneurialism without causing conflict with local or regional vendors providing related services. Past studies on the geospatial industry and jobs indicate a clustering in metropolitan areas; whereas, rural areas nationally have little to no private vendors offering GST services (Campins and Thrall, 2004). These results suggest that the NGTC will have to coordinate and inform community colleges on location specific issues relating to how they can best legally use GST programs for supporting institutional applications.

Recommendation #3

The NGTC will serve as a clearinghouse for community college geospatial data. The NGTC will coordinate and develop a "one-stop shop" for community college data through a web-based portal. This portal will allow any community college administrator, board member, faculty, community member or student to visualize and access local/regional information around any community college. The data and information housed by the site should be based upon extensive input from community college policy leaders. This input will assist the NGTC in designing a clearinghouse that best serves the community college system in addressing current and future issues, such as documenting access, student diversity, grant writing, economic development, and marketing. Services like this will enable GST in achieve the community college mission and develop a unique niche for the NGTC in promoting long-term sustainability.

Validation survey results indicate a majority of the national forum participants agree with recommendation number three. A majority of the participants see an active role for the NGTC in managing and disseminating data related to community college programming. This potential role for NGTC directly relates to the idea of developing long-term sustainability for the Center. Specifically, the NGTC should be aware that community college policy makers could be one of the user groups most likely to need the services of the Center. Using data and information are critical elements in developing entrepreneurialism within

modern community colleges. Clearly, the NGTC could play a role in developing and linking GST in promoting community college entrepreneurialism through data integration and spatial analysis.

Conclusion

GST can assist community colleges with transitioning to a more entrepreneurial environment by positioning institutions as regional hubs for accessing, mapping, analyzing, and communicating federal, state, and local data. GST can immediately address major questions for community college policy leaders such as:

1. Who are the current students, and how do they differ spatially throughout the service area?

2. Does enrollment reflect the diversity of the service area or are some audiences underrepresented on campus?

3. What are the demographic and economic trends within and outside the district and how do they vary over space and time? What type of interrelationships can be observed?

The NGTC should work with existing community college organizations to increase awareness of GST. Community colleges are in a unique position to demonstrate the value and need for more geospatial technicians. The very nature of managing and delivering services to students and communities served by community colleges provides a dynamic test-bed for demonstrating the utility of GST. Nationally the community college system has a number of professional organizations and research centers with which the NGTC could partner. Organizations like the American Association of Community Colleges coordinate a number of publications, annual meetings, and conferences attended by thousands of administrators working within the community college system. In addition, numerous community college research centers like the Community College Research Center (CCRC) at Columbia University serve as an excellent network in disseminating the value of GST to the community college research community. The following list represents a sample of organizations promoting community college research, development, and advocacy:

- Community College Research Center (CCRC), http://ccrc.tc.columbia.edu

- MDRC, www.mdrc.org

- American Association of Community Colleges, www.aacc.nche.edu

- Center for Community College Policy, www.communitycollegepolicy.org

- Community College National Center for Community Engagement, www.mc.maricopa.edu/other/engagement/index.jsp

- Council for the Study of Community Colleges, www.cscconline.org

- Rural Community College Alliance, www.ruralcommunitycollege.org

- Office of Community College Research and Leadership, http://occrl.ed.uiuc.edu

- Council for the Study of Community Colleges, www.cscconline.org

The NGTC needs to actively participate with these professional organizations in elevating the general awareness of GST to community college management issues.

In conclusion, GST's ability to improve community college entrepreneurialism can greatly enhance an NGTC's long-term sustainability by providing a unique service that colleges will pay for. Community college administrators and policy leaders regularly manage data and information that could be managed more effectively using GST, allowing them to help maintain the community college mission of providing cost effective education. This will be primarily accomplished by doing more with fewer resources, as GST will help target capital investment, services and information needed for data driven policy development. National forum participants strongly agreed that this will help elevate the need for GST on community college campuses. Increasing needs for good student marketing, documenting access/diversity, revenue generation, grant writing, and efficient facilities management represent an opportunity for the NGTC to assist the national community college movement in addressing critical institutional challenges.

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Geospatial Technology Future Trends

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Overview

The goal of this report is to determine if an NGTC should serve as a resource on trends in geospatial technology. To provide additional insight on this issue, a cursory review of current and potential sources for trends in the geospatial industry was conducted, guided by four research questions:

1. To what geospatial technology changes will the GIS educational community need to adapt?

   a. Web-based GIS

   b. Remote Sensing

   c. GPS

   d. Multiuser GIS databases

   e. Data Models (geodatabases)

   f. Other

2. How will the GIS educational community need to adapt to the changes in how GIS is being used by a broader sector of our workforce?

3. Which sectors of the economy are expected to have the largest increase in the use of geospatial technologies over the next five to 10 years?

4. What organizations (e.g., industries, businesses, government agencies, and research/educational institutions) will be the key players in developing and using geospatial technologies?

Background Research

For the past eight years, the Geospatial Information & Technology Association (GITA) has published the Geospatial Technology Report, a comprehensive industry survey that includes the completeness, complexity, and direction of GIS projects being implemented at nearly 400 infrastructure organizations. By far the most comprehensive source for the current and future direction of geospatial technologies, the report provides cross-industry analyses as well as detailed information on individual industries. The 2006 report also includes the Department of Labor's geospatial workforce trends analysis and benchmarking statistics from GITA's Industry Trends Analysis Group. The cost of the report is $229.00 for members and $449.00 for non-members.

In addition to GITA, other agencies such as the University Consortium for Geographic Information Science (UCGIS) and the National Research Council (NRC) have provided comprehensive reports that identify key educational issues associated with the changing nature of geospatial technolo-

gies. Another excellent resource for overall trends in the GST industry is provided by GeoWorld, a website that provides a year-end "futurecasting" feature where the editorial advisory board members reflect on the year's changes and discuss their implications for geospatial technology's future. There is a cost for using this document or any of its excerpts. However, it is an excellent source for industry trends and also contains a five year forecast.

1. **GITA 2006 Geospatial Technology Report**
   www.gita.org/resources/geo_report/georeport.html

2. **UCGIS Body of Knowledge**
   www.ucgis.org/priorities/education/
   modelcurriculaproject.asp

3. **GeoWorld Industry Outlook 2006**
   www.geoplace.com/uploads/FeatureArticle/
   0512io.asp

4. **National Research Council - Beyond Mapping: Meeting National Needs Through Enhanced GIS**
   www.nap.edu/catalog/11687.html

This summary report represents responses to the posted questions as derived from GITA, UCGIS, and other industry reports.

Research Questions

1. To what geospatial technology changes will the GIS educational community need to adapt?

A. Web-based GIS

It is been predicted that web-based GIS may eventually become the dominant form for accessing GIS information. Web-based GIS currently has a higher potential user base and the lowest cost per user (Longley et al., 2001). This is apparent with the increasing use of web-based geospatial technologies such as Google Earth. We are experiencing a continuous, global, and rapid increase in web technology and Internet mapping services. The educational system must react with both client-side and server-side applications. For example, web-based geospatial instruction will involve IT integration and customized user interfaces. Distance education and the introduction of GIS in such areas as K-12 also make the future of web GIS very bright. The following links provide information on web-based GIS and what the future may hold.

Internet GIS - Future Impacts and GIS Web Services
http://map.sdsu.edu/gisbook/ch14.htm
This book provides an overview of current developments

in distributed computing and Internet GIS services. The discussions are intended to help the GIS community adopt a sustainable, integrated strategy in developing open and distributed geographic information services.

Trends in Web Mapping: It's All about Usability
www.directionsmag.com/article.php?article_id=1988&trv=1
Written by Maurits van der Vlugt and Ian Stanley, this article presents guidelines and some "dos and don'ts" of Web mapping design. Aspects of Web design such as user profiling, task definition, and usability testing are discussed. The article also presents information on recent best practice case studies on web mapping trends.

Server GIS Trends (ESRI)
www.esri.com/technology_trends/server_gis/index.html
To deliver geospatial information and functionality throughout the enterprise, organizations are choosing to extend their traditional desktop GIS implementations with innovative server-based GIS solutions that provide content and capabilities via Web services, such as ESRI, the leading provider of GIS technology. This paper discusses issues associated with web-based GIS including integration, collaboration, and the use of web-based GIS to support organizational workflow.

NCGIA Core Curriculum in Geographic Information Science: Unit 133-WEBGIS.
www.ncgia.ucsb.edu/giscc/units/u133/u133_f.html
This unit is part of the NCGIA Core Curriculum in Geographic Information Science (www.ncgia.ucsb.edu/giscc/). These materials may be used for study and research and are authored by Kenneth E. Foote and Anthony P. Kirvan under the aegis of the project, NCGIA Core Curriculum in GIScience.

Advancing Web GIS "Beyond Mapping"
www.geo.orst.edu/ucgis/webgis.html
Moving Web-based GIS beyond mapping is a research topic with the UCGIS. This page includes a research paper entitled Pervasive Computing (www.geo.orst.edu/ucgis/q_pervasive_computing.pdf) that discusses some of the critical issues with web-based GIS. Issues to be addressed include the need for the development of a data structure to accurately represent movements across networks, file permissions, legacy files and data sets, teleportation, etc.

Web-Based GIS: Frequently Asked Questions
www.hrg-inc.com/webGIS.asp
This website provides an industry approach to some of the basic questions and answers for the development and implementation of web-based GIS.

B. Remote Sensing
Remote sensing (RS) is a rapidly developing geospatial technology that complements both GIS and global positioning systems (GPS). Its power is its ability to discern

and quantify the land cover characteristics at a given time. An orthorectified remotely sensed image (corrected to minimize effects of camera tilt and lens distortion) becomes a very valuable base map for GIS analysis. RS technology involves a variety of sensors that are rapidly and continuously improving in their ability to provide greater spatial, spectral and radiometric resolution.

When combined with feature-based extraction methods, these sensors have the power to provide a detailed land cover map that can clearly identify land cover types, species of flora/fauna, ocean and atmospheric conditions, mineral deposits, pest infestations, and pollution plumes, to name a few possibilities. The development of new software algorithms combined with fast computing and large data storage capabilities has moved us to the threshold of a "golden age" of remote sensing. The biggest hurdle to the rapid integration of RS technology in society is the lack of sufficient development of the end user community of RS products. This is a challenge that will have to be addressed by systemic RS literacy initiatives by the geospatial education community. The following links provide information on the future of remote sensing.

The Ten Year Remote Sensing Industry Forecast
www.asprs.org/news/forecast/10-year-ind-forecast.pdf
In August 1999, the National Aeronautics and Space Administration (NASA) and The American Society for Photogrammetry and Remote Sensing (ASPRS) agreed to undertake a comprehensive study of the remote sensing and geospatial information industry in the United States. Their ultimate goal was to develop a continuing forecast of the remote sensing industry. In 2002, the National Oceanic and Atmospheric Administration (NOAA) formally joined NASA and ASPRS to support the documentation and analysis of the forecast and to provide further information to the private sector and government agencies.

RAND Corporation Science and Technology Policy Institute
www.rand.org/scitech/stpi/ourfuture/Internet/sec4_sensing.html
A federally-funded research and development center,the Institute is sponsored by the National Science Foundation and managed by the RAND Corporation. The Institute's mission is to help improve public policy by conducting objective, independent research and analysis on science and technology policy issues. The link above is an article published by RAND on the future of remote sensing.

The Future of Remote Sensing
www.pegasus4europe.com/pegasus/workshop/home.htm
Sponsored by the VITO research organization, the website for the second international conference on the future of remote sensing provides a variety of articles on future technology trends.

C. Global Positioning System (GPS)

GPS has emerged as a very powerful technology for collecting geodetic and mapping quality data for GIS applications. The future of GIS is therefore tied to the future of the GPS technology. The following links show some of the future application areas of the GPS technology, which will help with the development of course curriculum that enables people to tailor their training to areas of interest.

Geospatial Solutions

www.geospatial-solutions.com/geospatialsolutions/
www.geospatial-online.com/geospatialsolutions/article/
articleDetail.jsp?id=118593
The website covers all areas of the geospatial technology fields, including GPS, GIS, and remote sensing. The article is about the future of these geospatial technologies.

The Origins, Status, and Future of GPS

www.its.umn.edu/seminars/2003/3parkinson.html
This paper discusses some of the potential application areas of GPS.

GPS World

www.gpsworld.com/gpsworld/
GPS World's market-segmented microsites are the most recent out-of-the-box tools for professionals in every technology field that uses or seeks to use GPS and timing.

CNS Systems, Inc.

www.cnssys.com/CNSLinks.html
A provider of communication, navigation and surveillance systems, CNS Systems' website provides a list of key GPS resources including NASA, the Federal Aviation Administration (FAA), the Institute of Navigation (ION), and many others.

Global Positioning System (GPS) Resources

edu-observatory.org/gps/
This comprehensive resource link provides information on resources for GPS education, technical papers, commercial resources, and consumer equipment resources.

D. Multi-user GIS databases

Historically, the introduction of GIS into an organization begins with a single user system operated by a small number of employees or specialists. Over time, the use and integration of GIS technology increases and the technology becomes a necessary component of the organization's overall data management, requiring geospatial data access for multiple users and leading to the integration of spatial and non-spatial data systems within an enterprise GIS system.

> *An enterprise GIS is an integrated, multi-departmental system for collecting, analyzing, visualizing, managing, and disseminating geographic information. It includes the infrastructure, mission critical capabilities, and robust architectures associated with other enterprise software. It is intended to address both the collective and individual needs of an organization, and to make geographic information and services available to both GIS and non-GIS professionals (Dangermond, 2006).*

The GIS educational community will have to adapt as multi-user GIS becomes more widespread. It is relatively simple to provide GIS instruction from a single-user platform on stand-alone computers. Providing instruction from a networked multi-user platform takes more resources, IT infrastructure, and instructor management. The evolution of GIS toward a networked system follows closely with IT trends. The following links provide information on multi-user and enterprise GIS.

Interoperability in Enterprise GIS

www.esri.com/library/whitepapers/pdfs/
interoperability-in-enterprise-gis.pdf
This ESRI white paper outlines a strategy for supporting enterprise GIS given current trends in the software industry. It includes a discussion of implementation issues that can be used as a guide for academic programs.

Secure Access Control in a Multi-user Geodatabase

http://gis.esri.com/library/userconf/proc02/pap0355/
p0355.htm
As GIS transforms from a single- to multi-user environment such as enterprise GIS, one of the issues associated with this paradigm shift is data security. This paper examines the confidentiality issues in GIS context and defines an access control model for a multi-user geodatabase within an enterprise-level GIS environment.

A Road Map to Implementing an Enterprise GIS

http://gis.esri.com/library/userconf/proc01/
professional/papers/pap315/p315.htm
This paper summarizes the implementation process of an example of multi-user GIS application in four phases: data model design, building a geodatabase into a multi-user GIS, migrating CAD data to a geodatabase, and GIS deployment and data maintenance strategies. Major roadblocks related to each phase are identified, and alternative solutions are provided.

Spatial Data Management in an Enterprise GIS

http://gis.esri.com/library/userconf/proc01/
professional/papers/pap742/p742.htm
This paper describes the experience of the St. George Consulting Group and the Maine Department of Environmental Protection in creating a spatial data management infrastructure for an enterprise GIS. It also discusses the issues involved in creating large extent spatial datasets, data inventory and organization issues, data migration issues, tuning experience for ArcSDE in Oracle 8i, and the storage of imagery in ArcSDE.

2. How will the GIS educational community need to adapt to the changes in how GIS is being used by a broader sector of our workforce?

As GIS becomes ubiquitous in almost all industries, the traditional way of teaching GIS in a small sector of the academic curriculum may need to be revisited. GIS educators will need to consider the expansion of GIS courses to other disciplines to support discipline-specific programs as an enabling technology, which may require the establishment of additional infrastructure to support expanded instruction.

Similarly, as GIS usage expands, it is important to ensure that all members of our society have full access to these technologies and data. As an emerging technology, new careers in GIS have the potential to attract underrepresented groups such as women and minorities. With its emphasis on visual approaches and spatial reasoning, GIS may provide new tools and approaches for teaching students who have difficulty learning through traditional teaching methods. GIS educators need to ensure access to education for all students, including those with physical or learning impairments and those from underrepresented racial, age, gender, and socio-economic backgrounds.

It is increasingly becoming apparent that the traditional one-size-fits-all GIS curricula will not work in the new education environment. Educators need to consider course development based on the various demands of GIS workplaces and the needs of different types of students. Improving GIS education will therefore require the specification and assessment of curricula for a wide range of student constituencies. Working professionals will be an important constituency for GIS education; as more and more industries begin to use this technology, current workers will be required to get relevant professional training. This may change the design of traditional GIS education. Perhaps a seamless model that provides flexibility for in and out of the classroom can be considered by GIS educators. Similarly, GIS educators may have to expand their conventional GIS classroom teaching to include Internet-based teaching to accommodate professionals who cannot come to their classrooms.

Program accreditation and certification is another critical issue that needs to be addressed as GIS education is greatly expanded.

3. Which sectors of the economy are expected to have the largest increase in the use of geospatial technologies over the next five or 10 years?

Municipalities. GIS is well-established as a management tool for mid- to large-sized city and county governments. A larger number of small municipalities are now beginning to use GIS.

Utilities. This includes utility companies, such as power, gas, telecommunications, television, pipeline, water/wastewater, local government, and public works. Increasing concerns regarding national security make it imperative that utility facility data is easily shared, warehoused, and accessed.

Transportation and Distribution. Examples include

vehicle navigation systems, tracking, hazardous material routing, and aircraft landing.

Real Estate. Real estate sectors include residential, commercial, land, farm, and government land agencies.

Consultants. GIS tools are used by consultants in every industry, including civil, construction, environmental and utility engineers, surveyors, planners, researchers, and analysts. As governments continue to distribute work to private entities, accurate and timely data sharing and distribution becomes more important.

Marketing. GIS information can be key to marketing, no matter the approach. Retailers, advertising agencies, and telemarketers can use GIS tools to find new sites and customers, and economic development boards can use them to find and bring new companies and industries to an area.

Emergency Response. From homeland security to local emergency response, GIS is critical in situation management and preparedness. Accurate data on hazardous materials, effects of climatic conditions, location of drainage ways, flood hazards, utilities, and much more can be organized and distributed utilizing GIS and GPS technologies.

Recreation. Outfitters and guides, hunters and fishermen, off-road enthusiasts and snowmobile users need maps, geographic weather predictions, fishing reports, and GPS networks.

Location-based Services. Wireless application of GIS ranges from onboard navigation systems in cars to business uses such as petroleum prospecting and exploration. And as GIS becomes more fully integrated into cell phones, it's likely that consumers will be able to use it to find geographic information about people and businesses.

4. What organizations (e.g., industries, businesses, government agencies, and research/educational institutions) will be the key players in developing and using geospatial technologies?

Geospatial technologies developers will include software developers such as ESRI (ArcGIS), Leica Geosystems (ERDAS Imagine), and Clark Labs (IDRISI). Similarly, hardware developers such as Magellan, Trimble, and Leica will play a significant role in the development of the GPS technology. Geospatial data collection and packaging companies, such as the U.S. Geological Survey (USGS), various state clearinghouses, regional development centers (RDC) and small data supply companies will also have a larger role in the future of GST. GST users such as car manufacturers, utility companies, and phone companies will help define the direction and future of the geospatial industry. In addition to developers and users, research and education institutions including primary and secondary education, technical colleges, and universities; and professional association and federal data standards organizations such as the Federal Geographic Data Committee (FGDC),

National Spatial Data Infrastructure (NSDI), UCGIS, the American Congress on Surveying and Mapping (ACSM), the Geospatial Information and Technology Association (GITA), the Urban and Regional Information Systems Association (URISA), the American Society for Photogrammetry and Remote Sensing (ASPRS), and the Association of American Geographers (AAG) will define the educational direction of the industry.

Conclusion

Geospatial education needs to address two themes that recurred throughout the various source documents. First, there is an increasing need for the inclusion of information technology instruction in the geospatial curriculum, including issues related to the evolution of GIS to enterprise GIS.

Second, there is a growing need for web-based instruction and data delivery. By serving as a resource for future trends in GST, an NGTC will help users in industry, government agencies, and research and educational institutions stay abreast of critical technology and economic changes.

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Appendix A

GeoWDC Geospatial Competency Model

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

	Competency	Applications Development	Coordination	Data Acquisition	Data Analysis	Data Management	Management	Marketing	Project Management	Systems Analysis	Systems Management	Training	Visualization
Technical	Ability to Assess Relationships Among Geospatial Technologies		●				●	●		●	●	●	●
	Cartography			●	●								●
	Computer Programming Skills	●		●		●				●			●
	Environmental Applications	●			●								●
	GIS Theory and Applications	●			●	●	●		●		●	●	●
	Geology Applications				●								
	Geospatial Data Processing Tools			●	●					●	●	●	●
	Photogrammetry	●		●	●								●
	Remote Sensing Theory and Applications	●		●	●						●		●
	Spatial Information Processing	●		●	●							●	●
	Technical Writing	●	●		●		●	●	●	●	●	●	●
	Technological Literacy	●		●	●	●	●		●	●	●	●	●
	Topology				●								●
Business	Ability to see the "Big Picture"	●	●			●	●	●		●	●	●	
	Business Understanding		●				●		●				
	Buy-in/Advocacy		●				●	●		●		●	●
	Change Management	●	●		●	●	●	●	●	●	●	●	●
	Cost Benefit Analysis / ROI		●				●	●	●		●	●	●
	Ethics Modeling				●		●	●	●		●	●	●
	Industry Understanding	●	●				●	●				●	●
	Legal Understanding		●										
	Organization Understanding		●				●				●		
	Performance Analysis and Evaluation			●			●		●	●	●	●	
	Visioning		●				●	●	●	●	●	●	
Analytical	Creative Thinking	●	●	●	●	●	●	●	●	●	●	●	●
	Knowledge Management		●		●		●		●		●	●	●
	Model Building Skills	●				●	●				●	●	●
	Problem-Solving Skills	●	●	●	●	●	●	●	●	●	●	●	●
	Research Skill	●			●							●	
	Systems Thinking	●					●			●	●	●	●
Interpersonal	Coaching		●				●					●	
	Communication	●	●	●	●	●	●	●	●	●	●	●	●
	Conflict Management		●				●		●		●	●	
	Feedback Skills	●	●	●	●	●	●	●	●	●	●	●	●
	Group Process Understanding		●				●		●		●	●	
	Leadership Skills		●			●	●	●	●		●	●	●
	Questioning		●				●	●		●	●	●	
	Relationship Building Skills		●				●	●	●	●	●	●	
	Self-Knowledge/Self-Management		●				●	●		●	●	●	

Appendix B

Recommendations for Closing the Gap between
Geospatial Workforce Demand and Supply

From *Defining and Communicating Geospatial Industry Workforce Demand*, Phase I Report, Draft for Comment. GITA 2006.

- GIS education needs to become much more prevalent in all levels and links between related areas of study. The percentage of students enrolled in GIS programs needs to be significantly increased through aggressive outreach campaigns and by building awareness of the geospatial industry in general.

- Geographical sciences and geospatial technologies must be embedded in core curricula of K-12 and K-16. The entire educational continuum (from K-12, community colleges, undergraduate and graduate programs, to life-long continuing education) must be involved.

- The National Research Council's publication Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum should be used to better integrate geospatial thinking into existing courses. The report is available on line at www.nap.edu/catalog/11019.html.

- In addition to the NRC report, efforts by professional associations, such as the AAG's Enhancing Departments and Graduate Educations (EDGE) project and Teacher's Guide to Modern Geography; the forthcoming Geographic Information Science and Technology (GI S&T) Body of Knowledge; and the NCGIA's Core Curriculum in GISci, should be leveraged to help build a comprehensive educational strategy to help meet the current and future geospatial workforce demand.

- Employers and educators must work together to develop effective strategies to close the gap between geospatial workforce demand and supply. The geospatial industry must articulate its workforce needs to ensure that educators respond with curricula that result in appropriately educated and trained individuals.

- Two year (community-based) colleges should assume a strong role in training new geospatial technologists and meeting on-the-job training needs of local professionals.

- Within social, behavioral and economic sciences, there is not enough emphasis on use of geospatial methods and techniques. There is a need for training in spatial analysis within the domains of statistics and quantitative analysis.

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Appendix C

Project PIs

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Appendix D

Agenda
National Form on Geospatial Technology Education
January 5-7, 2007

Friday, January 5

5:00 - 7:00 pm   Introductory Meeting and Overview with 5 minute presentation on
                        each critical issue (participants sign up for two issues.)
                        Hors d' oeuvres will be served (Bay View Room)

Saturday, January 6

7:00 – 7:45 am   Breakfast

8:00 – 8:30   Opening Session and Overview to UCGIS Body of Knowledge

8:30 – 10:00   Five Critical Issue Breakout Groups (small groups)

10:00 – 10:15   Break

10:15 – 12:15   Report Out and Discussion of Five Issues (all together)

12:15 – 1:00   Lunch

1:00 – 2:30   Five Critical Issue Breakout Groups (small groups)

2:30 – 2:45   Break

2:45 – 4:00   Report out and Discussion of Five Issues (all together)

4:00 – 5:00   Break

5:00 – 6:00   Presentations by AAG, NSF and short wrap up of day

6:00   Dinner with advisory committee at the hotel or on your own

Sunday, January 7

7:00 – 7:45 am   Breakfast

8:00 – 10:30   Critical Issue – Qualities of a Successful ATE Center (MATE and AgrowKnowledge
                        examples) related to all other Critical Issues and the survey results (all together)

10:30 – 10:45   Break

10:45 – noon   Closing session – building partnerships and consensus – Short (3 minutes)
                        presentations by those interested in participating in a Center

Noon   Lunch