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TRENDS IN CURRICULUM DEVELOPMENT – THE EXAMPLE OF THE MASTER OF SCIENCE "APPLIED GEOINFORMATICS" AT THE UNIVERSITY OF SALZBURG

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Abstract: While GIS as a technology is about 50 years old and somewhat mature (but continuously evolving), the scientific field of Geographic Information Science (GIScience in short) and the methodology of Geoinformatics are still vaguely defined. Using the example of the University of Salzburg with almost 30 years of tradition in teaching GIS this article investigates how curricula changed over time when analysing them against the Geographic Information Science and Technology Body of Knowledge (GIS&T BoK). Although exact figures are difficult to retrieve, the results mirror the trends of a recent survey of demands of the GIS&T workforce in Europe, most notably regarding analysis tasks, programming and application development and web-services related topics. While Geography seemed to be influential in the first years, an interaction of disciplines including Computer Science, Surveying, or Image Processing and application fields ranging from Geology to Spatial Planning, have played an important role in the technical realm.

Keywords: GIS&T Body of Knowledge, Master of Science "Applied Geoinformatics", University of Salzburg

TRENDS IN DER ENTWICKLUNG VON CURRICULA – DAS BEISPIEL DES MASTERSTUDIUMS „ANGEWANDTE GEOINFORMATIK" DER UNIVERSITÄT SALZBURG

Zusammenfassung: Geographische Informationssysteme (GIS) sind als Technologie etwa 50 Jahre alt und ausgereift, obwohl sie sich ständig weiterentwickeln. Die Wissenschaft (GIScience) hinter GIS und die Methoden der Geoinformatik sind dagegen immer noch vage definiert. Am Beispiel der Universität Salzburg, an der es beinahe 30 Jahre Erfahrung in der Lehre von GIS gibt, untersucht dieser Beitrag den Wandel der Curricula. Um den Wandel abzubilden, wurden mehrere Curricula auf den *Body of Knowledge* im Bereich der Geoinformationswissenschaft und Technologien (GIS&T) abgebildet. Auch wenn harte Zahlen nur schwer ermittelt werden können, so spiegeln die Resultate der Analyse Trends wider, die in einer kürzlich durchgeführten europaweiten Umfrage zu den Anforderungen an Dienstnehmer im Bereich GIS&T identifiziert wurden. Diese geforderten Entwicklungen von GIS&T Dienstnehmern betreffen vorrangig Kenntnisse von Datenanalyse, Programmierung und internetbezogene Technologie und Dienste. Disziplinen, die Einfluss auf Curricula in Salzburg hatten, waren anfangs die Geographie, und im technischen Bereich Informatik, Vermessung, digitale Bildverarbeitung; Anwendungsfelder reichen von der Geologie hin zur Raumplanung.

Schlüsselworter: GIS&T Body of Knowledge, Master of Science „Angewandte Geoinformatik", Universität Salzburg

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1 INTRODUCTION

Geographic information systems (GIS) originated in the 1970s as tools for integrating, analysing and visualising spatial data. Since then, GIS has matured and developed into a multidisciplinary field. In the English speaking world, the term 'Geographical Information Science', or GIScience in short, which was introduced by Goodchild (1992), evolved and characterizes a scientific field which investigates conceptual questions related to spatial data, analysis, GIS and more (Goodchild 1992). Blaschke & Merschdorf (2014) defined GIScience as a multidisciplinary and multi-paradigmatic field and also discussed the slightly different, yet overlapping term 'Geoinformatics' which is widespread in the German speaking and some Eastern European and Asian countries. As a relatively young field strongly linked to technological advances, Geoinformatics is constantly changing.

After nearly 50 years of GIS there might still be fundamental issues associated with the use of GIS technology and a need for theoretical foundations of GIS. The more technical issues of e. g. mobile computing, sensor integration, interoperability standards etc. seem to be more often subsumed under the term Geoinformatics. Likewise, GIScience seems to be more associated with e. g. formalizing human spatial thinking capabilities into geographic knowledge and addressing the impact of geographic information technology on societal issues including democracy and privacy.

There were several attempts to define a GIScience research agenda. Twenty-odd years after the 1992 article Goodchild revisits the fundamental issues of GIScience, and establishes what progress has been made in this field. His findings were published in the paper entitled 'Twenty years of progress: GIScience in 2010' (Goodchild 2010), where he also revisits the research agenda of GIScience, proposed in his earlier paper. Blaschke & Strobl (2010) identified ten major developments in GIScience although, from today's point of view and when following the logic of Blaschke & Merschdorf (2014) some of the trends identified would maybe more appropriately assigned to Geoinformatics – if such a distinction is really needed. This leads us to an important question, namely the naming of Departments and University study programmes.

As Blaschke & Merschdorf (2014) point out, confusion and uncertainty in naming conventions may disadvantage scholars in terms of funding success and recognition of academic programmes. Another related issue as discussed in Bill & Hahn (2007) and Bill & Naumann (2012) is that potential students and employers have difficulties comparing degrees. The number of Geoinformatics programmes in German speaking countries is considerable. The Geoinformatics service of the University of Rostock (http://www.geoinformatik.uni-rostock.de) lists 700 study programmes in Geoinformatics and related application domains; the number of German study programmes with a specific Geoinformatics focus exceeds 50 (Ehlers 2008). A means to support the comparison of curricula through students, employers and accreditation institutes is the German Geoinformatics core-curriculum (Kerncurriculum Geoinformatik) (Schiewe 2009). This Geoinformatics core-curriculum lists competences, knowledge and skills a Bachelor in Geoinformatics in Germany should cover. The focus on competences acquired through study programmes got enforced by the Bologna reform (Schulze et al. 2011). An analysis of dimensions of competences required to work successfully in the GIS&T domain was provided by (Schulze et al. 2011), who identified problem-solving, spatial thinking and technical knowledge, skills and competences as required competence dimensions. DiBiase, Tripp et al. (2010) presented the New Geospatial Technology Competency Model (GTMC), which identifies core geospatial skills and knowledge and is intended to support an assessment of how curricula relate to workforce demands.

Knowledge Area	Abbreviation	Example units included
Analytical Methods	AM	spatial statistics, data mining, analysis of surfaces
Conceptual Foundations	CF	domains of geographic information, imperfections in geographic information
Cartography and Visualization	CV	graphic representation techniques, map production, map use and evaluation
Design Aspects	DA	database design, application design, project definition
Data Modeling	DM	database management systems, basic storage and retrieval, vector and object data models
Data Manipulation	DN	generalization and aggregation, transaction management
Geocomputation	GC	cellular automata, heuristics, genetic algorithms, uncertainty
Geospatial Data	GD	map projections, aerial imaging and photogrammetry, metadata, standards and spatial data infrastructures
GIS&T and Society	GS	legal aspects, economic aspects, geospatial information as property
Organizational & Institutional Aspects	OI	managing the GI system operations and infrastructures, coordinating institutions, origins of GIS&T

Table 1: Knowledge Areas of the GIS&T BoK (after DiBiase, DeMers et al. 2006)

In the remainder of this article considering its expected succinctness we will exemplarily describe the situation of the Geoinformatics programme at the University of Salzburg, Austria, as one of the long-standing education institutions in Europe where first GIS classes where taught as early as 1986. We will highlight the change of the field, from GIS to Geoinformatics or GIScience, respectively, and how these changes are reflected in the curricula of Geoinformatics studies. In this contribution we analyse the development of the 'Master of Science (MSc) Applied Geoinformatics' programme, which is offered at the University of Salzburg. While specialisations in 'Applied Geoinformatics' (AGI) within the Geography programme were possible from 1990 onward, a stand-alone master programme in Geoinformatics was introduced in 2002 and its curriculum underwent several revisions and iterations.

As a means to identify changes and apparent trends, the Body of Knowledge (BoK) in the field of Geographic Information Science and Technology (GIS&T) is used as reference and is analysed against four MSc AGI curricula (2002-2013). The GIS&T BoK has been introduced as domain inventory for supporting curriculum design through an American initiative in 2006 (DiBiase, DeMers et al. 2006). The GIS&T BoK is used rather than the German Geoinformatics core-curriculum as the latter specifically focuses on education at Bachelor level. An approach to map curricula to the BoK and thereby highlight their focus areas has been proposed in Rip & Van Lammeren (2010).

A recent survey of demands of the GIS&T workforce in Europe highlighted the developments in the data analysis sector, regarding programming and application development and web-related topics (Wallentin et al. 2015). The changes of the MSc Applied Geoinformatics over the past decade point into a similar direction. These findings illustrate that constant change in GIS&T education is required for preparing students for the requirements of the continuously evolving GIS&T domain.

2 BOK AND BOK 2.0

The first version of the GIS&T Body of Knowledge was published by the US University Consortium for Geographic Information Science (UCGIS) in 2006 (DiBiase, DeMers et al. 2006). It was the result of a discussion process on conceptual foundations and competences for the geospatial domain and a successor of the NCGIA core curriculum of the 1990ies. The BoK lists ten knowledge areas that are hierarchically structured into units and topics. The knowledge areas and some exemplary units are listed in Table 1. Intended uses of the BoK are curriculum development, accreditation, comparison of study programs and profiles of GI experts (Prager & Plewe 2009, Reinhardt 2014).

As the BoK originated from a geography-oriented view on GIS&T, several topics like spatial data infrastructures, standards and the OGC process, remote sensing, or coordinate reference systems have been found underrepresented (Reinhardt & Toppen 2008, Reinhardt 2014). In addition, technological and conceptual advances in GIS&T ask for consideration in a BoK 2.0 (e.g., Câmara et al. 2009). Currently, there are initiatives to update the BoK considering developments of the past years and potential extensions to the BoK in version 1. These initiatives happen in the US and in Europe (the project Geoinformation need to know – GI-N2K) and include expert input and analysis of demands and supply of GIS&T knowledge (Wilson 2014, Wallentin et al. 2015).

The BoK is an extensive document detailing the contents of knowledge areas, units and topics. Several tools have been proposed to make this domain inventory more accessible; for example, Ahearn et al. (2013) developed an ontology of BoK concepts that represents crosslinks between the concepts. Hossain & Reinhardt (2012) developed a tool for planning courses and individual pathways based on content outlined in the BoK. The current revisions of the BoK include the prototyping of additional tools.

3 ANALYSING THE CURRICULA OF THE MSC APPLIED GEOINFORMATICS AT THE UNIVERSITY OF SALZBURG

3.1 ROOTS AND DEVELOPMENT

Geoinformatics at the University of Salzburg was established at the Geography department around 1985 with first GIS classes held in 1986. Over the years, GIS and Geoinformatics became indispensable when educating University students in spatially related fields. Due to strong research efforts and methodological developments Geoinformatics became more and more an own research field. When establishing the Bologna scheme (Bachelor-Master-PhD) after the year 2001 in Austria, Geoinformatics at the University of Salzburg separated from Geography and developed into an own Master programme. In the first years the Department of Geography was the academic host of the programmes. Over the years, Z_GIS, the Centre for Geoinformatics Salzburg founded in 1988 as a research institution, adopted the leading role in Geoinformatics educations, both for the UNIGIS distance learning programmes starting in the academic year 1993/94 (Blaschke & Strobl 1997, Strobl 2011) but later also for the MSc Applied Geoinformatics (AGI). Leaving out many details here the culmination of this development was the establishment of a separate (Interfaculty) Department of Geoinformatics – Z_GIS in August 2012.

The strong ties between Geography and Geoinformatics lead to exchange in applications and spatial concepts. It can be assumed that the first curriculum versions of the MSc AGI were strongly influenced by Geographic concepts. This will be analysed in the next subsection.

The focus of the MSc Applied Geoinformatics has always been linked to the whole cycle of Geoinformatics projects starting with data acquisition, the design of data models, the analysis of the data and their visual communication for decision support. Remote Sensing has a growing importance in the master programme thanks to expertise available in the Interfaculty Department of Geoinformatics.

3.2 ANALYSIS OF FOUR CURRICULA VERSIONS 2002-2013

To identify trends in the curricula of the MSc AGI we follow an approach to map courses to the BoK presented in Rip & Van Lammeren (2010). In our analysis, each course is assigned to exactly one knowledge area of the BoK. This matching does, therefore, not consider different elements taught within course. For instance, a course related to an implementation of a project certainly includes aspects of project management, data analysis, communication of results etc. To avoid subjectivity in the assignment of the courses to the BoK such a level of differentiation is not applied here.

Five versions of the curriculum of the master were presented between 2002 and 2013: 2002, 2006, 2007, 2009 and 2013. The version of 2007 includes no changes to the courses themselves and is therefore not further considered in the analysis. The matching focuses on compulsory courses offered to the students. Electives are not included in the analysis as the choice of each student may be different. In such, the analysis only reflects the core of the curriculum.

As has been demonstrated in Rip & Van Lammeren (2010), not all courses of a curriculum are related to the content of the BoK. Courses on programming, Physical Geography, scientific writing, presentation skills etc. have been registered as courses with no direct match (NDM). The percentage of courses with no direct match varies between 30%-39% of the total.

Rip & Van Lammeren (2010) proposed to group knowledge areas (KAs) according to general topics addressed in order to avoid distortions due to the alphabetical arrangement of KAs. The grouping they suggest is presented in Table 2. This grouping has been applied to the data in our analysis; the results are displayed in Figure 1.

Society&Organisation (soc., org.) GIS&T and Society (GS) Organizational and Institutional Aspects (OI)	**Physical Reality (phys. real.)** Data Modeling (DM) Geospatial Data (GD)
Concepts, Methods, Tools (c, m, t) Analytical Methods (AM) Conceptual Foundations (CF) Design Aspects (DA) Data Manipulation (DN) Geocomputation (GC)	**Presentation (pres.)** Cartography and Visualization (CV)

Table 2: *Topic-wise rearrangement of Knowledge Areas following Rip & Van Lammeren (2010)*

Figure 1 shows that the curriculum puts emphasis on the groups *concepts, methods and tools* and *physical reality* (which in our understanding is rather representation than reality). The groups *society&organization* and *presentation* have a smaller share of courses. The gross difference between the representation of the groups in the curriculum may be biased by our decision to map each course to exactly one knowledge area as mentioned above. The presentation aspect, for example, certainly plays a role in courses other than the cartography course as well. In addition, the grouping itself includes different numbers of knowledge area, which influences the diagram as well. Therefore, we cannot emphasize exact figures or changes within groups of knowledge areas, but rather point out the reasons for some of the changes that can be observed.

After the first version of the curriculum in 2002, there is an increase in courses related to data modelling and geospatial data. The KA geospatial data includes basics of Remote Sensing and image interpretation, which contribute to this increase. Between the curricula of 2009 and 2013 we can observe an increase of the group *concepts, methods and tools*. This is because the current curriculum includes courses on GIScience and therefore puts more emphasis on the KA conceptual foundations.

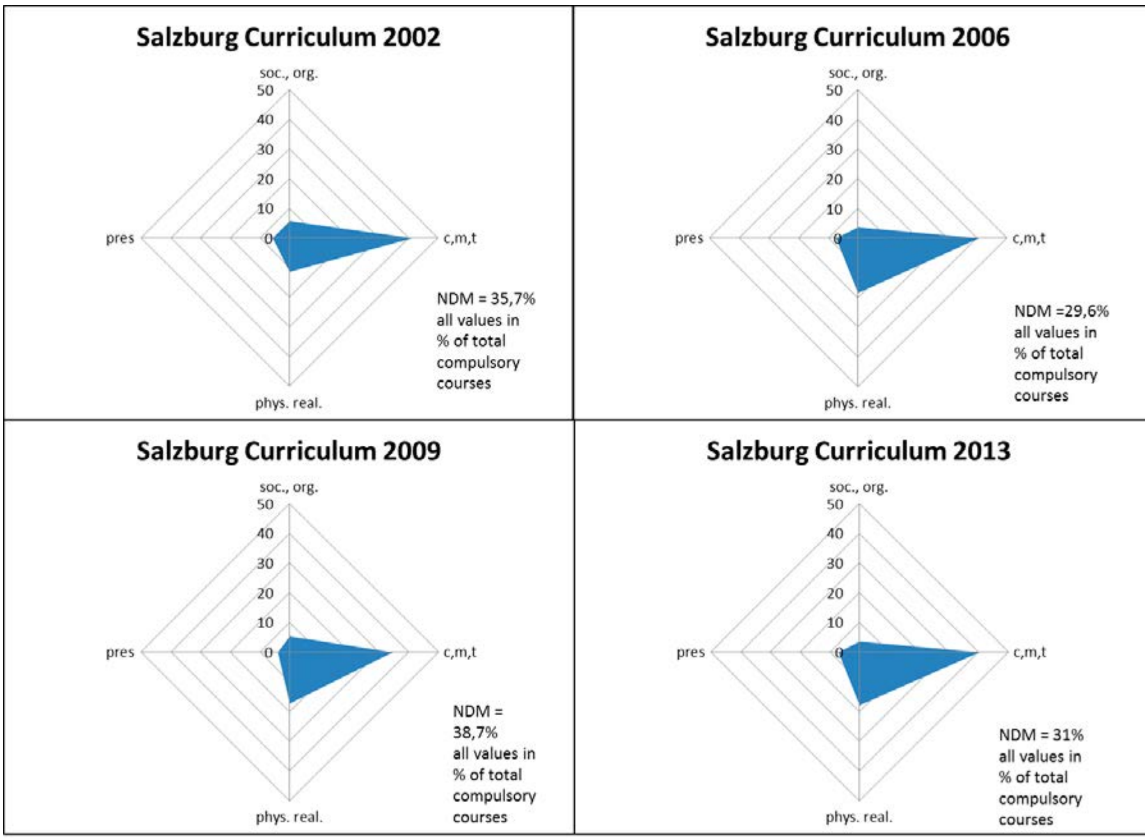

Figure 1: *Distribution of topic-wise grouping of knowledge areas excluding no direct match courses (NDMs)*

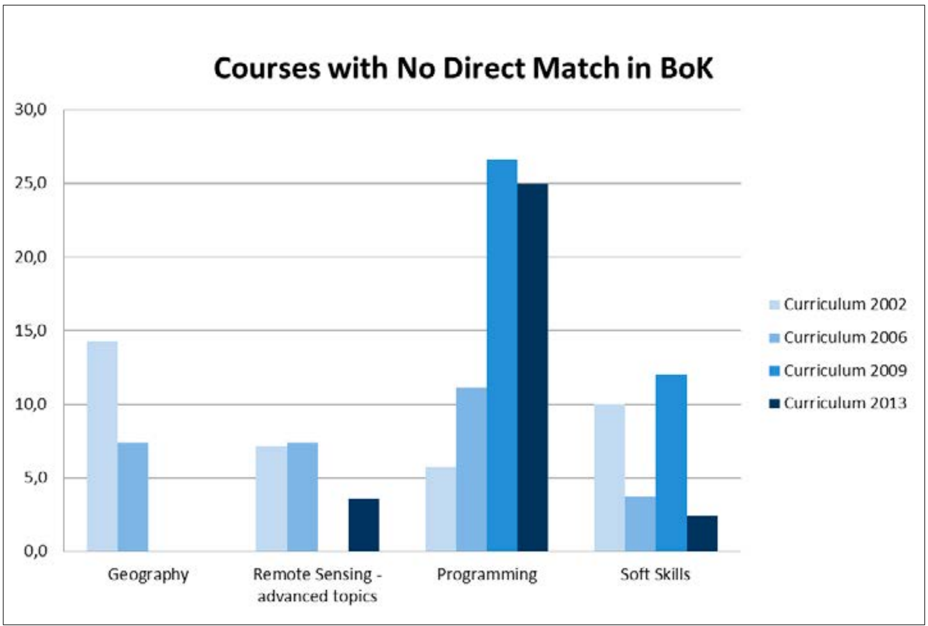

Figure 2: Insight into the distribution of courses with no direct match in the BoK per subject area

The courses with no direct match to the BoK reveal trends in the last ten years of curriculum development in the MSc Applied Geoinformatics (AGI, figure 2). We differentiate courses in Geography, Remote Sensing (advanced topics), programming and soft skills. As the curriculum originally was tightly integrated with a curriculum of Geography, early versions of the AGI curriculum reflect this linkage.

Remote Sensing is a topic that is partly covered by the BoK. We separated courses with specific Remote Sensing content, like object-based image analysis and advanced photogrammetry, from introductory courses on the same topic. Introductory courses were mapped to the KA geospatial data; advanced courses were assigned to the group of courses with no direct match. Figure 2, therefore, only shows additional courses on remote sensing in the curricula over time.

Courses on programming definitely increased. These courses cover introduction to programming languages as well as application projects and project development.

What is somewhat ambiguously subsumed under 'soft skills' – a useful alternative would be the term 'transferable skills' – includes business administration for Geoinformatics, entrepreneurial skills, English language classes. Most of these skills seem to be indispensable, but are increasingly expected to be at least partially covered in an underlying Bachelor's programme. As the whole MSc is taught in English, a good command of the English language is a precondition for the studies in Salzburg.

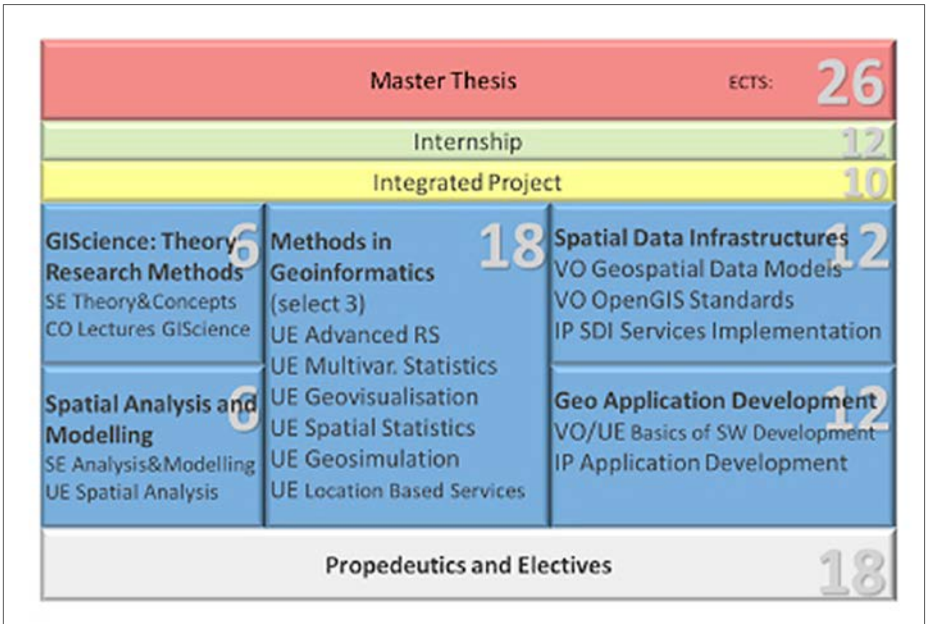

Figure 3: Structure of the 2013 MSc AGI (Applied Geoinformatics) curriculum with the respective ECTS figures

4 DISCUSSION AND CONCLUSIONS

The MSc AGI developed out of a former Geography programme; it can be confirmed that this has been visible in the curriculum development. Today, the MSc AGI puts emphasis on programming and application development, conceptual foundations and geospatial data (the current curriculum is displayed in Figure 3). This matches findings of a recent analysis of GIS&T workforce demands. Wallentin et al. (2015) found that the data analysis rather than data capture, programming skills and application development and web-related topics need more prominence in a BoK 2.0.

This short article could reveal trends and could confirm the underlying hypotheses – mainly that the curricula disclose less and less traces of its original Geography provenance and become more 'technical'. Although clearly visible these trends can hardly be quantified. The underlying principle of the analysis against the BoK was that every course or class is only assigned to one single knowledge area (KA) of the BoK. One development, which cannot be discovered in the data using this technique, is that the AGI programme has become more and more research-based.

Potential employers emphasize the importance of transferrable skills for success on the job market (Bill & Hahn 2007). The development of a curriculum always requires that a balance between occupation-specific knowledge and skills and personal competences is sought. A continued effort for complementing and updating a curriculum taking the academic and the market perspective into consideration is inevitable. We conclude, that the consensus reached on competences and skills required in the GIS&T field, e.g., in the BoK, supports the assessment and adaptation of study programmes.

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