Educating 21st Century Geospatial Technology Industry Workers with Open Source Software

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Abstract

The global geospatial technology industry, in a study by UK-based Oxera commissioned by Google in January 2013, has been estimated at $150 USD billion to $270 USD billion per year ($110 billion euro to $199 billion euro). In a similar US-focused study, also commissioned by Google in 2013, the Boston Consulting Group (BCG) found the geospatial services industry employs approximately 500,000 people and generates around $75 (USD) billion in annual revenue ($55 billion euro). By any measure, the geospatial industry is large one, in both the US and globally. With this explosive growth, combined with the current generation of geospatial workers nearing retirement age in the next decade, it has become imperative to increase the number of well-qualified graduates from higher education programs, knowledgeable in the latest geospatial technology. This report describes one effort in the US to increase both the quantity and quality of these workers through the use of a new innovative geospatial curriculum built around open source software.

Keywords: Curriculum, open source, FOSS4G, education, university, college, QGIS, GTCM, DACUM, teaching, learning, ESRI, Google, FOSS.

1 Demand for Geospatial Industry Workers

The global geospatial technology industry, in a recent study by UK-based Oxera commissioned by Google in January 2013, has been estimated at $150 USD billion to $270 USD billion per year ($110 billion euro to $199 billion euro). In a similar US-focused study, also commissioned by Google in 2013, the Boston Consulting Group (BCG) found the geospatial services industry employs approximately 500,000 people and generates around $75 (USD) billion in annual revenue ($55 billion euro). By any measure, the geospatial industry is large one, both in the US and

globally. With many of the current generation of the world's geospatial workers nearing retirement age in the next decade, it has become imperative to increase the number of well-qualified graduates from higher education programs, knowledgeable in the latest geospatial technology, to replace retiring workers and to meet the demand for even more workers in this expanding industry. Table 1 depicts this demand in the United States of America.

2 Limited Software Options for Students

In the US, software from a single vendor is used almost exclusively by 90% of the 1400 colleges and university academic GIS programs nationwide. By focusing heavily on the US higher education market for more than two decades, this vendor can legitimately claim their product is used to train 9 out of every 10 graduates in the US. Although their nonacademic business share of the global market was estimated at 40% in 2012, they dominate the US higher education section by a disproportionally large margin. This lopsided representation, we believe, is detrimental to the global competitiveness of US workers, as well as limiting their technical skill set. By providing a robust and well marketed GIS education program, this vendor dominates the academic GIS market. In the latest survey of US academic GIS departments nationwide (GeoTech Center; annual report, 2012), only 5% of colleges and universities reported offering any form of open source geospatial software. This same survey revealed that more than half of the faculty responding indicated an interest in using open source in their classrooms and labs.

3 What Is Lacking in Geospatial Software Instruction?

In order to provide students with the opportunity to work and gain competence in open source geospatial software, we must first build instructors an Open Source Software Learning Infrastructure. This in-

Occupation	Employment (2010)	Projected Growth (2010-2020)	Projected Growth Rate (2010-2020)
Geospatial Information Technician	210,000	51,600	3 to 9%
Remote Sensing Scientists and Technologists	30,000	13,300	3 to 9%
Remote Sensing Technicians	62,000	33,500	10 to 19%
Geodetic Surveyors*	51,000	24,200	20 to 28%
Mapping Technicians	57,000	20,000	10 to 19%
Cartographers and Photogrammetrists	14,000	6,100	20 to 28%
TOTALS	**424,000**	**148,700**	**(3 to 28%)**

Table 1. Geospatial Occupations U.S. Department of Labor Employment and Training Administration Projected Geospatial Job Grow (DOLETA). Source: U.S. Department of Labor Employment and Training Administration, O*NET Online, http://online.onetcenter.org/, September 1, 2013

frastructure must be as equally robust as the current leading commercial vendor's framework. This framework is able to offer a complete, ready-to-use curriculum and support products to academics at competitive pricing. This support includes: a) textbooks and lab manuals for all levels of learners, b) a virtual campus of online courses, c) professional development for educators through workshops, and d) robust community of practice through regional user's group and conferences. Compare this to the open source educational resources, where there is a lack of ready-to-use curriculum, limited opportunities for professional development, limited number of textbooks and online courses, and a small, but growing community of practice among educators using open source software. We cannot fully achieve the Geo-For-All initiative of the ICA-OSGeo pact without this infrastructure. The goal of our research is to increase the quantity and quality of open source software curriculum resources available to higher education faculty in order to boost its broader adoption in colleges and universities across the United States.

4 Determining the Worker's Knowledge, Skills and Abilities

The US Department of Labor's Geospatial Technology Competency Model (GTCM) is the recognized standard in defining the requisite skills of the indus-

try workforce. This model provides a comprehensive list of the knowledge, skills, and abilities (KSA) required of workers in the geospatial technology industry. The model is represented as a pyramid, with the most fundamental skills at the base and building upward into more specialized knowledge areas. This model (Figure 1) has been used by hundreds of educators in the US, Europe and Asia to align GIS courses and curriculum with industry-identified KSAs. Beginning at the lowest tier (1), the foundational knowledge and skills are defined and applicable to all levels of workers in the industry—from entry-level technicians to expert scientist. Moving up in Tiers 2 and 3 more broad academic (Tier 2) and workplace (Tier 3) skills are defined, again applying to all workers in the industry. At Tier 4 we begin to define the foundation geospatial competencies required of all workers in the field. At Tier 5, the model separates into three broadly defined sectors of the industry, each with its own specific set of competencies germane to workers in that particular sector of the industry. The genius of the GTCM in Tier 5 was achieving, for the first time, a broadly accepted definition of the sectors. Moving into Tier 6, Occupational Specific Competencies, the model defines job-specific tasks and skills needed by those workers. These jobs are defined by the Department of Labor's Standard Occupation Codes, which are updated periodically, separate from the GTCM. Complimenting Tier 6 is the Geospatial Technology Management Competencies,

which have been defined by the Department of Labor through the work of URISA in 2012. This Tier defines the broad management skills needed to organize and management significant geospatial projects and departments.
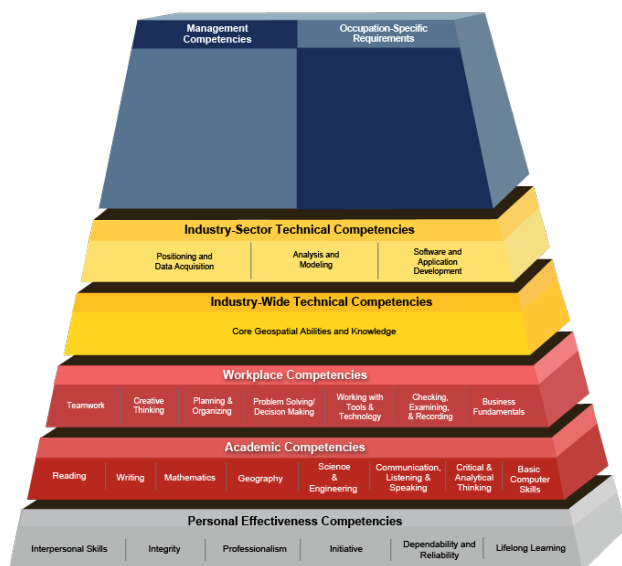

Figure 1. The US DOL Geospatial Technology Competency Model (GTCM). http://www.careeronestop.org/competencymodel/pyramid.aspx?geo=Y.

By contrast with the UCGIS Body of Knowledge (BoK), published in 2006, the Geospatial Technology Competency Model (GTCM) is the result of industry-driven input. The BoK, by comparison, contains some 1660 individual items and was created exclusively by a group of distinguished academics from Tier 1 research universities in the US. The GTCM contains a more finite 660 items, and represents the consensus outcome of a dozen industry-recognized experts in a two day panel that was conducted in March 2010. This panel of distinguished professionals represented the broadest possible cross-section of the industry, including surveyors, cartographers, geographers, computer scientists, remote sensing, photogrammetrist, and GNSS satellite experts. Their work was facilitated under the auspices of the US Department of Labor by a professional trained in the consensus-building process. The collective results of the GTCM national panel were then further vetted, during April 2010, among a much larger group of US Geospatial Industry professionals. This vetting included participation from national professional organizations, such as the American Association of Geographers (AAG), the American Society of

Photogrammetry and Remote Sensing (ASPRS), and others. Through electronic surveys and public commenting, the GTCM was further refined in May 2010. Finally, the GTCM was reviewed and approved for publication by the US Department of Labor on June 10, 2010.

5 Localizing the Model with Regional Input

To make the national GTCM, containing 660 items, even more usable by educators, the GeoTech Center undertook a series of industry-led workshops around the country. These facilitated panels performed what is known as a DACUM, or Developing A Curriculum building exercise. Similar to the process used in the national GTCM panel, these regional DACUM panels, consisting of 6 to 12 professional, were limited to industry worker participation. The KSAs identified in these workshops were then vetted among a larger group of GIS professionals in the region using electronic surveys. These results were then finalized and published on the GeoTech Center website. While academics were allowed to observe, they were prohibited from participating in the actual workshop, assuring the results represented only industry-derived KSAs. The workers participating in the DACUM panels and electronic surveys included government workers, engineering technicians, GIS managers, etc. The results of these individual DACUM panels, held at five different locations between 2009 and 2012. These results were then collated and mathematically ranked using regression analysis to arrive at a final meta-analysisor MetaDACUM. The final report was peer-reviewed and published in the URISA Journal article 2010 no.2: p55-72 (http://www.freepatentsonline.com/article/URISA-Journal/253845098.html).

6 From Model to Material

The final step in making the GTCM and Meta-DACUM analysis relevant for educators was a two-year long curriculum-building effort that engaged more than 50 higher-educators from two year colleges and four year universities. In a collaborative effort, the 660 KSAs found in the GTCM and Meta-DACUM were further refine into a more definitive 330 individual KSAs, ranked according to importance and categorized into a model program of study (POS) and course level student learning out-

comes (SLOs). Utilizing the proven methodology of facilitated group feedback and refinement used in the GTCM and DACUM workshops, the GeoTech Center, under direction of this author, convened a series of five educator workshops in 2011 and 2012 that produced the GTCM Model Certificate and Courses. These course outlines contain the basics of: a) syllabus, b) student learning outcomes (SLO), objective question assessments, and resource recommendations, provides a basis for the design of new GIS curriculum that reflects the true state-of-the-art in current geospatial technology, as defined by industry, and interpreted by academics. This GTCM Model Certificate and Course recommendation is published at http://www.geotechcenter.org/gtcm-curriculum-guide-20.html.

7 Final Step in Curriculum Development

These Model course outlines became the basis for further curriculum development work directed by the author for the US Department of Labor National Information, Security & Geospatial Technology Consortium (NISGTC) between June 2012 and June 2014. The result is a complete set of GIS courses, including lecture and laboratory curriculum materials, for five complete GIS courses. These courses include: a) GST 101—Introduction to GIS, b) GST 102—Spatial Analysis, c) GST 103—Data Acquisition and Management, d) GST 104—Cartography, and e) GST 105—Remote Sensing, represent the model program of study for a GIS Technician and are shown in Table 3.

Course Number	Course Title
GST 101	Introduction to Geospatial Technology
GST 102	Spatial Analysis
GST 103	Data Acquisition & Management
GST 104	Cartographic Design
GST 105	Remote Sensing

Table 3. National Model Certificate GTCM FOSS4G Courses.

These courses are now complete and ready for distribution under the Creative Commons 3.0 license allowing for the free use and redistribution with attribution (http://nter.riosalado.edu). While the lecture portion of these five courses is generic and applicable to any software implementation, the initial laboratory portion was built using Esri ArcGIS 10.1 proprietary software, as required by our contract

award with the US federal funding agency, the US Department of Labor.

In 2014, we have completed a series of complimentary set of GIS laboratory experiences based around the latest Quantum GIS (QGIS 2.2) software build. With this complete set of courses, labs, and support material, we are now prepared to begin building the open source geospatial educational infrastructure to develop a global community of practice among GIS educators worldwide. Beginning with their debut at the International FOSS4G 2014 Conference in September 2014, we will be prepared to launch a national initiative to increase the adoption of open source geospatial software in colleges and universities across the US. It is our goal to both compliment the proprietary software in existing GIS programs, as well as assist those colleges and universities desiring to start new GIS academic programs based on the open source software model. By leveraging the rapidly expanding ICA-OSGeo Open Source Software Laboratory Network, we will be offering our curriculum free of charge under the Creative Commons BY 3.0 license. This Geo-For-All initiative will further our commitment to bringing the latest possible technology learning experience to our students on a global scale.

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