[FC-01-038] An Introduction to the GIS&T Body of Knowledge

Abstract

This entry offers a brief history of the geographic information science and technology curriculum initiatives conducted during the past 35 years and then describes the various ways in which the most recent GIS&T (Geographic Information Science & Technology) Body of Knowledge (BoK) can be used to support education and training. It also documents the approaches that the University Consortium for Geographic Information Science (UCGIS) has taken to support and steward the GIS&T BoK during this time.

Keywords: education, GIScience, higher education, professional certification, professional development

Author & citation

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Explanation

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1. Introduction

Four community-driven geographic information science & technology initiatives have been launched since the 1990s, and the resulting products have provided pathways for practitioners, scholars, and students to learn about the key topics that describe geographic information science and the accompanying geospatial technologies.

The first initiative was hosted by the National Center for Geographic Information and Analysis (NCGIA) and funded by the U.S. National Science Foundation. This project, led by Karen Kemp and Michael Goodchild, provided course materials for teaching geographic information systems in the early 1990s, prior to the widespread availability of comprehensive textbooks. The crowd-sourced materials included lecture notes as well as discussion and examination questions, and they were distributed as a 1,000+ page document organized into three volumes – Introduction to GIS, Technical Issues in GIS, and Application Issues in GIS – with the idea that these materials could support a three-course sequence that spanned guiding principles, techniques and tools, and applications (Kemp and Goodchild, 1990). These materials filled an important gap and the NCGIA shipped 1,300 copies of the core curriculum to institutions in 70+ countries from August 1990 to January 1995 (Coulson and Waters, 1991; Kemp and Goodchild, 1991, 1992; Márkus, 1993).

Following the success of the original Core Curriculum, the NCGIA endeavored to lead the development of three new curricula – one for remote sensing, one for geographic information science, and a third for technical programs – using the web for development and distribution and the same international authorship and editorial input model used for the original project (Kemp, 1997). This initiative was short-lived but several of the participants continued their work as part of the first GIS&T project that was started by Duane Marble and colleagues in 1997 and finished under the auspices of the University Consortium for Geographic Information Science (UCGIS) nearly a decade later.

This second community-based initiative led to the publication of the first GIS&T Body of Knowledge (BoK) that was edited by David DiBiase and colleagues and published by the Association of American Geographers and the UCGIS in 2006 (DiBiase et al., 2006). This 160-page paperback book described the field as a series of Topics that were assigned to units and then these units, in turn, were assigned to one of the 10 Knowledge Areas listed in Table 1. The Topics included lists of 5-10 learning objectives that mirrored the needs of geospatial practitioners, scholars, and students with varying levels of knowledge and skill. The learning objectives themselves were useful, but the collection did not include sufficient material to support lectures and related classroom activities as had the NCGIA Core Curriculum in Geographic Information Systems.

Table 1. The numbers of units and topics by knowledge area included in the first edition of the GIS&T BoK Project (DiBiase et al., 2006).

Knowledge Areas	No. of Units	No. of Topics
Conceptual Foundations	6	30
Design Aspects	7	32
Geospatial Data	12	47
Data Modeling	5	24
Data Manipulation	3	14
Analytical Methods	12	59
Geocomputation	9	40
Cartography & Visualization	6	27
GIS&T and Society	7	24
Organizational & Institutional Aspects	6	32
Totals	73	329

The first edition GIS&T BoK nevertheless attracted a great deal of attention from geospatial scholars and practitioners. First and foremost, this was another step forward in terms of building open education resources (DiBiase, 2011) and numerous scholars described early on how the contents could be used to guide curriculum design (i.e., Prager and Plewe, 2009; Prager, 2012). Secondly, some scholars took the curriculum design opportunities a step further and proposed ways to customize the contents using dynamic ontology-based paths to serve different needs (i.e., Painho and Curvelo, 2012; Ahearn et al., 2013). The third and most enduring outcome was the impetus and input this collection provided for the development and launch of the Geospatial Technology Competency Model by the U.S. Department of Labor (DiBiase et al., 2010) and subsequent efforts to build out the Geographic Information Science Certification Institute (GISCI) and the Geographic

Information Systems Professional (GISP) designation awarded to 11,000+ qualified professionals in the geographic information systems field that certifies their knowledge and experience (Obermeyer, 1993a, b; Kemp, 2003; Huxhold and Craig, 2003; Wikle, 2015; Mathews and Wikle, 2017; Li et al., 2020).

The third community-based initiative connects two European projects. The first was the GI-N2K project led by the Spatial Applications Division at KU Leuven and funded from 2013 to 2016. This project supported an extensive network of 31 academic and non-academic partners from 25 countries and aimed to better align GIS&T curricula at the academic level and in vocational training offers, with the needs of the GI job market (Vandenbroucke and Vancauwenberghe, 2016.). The second was the EO4GEO Erasmus+ Sector Skills Alliance project which aimed to bridge the skills gap in the space and geospatial sectors by creating an alliance with 26 partners from 13 European Union countries to promote the uptake and integration of space/geospatial data and services.

This pair of projects are noteworthy because they produced a European GIS&T BoK and they led the development of software architectures that used the ontology-based search tools and services proposed by Painho and Curvelo (2012), Ahearn et al. (2013), and others to present the BoK concepts and assets that were relevant to the European setting. The value of these new ways of presenting and using the BoK extends both the life and utility of these kinds of resources (Lemmens et al., 2022).

This brief history brings us to the fourth of these initiatives which was launched at the UCGIS Symposium in Pasadena, California in June 2014, where scholars and students helped to set the stage for creating an updated version of the 2006 GIS&T BoK (DiBiase et al., 2006). In 2013, UCGIS President Laxmi Ramasubramanian had asked John Wilson to oversee a process for revisioning and updating the BoK, and his agreement launched a decade-long volunteer endeavor. To begin, Wilson organized a preliminary Steering Committee that began to share their opinions, the first of which was that more data was needed (Wilson 2014). In spring 2014 an online survey was distributed across GIScience channels that asked respondents to indicate the relative importance (range from high importance to no longer relevant) of the 329 topics in the original (2006) BoK, and a second question on the relative quality of the written BoK content itself (Wilson 2014). Fewer than 25 people completed the full survey, leading us to believe that an in-person workshop might be a more effective approach to gather community input. The path taken and the work to do this are described in the next section.

2. The Path Taken Over the Past Decade

During the 2014 UCGIS Symposium in Pasadena, registrants participated in a day-long interactive session with a focus dedicated to the GIS&T BoK. About 100 people, divided into five groups, spent a full day discussing current and emerging GIS&T themes and the relevant topics that could and should be associated with those (Wilson 2014). Detailed notes were captured throughout the day, and this became the food for thought used to form the next ideas for topics and knowledge areas, many of which mirrored those used in the first GIS&T BoK in some ways but not others.

During the 2014-2015 academic year, UCGIS leadership – under the direction of President Steve Prager and Executive Director Diana Sinton – researched and debated multiple

directions for both the content and the delivery platform. A wiki-based approach, involving community-generated and curated content, was the early top contender but ultimately rejected in favor of one that would be more academically rigorous (Figure 1). The Stanford Encyclopedia of Philosophy (https://plato.stanford.edu/) served as the primary model for this approach.

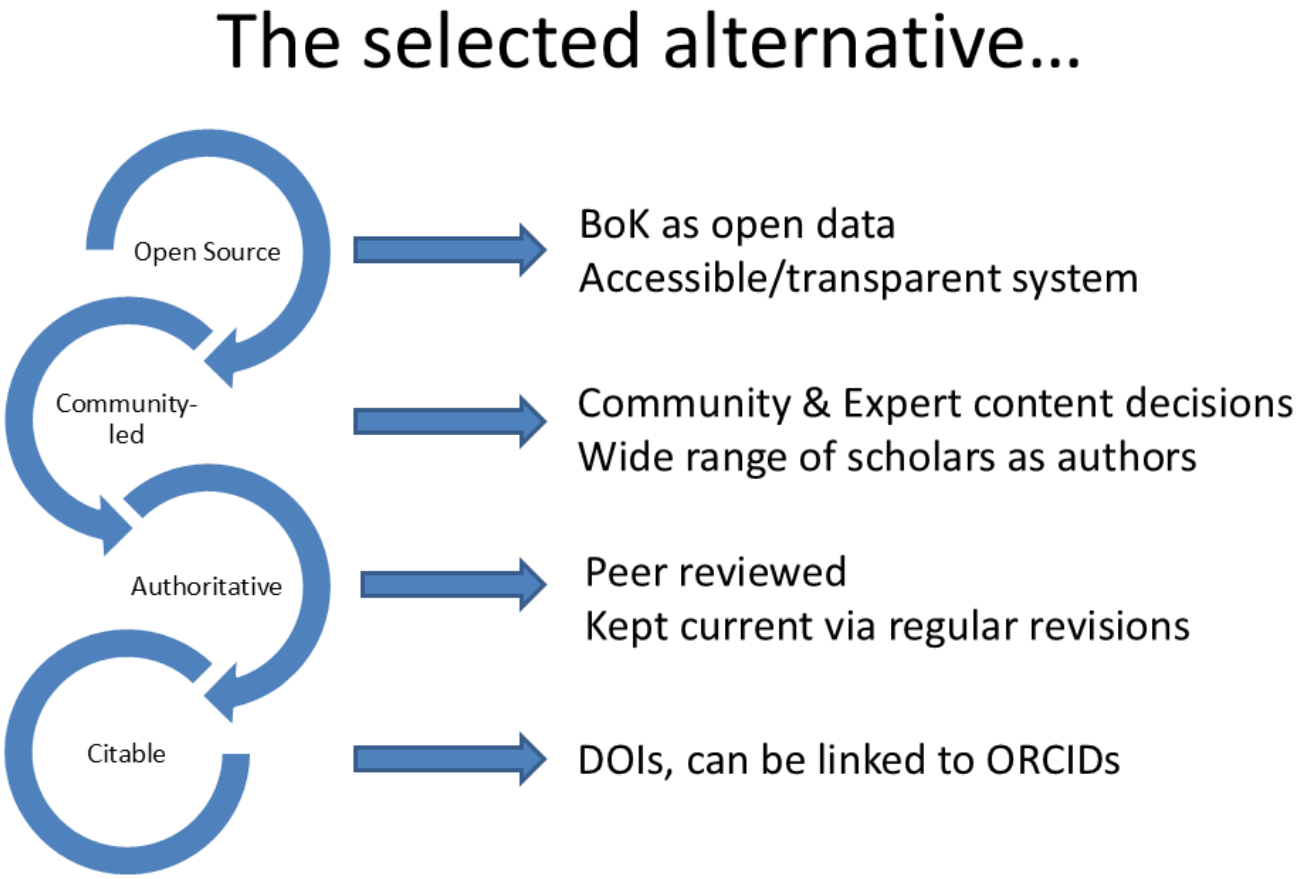


Figure 1. Factors contributing to the content development approach for revising the GIS&T Body of Knowledge, circa 2015-2016. Source: authors.

As the UCGIS website in that era was built on Drupal 7.0, in 2015 UCGIS contracted with a group to build a new Drupal-based website that would host the new content and provide basic functions for search, discovery, and basic visualization of relationships between Topics, something never before possible with the original analog version. A new template for each Topic was designed that allowed for detailed Topic descriptions, references, keywords, and learning objectives. John Wilson was appointed Editor-in-Chief and Diana Sinton began serving as a project manager to support production. UCGIS began using ScholarOne to manage the backend review process. The division of labor between the two authors of this entry mirrors that which has been followed since 2016, with meant that John Wilson – and additional editors in the past – handled the selection of authors, the review process, and the delivery of the final accepted entries to Diana Sinton, who then oversaw the final processing and publication of the entries online.

At the May 2016 UCGIS Symposium in Scottsdale, Arizona, a new GIS&T Editorial Board held its inaugural meeting. Wilson had appointed 10 Knowledge Area Editors – Jochen Albrecht,

Ola Ahlqvist, Ling Bian, Daniel Goldberg, Jeffrey Hamerlinck, Joseph Kerski, Wenwen Li, Robert Roth, Eric Shook, and David Tulloch – who helped to finalize the guidelines for prospective authors, the topics to be included in each of the Knowledge Areas, and the selection and recruitment of authors. Their help and guidance were crucial over the first 1-2 years of this project and one of these editors, Robert Roth, gathered and oversaw the review process for most of the entries that you can see today in the Cartography and Visualization Knowledge Area.

This updated and expanded edition has been a much larger lift than the first GIS&T BoK in part because authors have been asked to write approximately 3,000 words on each Topic and to provide supporting graphics and tables (as appropriate). Since summer 2016, when the first online edition was published, we have so far produced 294 of the proposed 331 entries spread across 53 Units and 10 Knowledge Areas (Table 2). The results portray the scale and heft of this project given that 379 authors and co-authors have been recruited to prepare the 331 entries included in the current version, which was updated quarterly between 2016 and 2023. Some individuals – Jochen Albrecht, Mark Armstrong, Greg Babinski, Babs Buttenfield, Keith Clarke, Daniel Griffith, Wenwen Li, Timothy Nyerges, Cheng-Zhi Qin, and Mehak Sachdeva, among others – contributed multiple entries over the 10+ years it has taken to produce this expanded second version.

Table 2. The numbers of units, topics, and published entries by knowledge area included in this second edition of the GIS&T BoK Project (as of June 4, 2025).

Knowledge Areas	No. of Units	No. of Topics	No. of Published Entries
Foundational Concepts	7	31	27
Knowledge Economy	4	18	17
Computing Platforms	5	25	25
Programming and Development	5	23	22
Data Capture	7	33	26
Data Management	7	47	39
Analytics and Modeling	9	58	56
Cartography and Visualization	6	36	35
GIS&T and Society	3	17	16
Domain Applications	NA	43	31
Totals	53	331	294

Considerable overlap exists between some but not all of the Topics from the first 2006 edition to today's. The first edition excluded any domain applications, and the transition from the first to the second edition included numerous updates that reflected how the computational platforms and tools have evolved tremendously during the past 20 years. The earliest entries are now more than 10 years old, such as those authored by Timothy Nyerges on types of models, and few have been revised since their first online publication, and we have more than 20 entries on new Topics published just since January 2025. While one could argue that some entries, such as those about fundamental concepts, are enduring and need little updating, the need to refresh some if not all the topics on a regular basis is a persistent challenge for the UCGIS and its partners moving forward.

3. Migration to New Online Platforms

By 2020 it had become clear that there were more functionalities desired in an online platform than the website could provide, and an upgrade from a deprecated Drupal 7 was inevitable. Under the direction of then-Presidents Karen Kemp and Jeremy Mennis, UCGIS ultimately decided to leave Drupal and align its approach with the platforms developed by the European groups behind GIN2K and EO4GEO. Between 2022 and 2024, developers helped us migrate the BoK content into our own instance of The Living Textbook, an open-source platform designed at the University of Twente in the Netherlands to support education through customizable knowledge networks (e.g., ontologies). An additional suite of complementary tools, built at the University of Jaume I in Spain, was adopted as well, though currently UCGIS has deployed only the Search & Visualization tool.

3.1 The GIS&T BoK Visualization & Search Platform

The Visualization & Search platform (https://gistbok-topics.ucgis.org) supports simple search and discovery across the full and current collection of Topics within the GIS&T BoK, and this site is currently intended as the BoK GIS&T starting point (Figure 2). The complete collection is represented within the color-coded graphic, and Topics can be accessed directly via the graphic, search, or alphabetical lists. The interactive interface is optimal for exploring the nested hierarchy of Topics. The DOI for every published Topic has been redirected to each Topic's permalink on this site, and this capability can be used to easily bookmark and retrieve content. The elements of every Topic, including its description, references, and learning objectives, are available to be expanded for easy viewing.

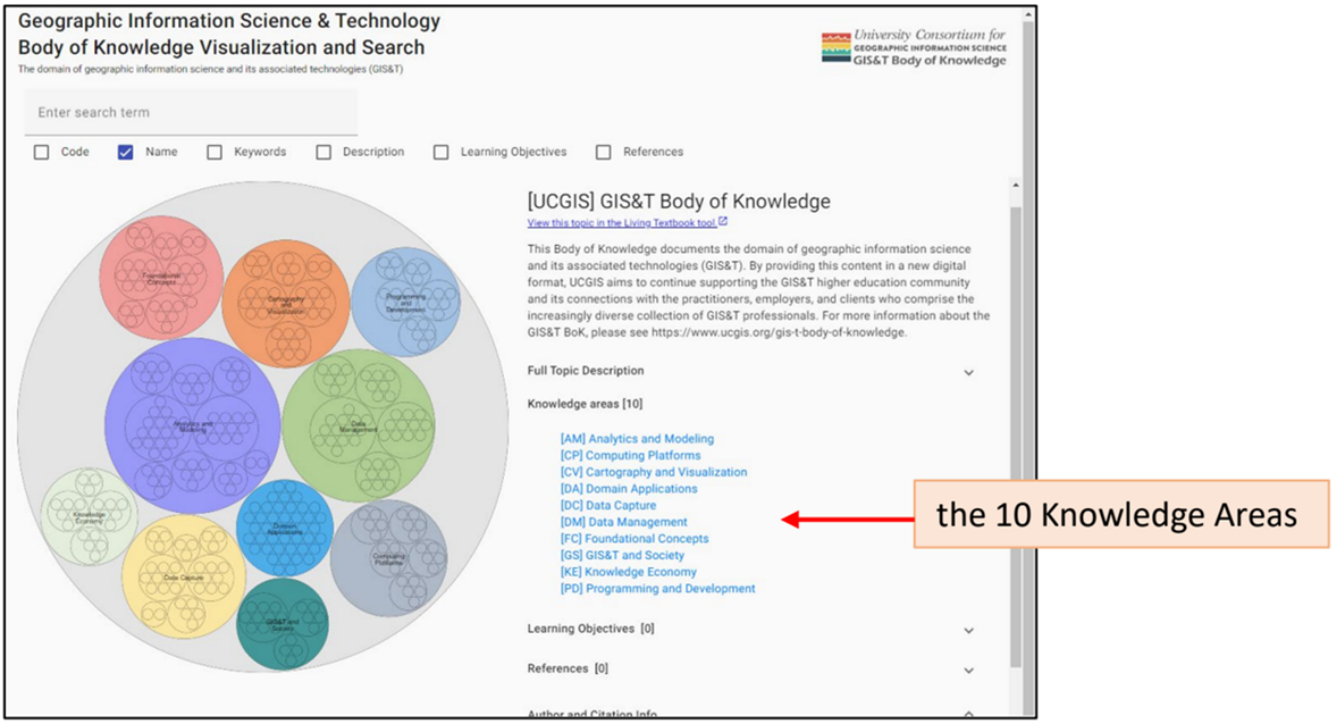


Figure 2. A screenshot from the Visualization and Search Tools used to explore the GIS&T BoK. The circles represent the 10 Knowledge Areas and individual Topics can be accessed via the graphic, the search, or the alphabetical lists. Source: authors.

3.2 The GIS&T BoK Living Textbook Platform

While the Living Textbook platform (https://gistbok-ltb.ucgis.org) also supports search and discovery across the full and current collection of Topics within the GIS&T BoK, its power lies in its capacity for ontology building to visualize and explore relationships between Topics. Topics can be accessed directly through robust search functionality or via an animated knowledge graph that depicts assigned connections and relationships across the BoK content (Figure 3), Each Topic is available as an easy-to-read version of its description, learning objectives, and other elements (as is the case with the Visualization & Search platform). This platform also allows for more dynamic searching, sorting, and exploration across the full collection of BoK content, such as the collection of 4600+ references or 1800+ learning objectives, enabling different and more holistic research questions about GIScience knowledge and its applications.

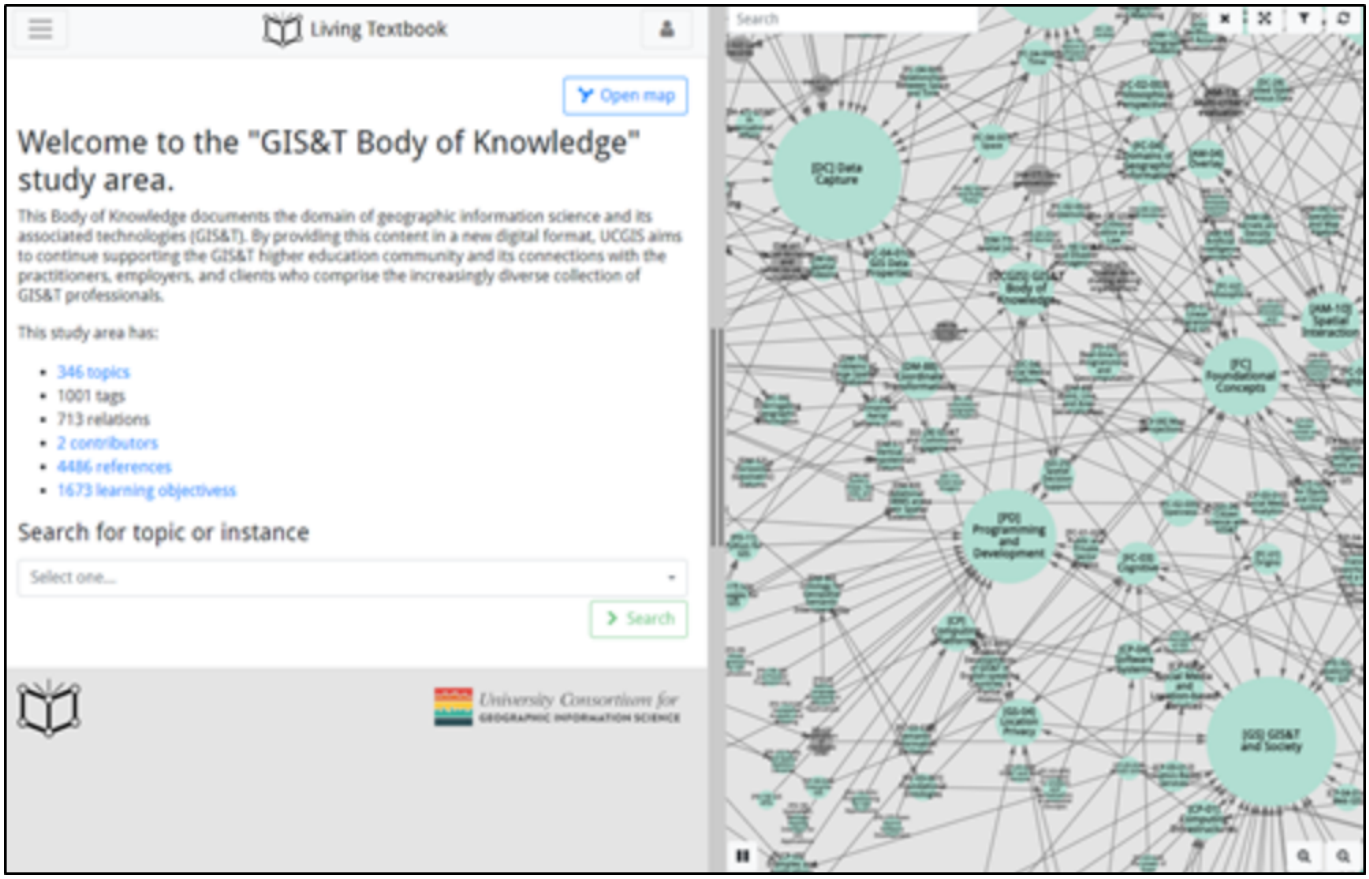


Figure 3. A screenshot of the Living Textbook used to explore the GIS&T BoK. The circles represent the 10 Knowledge Areas and Units, and individual Topics can be accessed via the graphic or the search box. Source: authors.

4. Some Closing Thoughts

The production of this edition of the GIS&T BoK would not have been possible without the support of the UCGIS leadership as well as the various Knowledge Area editors who helped with the early framing of this project and most of all, without the hundreds of colleagues who contributed entries and/or stepped up to review and provide advice so that the work of others could be stood up as part of this BoK.

This said, the current edition of the GIS&T BoK contains two notable features. The first is the shift from listing learning objectives to descriptions of the topics (more like what was

offered by the 1997 NCGIA Core Curriculum). While production of these expanded entries has been challenging, the comprehensive content continues to serve a supportive instructional role and as a resource for research as well. As examples, the digital collection has more recently been evaluated by librarians for its utility in information literacy (Sadvari 2019; Appel 2020), by computer scientists for its potential in building knowledge graphs (Du et al. 2021) and for natural language processing (Tian et al. 2023), and by geographers and cartographers to refine and modernize their curricula (Zhang et al. 2024; de Róiste et al. 2024; Nelson et al. 2024).

The second is the migration of the content from a simple website to the new open-source platforms. Together, these offer superior search, query, ontology-building functionality, and professional development support documented by Painho and Curvelo (2012), Ahearn et al. (2013), Hofer et al. (2020), and others that have long been available in the GI-N2K and EO4GEO projects. Limited funding to date has precluded UCGIS from a full customization and deployment of its new tools to fully realize those functions. Meanwhile, usage and expansion of these continue in Europe with a significant emphasis on Earth Observation, via the current space4Geo program, https://www.space4geo.eu/. Given the dynamic nature of our discipline, limited resources, and evolving demands of educators and professionals, UCGIS has many future opportunities and decisions to make about its stewardship of the GIS&T Body of Knowledge.

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