

A Case Study of Education Reform in Earth Observation Technology and Applications

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ABSTRACT

The ongoing technological development since the introduction of computerized data processing and increased access to the Internet has increasingly blurred the boundaries among the individual disciplines in the geo-sciences. As a consequence, some traditionally interdisciplinary areas such as remote sensing, geoinformatics and cartography have become particularly active or partly revitalized. In this paper we document two examples of International Master Study Programs at the Technical University Munich (TUM). One is the "ESPACE" (Earth-Oriented Space Science and Technology) program that started in 2005. The other is the international master program on "Cartography and Geoinformatics" that is intended to start in 2010. Both programs are rooted in the traditional German Diploma program "Geodesy and Geoinformation", but have been progressively reshaped as interdisciplinary and non-consecutive Master programs. While ESPACE has already become a successful story, the curriculum of "Cartography and Geoinformatics" incorporates and highlights the methods and applications in spatial data modeling, analysis and visualization of geographic information. Additionally this paper relates to the European education reform with the Bologna Declaration issued in 1999. The declaration aims at making European higher education more compatible, competitive and attractive for students from European countries and other continents.

Keywords: Cartography, Earth Observation Technology Education, University Reform

1. BACKGROUND & INTRODUCTION

Concerning the spatial or "geo" related sciences; it seems to be a classic way to divide the corresponding education programs into a number of disciplines such as geography, geomorphology, geodesy, geology, geophysics etc. Each discipline has a clearly definable profile and a major study area dealing with the subject "Earth" such as its surface, form, size, structure, and dynamic processes. This diverse composition with its wide application field has presented a challenge for a structured, comparable education system for cartography. As in 2003 David Forrest points out, the last four years has been a difficult period for cartographic education in the UK, with admissions suspended to one of the leading postgraduate courses and the decision to close the only dedicated undergraduate course. In contrast to this, there has been a significant expansion of courses in Geographic Information Systems or Science (Forrest, 2003). Cartography alone seems to have a difficult stand, but in combination with Geoinformatics it may well be a prosperous discipline. The rapid technological development with the introduction of computers, powerful data processing algorithms and improved sharing of data, information and knowledge via the Internet, has increasingly blurred the boundaries among these individual disciplines. As a consequence, some interdisciplinary areas such as remote sensing, geoinformatics and cartography have become particularly active or revitalized.

Cartography can act as an interdisciplinary field as many of the earth related subjects involve the use of cartographic representations. The Commission on Cartographic Education of the International Cartographic Association (ICA) defined Cartography as the totality of investigation and operations - scientific, artistic and technical - which have as their aim the making of maps and as well as the use of maps (ICA, 1999a). The ICA strategic plan for 2003-2011 offers a definition for cartography as: "The art, science and technology of making and using maps" or a more comprehensively, defining "Cartography as a unique facility for the creation and manipulation of visual or virtual representations of

geospace – maps – to permit the exploration, analysis, understanding and communication of information about that space” (ICA, 1999b).

Cartography is more than displaying results of a spatial analysis. It does also relate to the concept of Geovisualization, which provides theory, methods and tools for the visual exploration, analysis, synthesis and presentation of data that contain geographic information (MacEachren and Kraak, 2001). Additionally cartography may to some extent be linked with concepts of Visual Analytics (Thomas and Cook, 2005). As suggested by Andrienko e.a., “Visualization and interactive visual interfaces, as an effective way to provide material for human’s analysis and reasoning, are essential for supporting the involvement of humans in problem-solving. However, a simple combination of visualization with computational analysis and modeling is not sufficient for facilitating the mutual reinforcement of the abilities of humans and computers. New methods are needed, and such methods can only result from a focused cross-disciplinary research based on the achievements in the fields of geovisualization and information visualization, human–computer interaction, geographic information science, operations research, data mining and machine-learning, decision science, cognitive science, and other disciplines, so that a synergy of approaches and technologies could lay a basis for a synergy between humans and computers in solving complex decision problems.” (Andrienko et al., 2007) The growing technical spectrum makes the current cartographic education a non-trivial task as the new emerging ideas of using data representations still have to find the way into the current software tools and into the heads of the researchers, teachers and students.

The European education reform includes the Bologna Declaration issued in 1999. The three priorities of the Bologna process are: Introduction of the three cycle system (bachelor/master/ to some extent also the doctorate), quality assurance, recognition of qualifications and periods of study. Additionally the Bologna declaration aims at making European higher education more compatible, competitive and attractive for students from European countries and other continents. The Declaration states to promote mobility by overcoming obstacles to the effective exercise of free movement with particular attention. This applies to students, as they should have access to study and training opportunities and to related services and additionally to teachers, researchers and administrative staff, with their recognition and valorization of periods spent in a European context researching, teaching and training, without prejudicing their statutory rights (EUROPEAN-UNION, 1999). Therefore the international education within the Technical University Munich (TUM), in particular within the field of Cartography & Geoinformatics seems to be on the right track and in line with the Bologna declaration. For other earth related sciences the Bologna reform may also provide the chance to harmonize the education to some extent.

2. CURRENT EFFORTS IN EDUCATIONAL PROGRAMS – TWO CASES

Two examples of International Master Study Programs from Technical University Munich are introduced – “ESPACE” (Earth-Oriented Space Science and Technology) that started in 2005 and “Cartography and Geoinformatics” that is intended to start in 2010. Both programs are rooted in the traditional German Diploma program “Geodesy and Geoinformation”, but have been progressively reshaped as interdisciplinary and non-consecutive Master programs. Unlike a consecutive Master program which usually sits on a Bachelor program of the same name, a non-consecutive Master program can be backed up by a number of Bachelor programs that are equivalent from the methodological perspectives.

2.1 Master’s program Earth Oriented Space Science and Technology (ESPACE)

Earth-observation satellite missions become more and more important for geo-related research. Today, researchers within navigation, geodesy, remote sensing and geo-information as well as national agencies are all dependent on up-to-date satellite data. The increasing access to satellite data also open the way to new research issues within the classical cartography, particularly for geovisualization. Design, development and realization of Earth-observation missions require not only knowledge from space engineering like spacecraft technology, orbit control and data management, but also from the applications of these satellites, such as Earth system science, remote sensing and navigation. From the educational point of view this diversity is a challenge. The classical university programs cover parts of this spectrum in different disciplines. These are aerospace engineering, electronic engineering or geodesy, - just to mention a few, - and there is hardly any connection between these parts. Therefore several institutions in and around Munich decided to set up a Master’s Program, which combines space engineering with satellite applications. The Master’s program Earth Oriented Space Science and Technology (ESPACE) was founded in 2005. At that time Bavaria was already appointed to one of the ERA-STAR regions in Europe. ERA-STAR is a European network of public funding organizations which support

programs in the field of space applications (Boillot, 2005). Hence, the localization of ESPACE to Munich was a natural decision. The program utilizes the unique concentration of know-how and expertise related to space engineering and technology in and around Munich. ESPACE is coordinated at TUM with teaching staff coming from three different universities (TUM, University of Munich and University of Federal Armed Forces), several research institutions such as German Aerospace Center (DLR), German Geodetic Research Institute (DGFI) and space industry.

Currently 10 university professors and about 12 researchers are directly involved as teachers or guest lecturers. The teacher-student ratio is high, about 0.8. Hence, the students get a valuable and close contact with the state of the art research reaching far beyond the University. The program is open to students worldwide with a Bachelor or diploma degree in science or engineering. Admission to ESPACE is competitive and selection is done on the basis of the documents of application. About 60% of the applicants get admission. Interviews are sometimes necessary. There is a high level of foreign student participation (78%), altogether students from 19 different countries with the majority from Asia. The background of the 26 current students range from engineering disciplines (i.e. Aerospace, Electronics, Environmental, Geodesy, etc.) to natural science disciplines (i.e. physics, geo-science, etc.). The diverse backgrounds of the students require a particularly careful design of the curriculum. Figure 1 illustrates the structure of the ESPACE master program.

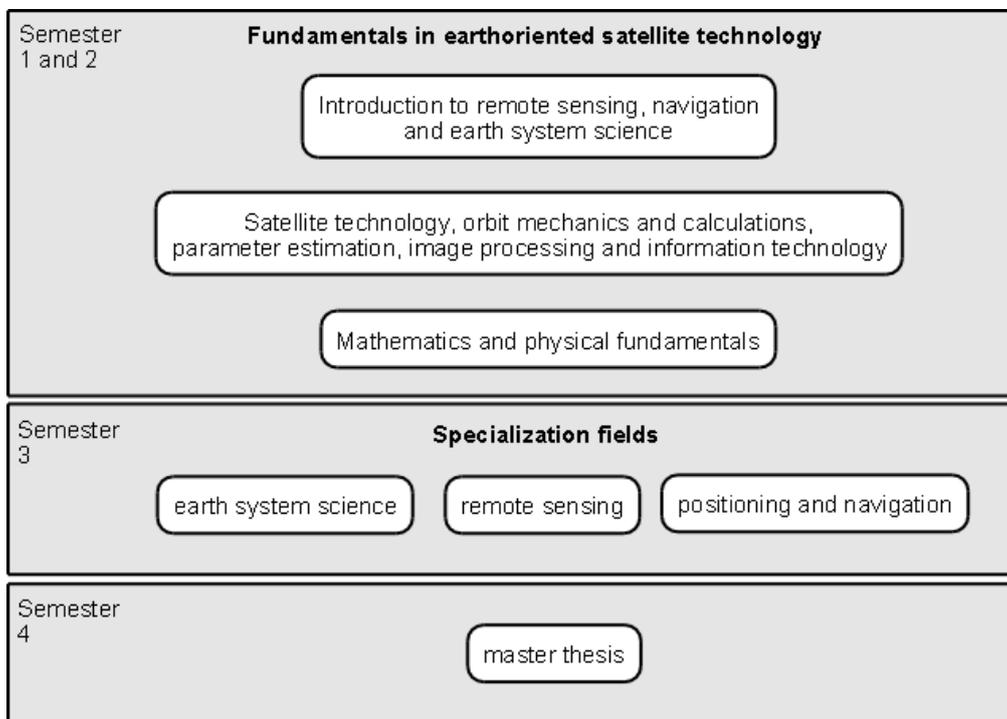


Figure 1. Structure of the ESPACE master program

The first year of the program has a rather fundamental character and combines spacecraft engineering with mathematical/physical foundations. During this year the students also obtain introductory courses in various satellite applications. In the third semester the students have the opportunity to specialize in one of three concentrations: 1) Earth System Science 2) Navigation and 3) Remote Sensing. These three areas are already rooted in the classical geodesy and geo-information diploma program.

Higher education at German state universities such as TUM is in general financed through taxes. The tuition fee is relatively low, about 500 EUR per semester. Already during their studies, many ESPACE students work as assistants for research activities or as tutors for lectures in lower semesters. ESPACE Alumni can be best described as satellite application engineers now working in national space agencies, space industry, research institutions or universities. The majority of ESPACE graduated students have gone on to pursue a PhD mostly in any of the cooperating universities or research institutions mentioned above.

2.2 International Master Program in “Cartography and Geoinformatics”

Following the successful example of ESPACE and on the basis of an extensive demand analysis in German speaking region, we have conceptualized a new international non-consecutive Master program Cartography and Geoinformatics. Being coordinated at TUM where the academic degree Master of Science will be conferred, it attempts to bundle the existing competence from other German universities or European universities such as Technical University of Dresden, ETH Zurich in Switzerland, Technical University of Vienna in Austria, and Royal Institute of Technology in Sweden. The locations of these participating Universities are shown in Figure 2.

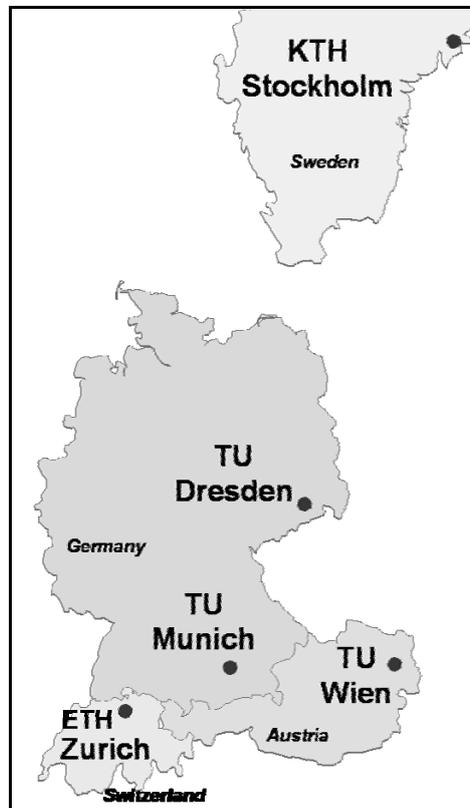


Figure 2. Universities to participate in the international master in "Cartography and Geoinformatics"

The curriculum incorporates and highlights the methods and applications in spatial data modeling, analysis and visualization of geographic information. The participating students are exposed to different organizational environments & cultures. In particular, various options concerned with mobility of students and teaching staffs are explained in detail. Moreover, a comparative study is given to various forms of academic degree such as single degree, double degree and joint degree.

The program is intended to start in 2010. With a very high concentration of scientific competence in Cartography and Geoinformatics, the program holds a unique feature not only in Europe, but also worldwide. There are hundreds of universities throughout the world where cartography and GIS courses are given, most of them are introductory courses just set up to give a basic idea how to deal with geospatial information and visualize it with the help of some software modules. There are a limited number of Universities and advanced technical colleges where students may specialize in cartography and GIS, on top of a basic program in geography or in geodesy.

The new Master of Science in “Cartography and Geoinformatics” will be the first one taught in English in the participating universities. The main objectives of this program are to maintain and to improve the high level of cartographic sciences in Europe and to create a "spearhead" in cartography and geoinformatics by the collaboration of 5 universities. Another goal is to enhance international relations and university collaborations in Europe, using the synergetic effects of 5 universities and combining their advantages. Furthermore, the program shall improve exchanges

of students and scientists worldwide. Through a comprehensive education in cartography and geoinformatics the program will educate top-level researcher in the subject.

The curriculum incorporates and highlights the methods and applications in spatial data modeling, analysis and visualization of geographic information. The conceptual idea is a 4-semester Master program which has an intake between 15 and 25 students per year. Students obtain altogether 120 ECTS credit points. The first semester offers different learning paths, addressing both the previous know-how and the requirements of the students (harmonization of knowledge). In general, the first 2 semesters contain mainly basic and advanced courses in cartography and geoinformatics. In addition, key competences (project management, research methods) are provided. Furthermore, a Summer School for special projects is planned. In the 3rd semester, students specify in a certain field of interest in cartography and geoinformatics and assemble the required credit points in one participating university which is particularly strong in that field. In the 4th semester, students are supposed to write their Master thesis. Students are able to choose in which University they would like to study for a certain period of time. Figure 3 illustrates three possible options among a variety of combinations.

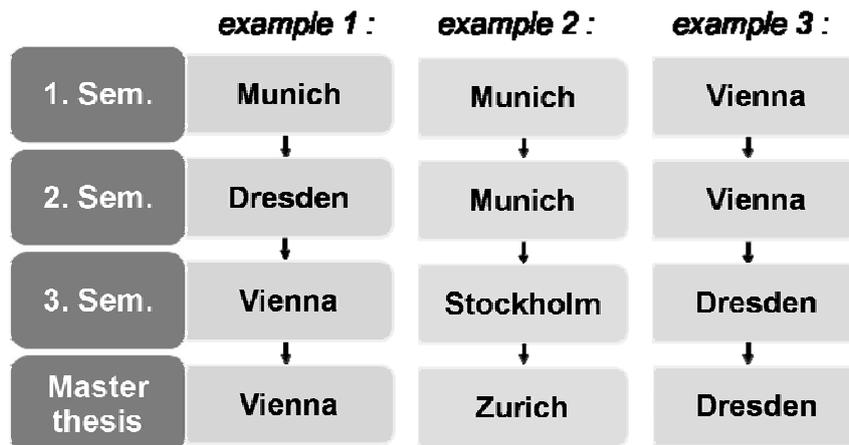


Figure 3. Examples for the possible locations of study locations

Besides of capability for solving practical and development tasks in the fields related to cartography and geoinformatics, students are supposed to be trained for taking part in research projects and aim for continuation of their studies for the PHD degree. Another advantage is that the program focuses on both, cartography and geoinformatics, which offers the students with excellent job perspectives, an easy access to an international research network and a scientific career. The academic degree will be issued by the coordinating university or by 2 jointly coordinating universities in the form of a double degree.

Target students are high-qualified students from all over the world especially from Asia and Europe, holding a bachelor or diploma degree in cartography or related subjects in the area of geo-science or informatics. The Master program will accept high-quality and top-level educated students to prepare them for current workforce demands while giving them a life-long career path. One important aspect is an intensive and individual supervision of the students.

The participating students are exposed to different organizational environments & cultures. One challenge will be to handle the mobility of students and lecturers between the co-operating universities. Therefore, different options are considered: block courses, hold amongst others by distinguished guest lecturers; integration into existing courses and possibly lecture transmission via video streaming, respectively e-learning. Funding for the accepted students may be provided by DAAD (German Academic Exchange Service) and the European Erasmus-MUNDUS program. Furthermore Erasmus-Mundus offers financial aid for scientists, guest-lectures and cooperating universities.

3. CONCLUSIONS & FUTURE EFFORTS

In this article we have presented two examples of how to successfully integrate geo-related science in studies on Master level and thereby expanding the field of geo-related science. ESPACE Master's program has managed to combine two

completely diverse disciplines such as space engineering and geo-related satellite applications. The program has also succeeded to draw students with various backgrounds. After graduation these students are now working or doing PhD in fields not only related to Geodesy and Geo-information but as well related to space engineering. Hence, ESPACE shall be regarded as a rather complementary program than a competing program to the Master's program Geodesy and Geo-information. The success with ESPACE will be continued by the establishment of an additional new Master's program. This new Master program will set innovative standards in the international Cartography & Geoinformatics education and research. The technological and methodological developments in the geosciences are the driving forces to this new international Master. With its unique features, it is an innovative approach that provides excellent job opportunities. The first principal steps for the new program are set and the general agreement as well as the industrial and research demand is given.

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