Geoinformation and Cartography in Higher Education: Body of Knowledge and Geospatial Capacity Building Perspectives

15th International Conference on Geoinformation and Cartography and the Day of the Faculty of Geodesy of the University of Zagreb

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5+ decades as an individual faculty

350. birthday
(Founded on 23.09.1669)
Contents

• Geospatial Capacity Building Perspectives
  • Standard Curricula and Frameworks for their Implementation
  • ... at Work ... mostly from my own experience

• Geospatial Capacity Building Challenges
Geoinformation and Cartography …

• Geoinformation | GIS | Geographic Information Science & Technology (GIS&T)
  • Term established in GIS&T Body of Knowledge (DiBiase et al., 2006)
  • Generic spatial sciences discipline (Goodchild, 1992, 2010; Onsrud & Kuhn, 2018) emerged from its original parent disciplines of Geography, Geodesy, Cartography, Computer Science and Planning (Strobl, 2017)

• Cartography
  • A professional and independent academic discipline (e.g., Gartner, 2014b) dealing with the art, science and technology of making and using maps (ICA, 2019)
    • Discussions on its relevance (Gartner 2014a; 2014b); defining a cartographer (Kraak, 2019b)
  • Often rooted in Geography and Geodesy widely re-establishing itself successfully within the GIS&T framework (Strobl, 2017; Kraak, 2017)
... in Higher Education

• GIS&T education (e.g. NCGIA; Unwin et al., 2012; Walford, 2017)
  training people to use GIS -> “GIS classes” & building domain knowledge
  -> curricula and syllabi for full geospatial education programs
  -> recognition as a professional field w. roles and job profiles
  -> standard BoKs, e.g. GIS&T BoK2 (Willson, 2014) or GI-N2K (Wallentin et al., 2015)

• Cartography education
  • The ICA Commission on Education and Training (https://education.icaci.org/)
  • basic cartography- classes - specializations in cartography – MSc programs (Kraak, 2017; 2019)
  • Knowledge area CV-Cartography and Visualization in GIS&T BoK2
    (https://gistbok.ucgis.org/knowledge-area/cartography-and-visualization)
  • activities towards a BoK for cartography (Fairbairn, 2017; AAG&ICA 2019)
Value of GIS Education for the Economy: The GIS Market

Report by MarketsandMarkets™

a detailed analysis of the GISystem Market on the basis of component, function, end user, and geography

• valued at **USD 5.33 Billion in 2016**, expected to reach **USD 10.12 Billion by 2023**
  cumulative annual growth rate (CAGR) = 9.6% between 2017 and 2023

• key driving factors:
  development of smart cities and urbanization,
  integration of geospatial technology with mainstream technologies for business intelligence,
  and growing adoption of GIS solutions in transportation

-> **Need for graduates who can utilize GIS&T for problem solving (Wikle, 2018)**

Value of GIS Education for the Economy: The GIS Market (cont.)

An industry-wide shortage of competent staff is widely acknowledged, with no trend towards improvement in sight

Geospatial Capacity Building Perspectives


- United Nations Global Geospatial Information Management (UN-GGIM)
- UN-GGIM Academic Network

United Nations 2030 Agenda and Sustainable Development Goals (SDG)

- an agreed global and united development policy to guide the way `all countries` collectively manage and report on the social, economic and environmental dimensions of people, planet and prosperity
- provides the main means and mechanisms for implementation and measuring and monitoring progress through to 2030
- presents the global policy community with a set of 17 SDGs – significant development challenges that are almost entirely geographic in nature
The 2030 Agenda is an integrated plan of action structured in four main parts: [...] Any national SDG implementations will be sub-optimal without strategies and frameworks to **integrate geospatial information** and other data into the measuring, monitoring and reporting processes.
### National Strategic Geospatial Information Policy Framework

**Vision:**
The efficient use of geospatial information by all countries to effectively measure, monitor, and achieve sustainable social, economic, and environmental development – leaving no one behind.

**Mission:**
Promote and support implementation and provide the leadership, coordination, and underpinning necessary to deliver integrated geospatial information that can be leveraged to find sustainable solutions for social, economic, and environmental development.

**Principles (Values):**
- Strategic Enablement
- Transparent and Accountable
- Reliable, Accessible, and Easily Used
- Collaboration and Cooperation
- Integrative Solutions
- Sustainable and Valued
- Leadership and Commitment

**Strategic Drivers:**
- National Development Agenda
- National Strategic Priorities
- National Transformation Programme
- Community Expectations
- Multilateral Trade Agreements
- Transforming our World: 2030 Agenda for Sustainable Development
- New Urban Agenda
- Sendai Framework for Disaster Risk Reduction 2015–2030
- Addis Ababa Action Agenda
- Small Island Developing States Accelerated Modalities of Action (SAMOA Pathway)
- United Nations Framework Convention on Climate Change (Paris Agreement)
- United Nations Ocean Conference: Call for Action

**Goals:**
- Effective Geospatial Information Management
- Increased Capacity, Capability, and Knowledge Transfer
- Integrated Geospatial Information Systems and Services
- Economy Return on Investment
- Sustainable Education and Training Programs
- International Cooperation and Partnerships Leveraged
- Enhanced National Engagement and Commit.
- Enriched Societal Value and Benefits

**Strategic Pathways:**
- Governance and Institutions: Leadership and Value Proposition
- Legal and Policy: Institutional Structures
- Financial: Data Protection and Access
- Data: Standards and Innovation
- Standards: Partnership and Capacity and Education
- Innovation: Capacity and Education
- Partnership: Integrated Engagement Strategies

**Benefits (Realised):**
- Knowledge, Decisions, Development, Society, Economy, Environment
- Users, Citizens, Access, Technology, Applications, Value
The efficient use of geospatial information by all countries to effectively measure, monitor and achieve sustainable social, economic and environmental development – leaving no one behind.
Geospatial Capacity Building Perspectives (cont.)


Geospatial Capacity Building Perspectives (cont.)


• argues for an ecosystem view of lifelong learning
  at the core of building and maintaining the brainware for geospatial information systems supporting our livelihoods

• ‘Brainware’, the human capacity and competence to manage Spatial Data Infrastructures (SDI) and related geospatial information frameworks
Geospatial Capacity Building Perspectives (cont.)


**C – A – S Framework**
- C Spatial Communication
- A Spatial Analysis
- S Spatial Systems
GIS&T and Cartography Standard Curricula and Frameworks for their Implementation
Mission

The ICA Commission on Education and Training acts as a forum to maintain an overview of cartographic and geospatial education worldwide; to deliver presentations, papers, workshops and contributions to other programmes, which focus on educational material in the subject of cartography and geospatial information science & technology; and to investigate and report on technologies, concepts and methods of educational and training courses. The CET webpage serves as a depository of records for such information.

TERMS OF REFERENCE 2019-2023

The ToR collectively addresses the three basic functions of the CET:

- To support the ICA efforts of developing a Body of Knowledge (BoK) for cartography, which could be used for developing contemporary educational programmes and encouraging the creation of specific cartographic modules with valid and viable learning outcomes.
Towards a BoK for Cartography


• Discussions
  • Contributing to the Knowledge Area CV – Cartography and Visualization of the GIS&T BoK2
  • AAG 2019: whether cartography as a discipline needs its own BoK
  • 07/2019: "Geospatial and Cartographic Education – Contemporary Challenges and Opportunities“ http://cet2019.cnu.edu.cn/
  • ICA 2019
GIS&T and Cartography
Standard Curricula and Frameworks for their Implementation

...at Work
GIS&T Body of Knowledge

Geographic Information Science and Technology Body of Knowledge (GIS&T BoK) was developed to provide (Ahearn & Skupin, 2016, p.66):

(i) a resource for course and curriculum planning;
(ii) a basis for comparison of education programs;
(iii) a foundation for professional certification, program accreditation, and articulation agreements; and
(iv) a resource for HR professionals

Example: Geoinformation @ CUAS, Villach 2004/05

Reaccreditation of the diploma study program after 5 years
(started in 2000, 8 semester 240 ECTS Dipl.Ing.(FH) degree)

• Requirements from the CUAS administration
  • Implement the Bologna system
  • Output: BSc (180 ECTS) and MSc (120 ECTS)

• Requirements of the School of Geoinformation Team
  • Study content needs to follow "some standards" in the GIS community
  • 2004 GIS&T BoK "Strawman Report" used to revise the curriculum
    so our graduates can benchmark their education on the national and international edu-market
Example: Geoinformation @ CUAS 2016-2018

BSc Geoinformation and Environmental Technologies @ CUAS in Villach (6 semester, 180 ECTS)

• CUAS Administration requested restructuring on a number of IT-related BSc programs into a single „Information Technologies“ BSc
  • Common: Maths, Physics, Computer Science, compulsory elective subject, …
  • Distinctive: qualification profile - GIS&T
• Framework, i.e. requirement
  • Retain the qualification profile while drastically reducing the GIS&T specific ECTS
• Output: http://www.fh-kaernten.at/geoit
Example: Geoinformation @ CUAS 2016-2018 (cont.)

Relevante Basis:
Qualifikationsprofil
  Geoinformatics "Learning Factory". In: Schlewe, J., Michel, U.;
  Geoinformatics pavilion, University of Osnabrück (Hrsg.):
  Osnabrück, S. 1

Standard Curriculum – GIScie
- GIS&T Body of Knowledge (BoK) (Dubois et al) is
  considered the main resource for specifying the
  GIS program (BSc and MSc)
- BoK2 project (Wilson, 2014):
  Analysis of the Importance of the knowledge

Arbeitsmarkt - Analyse
- GI: N2K assessment of workforce demand to

<table>
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<th>BSc Studium</th>
<th>MSc Studium</th>
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Inhaltliche Schwerpunkte in der Ausbildung
(Grobstruktur)

- GIS-Grundlagen und GI-Technologien
  - konzeptionelle Grundlagen der GI Wissenschaft
  - GI Erfassungsmethoden und Systeme, GPS, Fernerkundung, moderner Sensorik...
- Analytische Methoden
  - Wahrscheinlichkeitstheorie und Statistik, Interpolation, Mathematische Methoden...
  - Räumliche Analyse und Räumliche Statistik
- Datenmodellierung
  - Geodatenbanken, Modellierungswerkzeuge
  - Geodatenmanagement
- Kartographie und Visualisierung
  - Karton, Kartentechnik, Kartendarstellung, Information Visualization
  - Koordinatensysteme und Projektionen
- Designaspekte
  - Applikationsentwicklung
  - WebGIS & GI Services
- Angewandte Projekte, Berufspraktikum

A. Car: Geoinformation and Cartography in Higher Education: BoK and Geospatial Capacity
Example: UNIGIS@Salzburg (international) 2005-2011

- Online distance learning program specifically tailored to the needs of in-service professionals; https://unigis.at/en/welcome/
  - academic certificate or MSc, regionally offered dual degree
  - International students
  - Several study locations: Global Campus, Latin America, Central Asia, India, Nepal, Croatia

- At the time we looked into **quality aspects** of the program we offered

Car, A. (2007). Quality Aspects in Postgraduate Distance Education. In Teaching Geography in Higher Education. K. Donert (ed.), ESRI inc. with HERODOT.
Towards a UNIGIS QA Concept: Preliminary Results
UNIGIS Common Core Curriculum vs UCGIS Body of Knowledge

- MSc(GIS)
  - is computed and
  - implemented
  - establish
  - demonstrate
  - as a tool
- Internally: our exist
  - checked against the
  - to be changed and
  - comparison to other
  - the UNIGIS network
- Externally: CCC is
  - like networks

General framework when revising the Curriculum

Towards a UNIGIS QA Concept: Preliminary Results (2)
UNIGIS Common Core Curriculum vs UCGIS Body of Knowledge

- CCC - compulsory
- BoK - Knowledge Areas
- Basic structure of the UCGIS BoK and CCC

UCGIS BoK – Knowledge Areas
- AM: Analytical Methods
- CP: Conceptual Foundations
- CV: Cartography and Visualisation
- DA: Design Aspects
- DM: Data Modelling
- DN: Data Manipulation
- GC: Geocomputation
- GD: Geospatial Data
- GS: GIS&T and Society
- GI: Organisational and Institutional Aspects

Towards a UNIGIS QA Concept: Preliminary Results (3)
UNIGIS Common Core Curriculum vs UCGIS Body of Knowledge

Towards a UNIGIS QA Concept: Preliminary Results (4)
UNIGIS Common Core Curriculum vs UCGIS Body of Knowledge

Basic structure of the UCGIS BoK and CCC

Preliminary results from the comparison between CCC and BoK show the following:
- CCC or parts thereof that are not covered implicitly and/or explicitly in BoK
  - OpenGIS and Distributed GI Infrastructures (M6)
- BoK KA or parts thereof that are not covered implicitly and/or explicitly in CCC:
  - Geocomputation (GC1,2,4,5,7)
  - GIS&T and Society (GS2,6,7)
  - Organisational & institutional aspects (014)
  - Conceptual foundations (CF1, CF2,5-7)
  - Analytical methods (AM1, AM12,1-3)
  - Design Aspects (DA7 system implementation)
Example: UNIGIS@Salzburg (international) 2005-2011 (cont.)


• Clearly Defined Professional Qualifications

• Qualifications and their acceptance depend on a number of factors like:
  • Curriculum and syllabus
  • Professional relevance and employability
  • Track record with alumni and in industry
  • Formal accreditation and quality indicators
Example: GIS&T-CroHE 2007-2009

TEMPUS III Joint European Project (JEP) “Geographic Information Science and Technology in Croatian Higher Education” (GIST-CroHE)

- University of Salzburg – ZGIS; Jagiellonian University in Cracow; Faculty of Geodesy at the University of Zagreb
- €268,771, 2 year project, 01.09.2007
- Outputs:
  1. a revised MSc curriculum in GISc&T for the Faculty of Geodesy in accordance with the Bologna declaration and the modern, current GISc&T curricula, and supported with modern infrastructure;
  2. an increased number of graduates in GISc&T coming from various fields.
- Outcomes:
  1. Increased quality of education in GISc&T at the Faculty of Geodesy and in Croatia in general.
  2. Increased presence of qualified professionals in GISc&T in Croatia

Example: GIS&T-CroHE 2007-2009

TEMPUS III Joint European Project (JEP) “Geographic Information Science and Technology in Croatian Higher Education” (GIST-CroHE)

- University of Salzburg – ZGIS; Jagiellonian University in Cracow;
  Faculty of Geodesy at the University of Zagreb


Example: GIS&T BoK for Minors in GIS (2016-)


• Minor Programs in GIS&T
  • Aimed at students who wish to acquire a foundation in GIS&T
  • Offered as secondary subjects complementing a great variety of Major programs at undergraduate and graduate level (Strobl, 2008)
  • Focus on spatial competencies like geographic representation, analysis methods, mapping, or geospatial techniques (Verfaillie et al., 2012)

• Lack a framework for comparison or standardized core content reflected in learning outcomes

• We proposed one based on GIS&T BoK (DiBiase et al., 2006) as a reference document
Example: GIS&T BoK for Minors in GIS (2016-) (cont.)

Michael Goodchild (Foreword in Unwin et al. 2012, p.xvi):

"We teach mathematics and language skills to everyone – should we not also be teaching some subset of GIS&T to everyone?"

= professionals

Example: GIS&T BoK for Minors in GIS (2016-) (cont.)

- Framework for analysis
  - Metrics: Credits ("weights") and Contents ("learning outcomes")
  - Baseline for empirical study: website survey of existing GIS Minors and document analysis

- Analysis of current minors based on
  - readily available (online) documentation
  - criteria: status / level / certification / content structure / credits
  - Content structure and awarded credits show similarities => potential for comparison

=> subset of programs that reflect the diversity of academic environments in which the Minor programs are offered
## Analysis of the Sample Minors

**Contents**

Course topics taught in the sample GIS Minors

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<thead>
<tr>
<th>Core</th>
<th>Electives</th>
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</thead>
<tbody>
<tr>
<td><strong>Foundations of GIS</strong> [Science</td>
<td>Systems]</td>
</tr>
<tr>
<td><strong>Cartography and Visualization</strong> [maps</td>
<td>mapping</td>
</tr>
<tr>
<td><strong>Analysis</strong> [Spatial</td>
<td>Geographical]</td>
</tr>
<tr>
<td>Quantitative methods [statistics]</td>
<td>Cartography</td>
</tr>
<tr>
<td><strong>Geodata acquisition</strong></td>
<td>Image analysis</td>
</tr>
<tr>
<td>Geodesign</td>
<td>GI Tools</td>
</tr>
<tr>
<td>Research methods</td>
<td>Quality of Geodata</td>
</tr>
<tr>
<td><strong>GI Technologies</strong> [remote sensing, GPS]</td>
<td>Web dissemination</td>
</tr>
<tr>
<td>(Schulze, Kanwischer, and Reudenbach, 2013)</td>
<td>Project</td>
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<td>Discipline-specific courses</td>
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</tbody>
</table>

## Body of Knowledge for GIS Minors Proposal

**Sources and Criteria:**

I. **GIS&T BoK** *(DiBiase et al., 2006)*:
   Common core: 9 KAs and 26 of their constituent core Units, together with all of their Topics, considered the main resource for specifying course content for GIS Minors

II. **BoK2 project** *(Wilson, 2014)*:
   - we consider course content of a GIS Minor to be the “core of the common core” of BoK,
   - candidate topics for a GIS Minor course must be rated as “high importance”

III. **GI-N2K assessment of workforce demand to shape GIS&T** *(Wallentin, Hofer, & Traun, 2015)*

IV. **GIS Minor curricula analysis** (as presented in this paper)
   - Common content: concepts of GIScience, geodata acquisition, spatial analysis, cartography and visualization, GI-Technologies incl. remote sensing, GPS and GISystems, and GIS applications
Example: GIS&T BoK for Minors in GIS (2016-) (cont.)

Our Main Observations

- most of the programs consist of a combination of core and elective course(s), but the proportion of electives varies greatly
- to be taken as a serious add-on qualification, a Minor program should require roughly a full semester workload
- in general Minors tend to focus on general topics and practical skill sets, including
  - the foundations of GIScience,
  - data acquisition,
  - spatial analysis,
  - mapping and visualization,
  - the use of GI-technology
Example: GIS&T BoK for Minors in GIS (2016-) (cont.)
basis for the design of a BoK of GIS Minors

content of GIS&T BoK as the main source for a model curriculum
(reportedinWallentin, et al. 2015; Wilson, 2014)

+ set of criteria derived for specifying course content
Example: GIS&T BoK for Minors in GIS (2016-) (cont.)

Need for Further Debate

• help formulate core competencies acquired through a GIS-Minor
• identify the “core” topics in which any GIS Minor student needs to demonstrate some level of mastery
• agree upon comparable workloads and shares of electives between GIS Minors
• revise existing learning objectives and define new ones at the Topic level (GIS&T BoK2)
• the overall competency level that students should have already when they are about to start the undergraduate study is worth further exploration, particularly where problem-solving and critical creative spatial thinking are concerned
• differences with regard to GI core competences appropriate for different fields
Geospatial Capacity Building Challenges
Geospatial Capacity Building Challenge

There are well established foundations, starting from various “core curricula”, including UCGIS’ “Body of Knowledge” [http://gistbok.ucgis.org] and supported by EU projects like GIN2K [http://www.gi-n2k.eu]. Still, we see too few translations of these concepts and frameworks into attractive programmes of study. (Strobl 2018, 2019)
Geospatial Capacity Building Challenge (cont.)

Development of geospatial educational ecosystem (Strobl 2019)

- Collective effort of stakeholders
  Higher Education institutions, industry, professional institutions, media
- Involvement of „Brainware“ carriers
  - students in different learning stages & programs
  *Slew new users using cartography & cartographers (Kraak 2017, 2019)*


References


References


References
