

A CUTTING-EDGE HIGHER EDUCATION OF GEOINFORMATICS IN AALTO UNIVERSITY, FINLAND

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SUMMARY

The Aalto University School of Engineering, Finland, hosts the Master's Programme in Geoinformatics. This relatively new two-year curriculum is research-based and provides courses in geoinformation technology, geodesy, photogrammetry, laser scanning, and remote sensing. Since all teaching and teaching materials are in English, the programme is well suited for international students. We aim to help our students grow into skilled academic professionals in geoinformatics. Part of our success formula is to continuously develop our courses in order to provide top quality academic education. Aalto University also participates in the Nordic Master in Cold Climate Engineering Space Track, which has a focus area of Mapping and Navigation. Enrollees study one year at Aalto University, and another year at the Technical University of Denmark. This curriculum confers a double degree, and the courses in Aalto University are largely the same as in the Master's Programme in Geoinformatics. We gladly welcome talented students to the Master's Programme in Geoinformatics as well as to the Nordic Master in Cold Climate Engineering.

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INTRODUCTION

Aalto University, Finland, consists of six Schools and has nearly 20 000 students and over 4000 staff members. The university is relatively young, because in 2010 three previously independent universities (the Helsinki University of Technology, the Helsinki School of Economics, and the University of Art and Design Helsinki) were merged into one. Aalto University continues to maintain the legacy of these respected three universities and has recently been internationally recognized as the ninth best young university in the world (QS Top 50 Under 50, 2019).

Our campus (Figure 1) is located in Espoo (Otaniemi district), an eleven-minute subway ride away from the center of the capital Helsinki. Subway and bus connections make the campus easy to access, and there are many student apartments available. Students, student associations and hobby clubs ensure that the area is full of activities. In addition, shops, eateries and sport centers ensure that daily life is easy within the campus area.



Figure 1: The Aalto campus, with the Candidate Centre building in the front of the picture.

All Bachelor's and Master's programmes at the Aalto University School of Engineering were revised recently. The new Bachelor's programmes started in 2013 and the retooled Master's programmes started in 2016. The curriculum structure follows the Bologna declaration (European Ministers of Education, 1999), i.e., a 3 + 2 years structure. These changes had a strong impact also on the teaching of geoinformatics. One major decision was that all Master's programmes in our School be in English, thus allowing also foreign students to pursue Master's degrees in our new programmes. The Bachelor's level teaching is generally in Finnish. However, individual courses can be in English or offer bilingual study materials. In addition, there are a couple of English Bachelor's level programmes, in which foreign students may enroll.

The aim of this paper is to describe the current Geoinformatics curriculum in Aalto University. Since curricula are subject to change, the details of this paper apply to the situation in 2019. Up-to-date information on the courses and study structure can be found from the web pages of the programme (<https://www.aalto.fi/en/study-options/masters-programme-in-geoinformatics>). Our curriculum encompasses geoinformation technology, geodesy, photogrammetry, laser scanning, and remote sensing.

GEOINFORMATICS AT THE BACHELOR'S LEVEL

Currently, there is no separate Bachelor's programme for geoinformatics in Aalto University. The official route to study in the Master's Programme in Geoinformatics goes through the Bachelor's programme of Energy and Environmental Technology. From this Bachelor's programme it is possible to continue to the Master's programmes of Energy Technology, Geoinformatics, Geoenvironmental Engineering, or Water and Environmental Engineering. In their major studies, Bachelor's students are offered three courses dedicated to geoinformatics (Table 1). From these courses, one course is mandatory for all students in the Bachelor's programme of Energy and Environmental Technology.

In the mandatory geoinformatics course, Geoinformation in Environmental Modelling, students learn the basics of geoinformatics, and its subfields taught at Aalto University. The course goes through the basics of geodesy, measurements and data gathering methods, data management, analysis, and visualization in geoinformatics. In the elective courses, the students can build on this foundation to learn more about measurements and data gathering, as well as management of spatial data and spatial data sets.

Table 1: Bachelor's level courses in geoinformatics

Course	ECTS	Status	Teaching year	Language
Geoinformation in Environmental Modelling	5	mandatory	2 nd year	English
Surveying and Observing the Environment	5	elective	2 nd year	Finnish
Management of Environmental Data and Information	5	elective	3 rd year	English

In addition to these three courses, we offer a minor supporting geoinformatics: Computation and Modelling in Engineering. This minor includes 25 ETCS of courses that are highly useful for geoinformatics students. The minor also serves many other disciplines.

Should a foreign student wish to study a Bachelor's degree in English at Aalto University, and continue to the Master's Programme in Geoinformatics, we recommend the English Bachelor's Programme in Science and Technology - Data Science (<https://into.aalto.fi/display/enbsctech/Data+Science>). This programme is hosted by the Aalto University School of Science. In order to prepare for the geoinformatics major, the student should take at least two of the geoinformatics courses presented in Table 1.

MASTER'S PROGRAMME IN GEOINGORMATICS

Our Master's Programme in Geoinformatics is a two years' curriculum. When it started in 2016, we dedicated a considerable amount of planning in order to allocate courses to all sub-fields, to prevent unnecessary overlap between courses, and to ensure that necessary core content would be covered. Because the previous curriculum structure was radically changed, we had the opportunity to carefully plan and restructure the programme. More details about the planning process can be read from Rönholm and Haggrén (2016).

Our aim is to provide our students a higher education that develops their abilities to their full potential. This includes learning core substance matter of

geoinformatics as well as general working-life skills. Applied mathematics, technologies, algorithms and programming are integrated in our courses. In addition, our students learn communicating, networking, project work and management, oral presenting, scientific writing, team work, and information searching, just to name few. Our teaching staff is motivated and pedagogically experienced which creates a favorable environment for learning. A broad range of teaching methods and assignments develop students' skills in an efficient way. Our students grow as independent, skilled academic professionals who are able to face new and complex problems, acquire the most recent knowledge, and have the courage to develop new solutions.

The overall structure of the curriculum of our Master's Programme is illustrated in Figure 2. The curriculum consists of 30 ECTS of major studies, which are mandatory for all students. These courses are all given during the autumn semester (Table 2). The course list reveals that our students get a very broad foundation in all aspects of geoinformatics. This ensures that students understand the contents of each subfield. The students then select 30 ECTS of elective major studies (see list in Table 3) in order to deepen their understanding of the field(s) they wish to study more. Elective major studies enable students to specialize in one or more subfields of geoinformatics. In practice, the topic of the Master's thesis is usually selected from these focus areas.

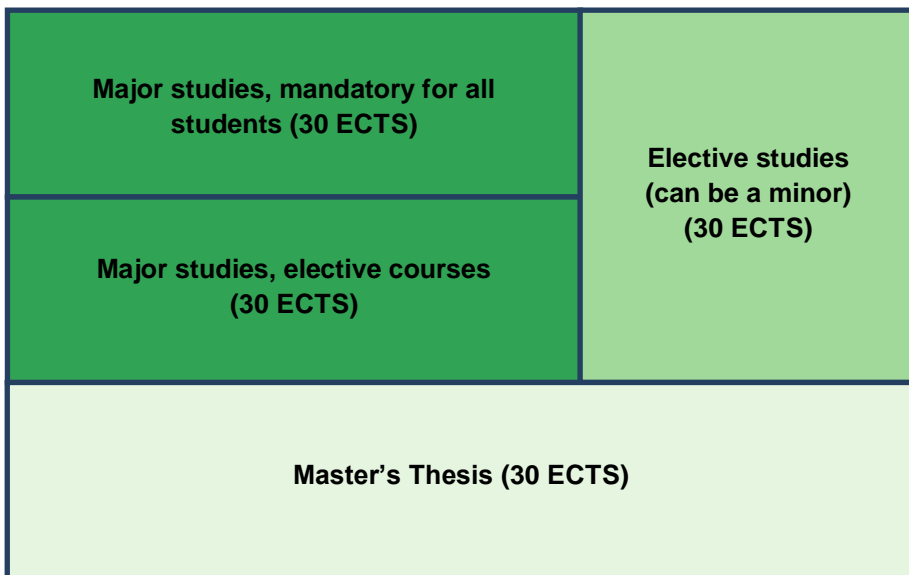


Figure 2: The curriculum structure.

Table 1: Mandatory major courses in the curriculum of the Master’s Programme in Geoinformatics to be completed during the first semester (periods I-II).

Course	Period
GIS-E1010 Geodesy and Positioning (5 ECTS)	I (autumn)
GIS-E1020 From Measurements to Maps (5 ECTS)	I (autumn)
GIS-E1030 Introduction to Spatial Methods (5 ECTS)	I (autumn)
GIS-E1040 Photogrammetry, Laser Scanning and Remote Sensing (5 ECTS)	II (autumn)
GIS-E1070 Theories and Techniques in GIS (5 ECTS)	II (autumn)
GIS-E1060 Spatial Analytics (5 ECTS)	II (autumn)

Table 3: Elective major courses in the curriculum of the Master’s Programme in Geoinformatics. Students select 30 ECTS from this list of courses.

Course	Year	Period
GIS-E3010 Least-Squares Methods in Geoscience (5 ECTS)	1 st	III (spring)
GIS-E3020 Digital Image Processing and Feature Extraction (5 ECTS)	1 st	III (spring)
GIS-E4020 Advanced Spatial Analytics (5 ECTS)	1 st	III-IV (spring)
GIS-E3030 Advanced Laser Scanning (5 ECTS)	1 st	IV (spring)
GIS-E3040 Advanced Photogrammetry (5 ECTS)	1 st	IV (spring)
GIS-E5040 Mathematical Geodesy (5 ECTS)	1 st	IV (spring)
GIS-E3050 Advanced Remote Sensing (5 ECTS)	1 st	V (spring)
GIS-E4030 GIS Development (5 ECTS)	1 st	V (spring)
GIS-E5030 Physical Geodesy (5 ECTS)	1 st	V (spring)
GIS-E6010 Project Course (10 ECTS)	2 nd	I-II (autumn)

A set of elective courses totaling 30 ECTS can constitute a minor. However, it is possible to select any elective courses, even if they are not related to each

other. This option allows students to learn various skills to strengthen their professional profile.

The Master's thesis process allows students to shine and use all their skills to make a coherent academic study. Students can find the topic for a thesis from the industry, municipalities, university, or research institutes. In Finland, in addition to universities, we have several active research institutes giving excellent opportunities for research careers. In all cases, our staff gives high quality supervision and guidance to students ensuring great possibilities for success. Because a Master's thesis requires profound work and exhaustive literature reviews, students also learn a lot during the process. An excellent Master's thesis is like the student's business card to future employers.

Especially the elective major studies of the curriculum in geoinformatics are strongly research-based, and offer students access to the very latest knowledge, thinking and instrumentation in the field. The teachers in our Master's programme are active also in research, and well networked with the national and international scientific communities in their own disciplines. For example, in 2019, our teachers are involved in the Centre of Excellence in Laser Scanning Research in Finland, run a highly prestigious remote sensing project funded by the European Research Council, and develop open geospatial information infrastructures at national-level. A few Master's students each year also work as research assistants in the projects. Overall, our Master's programme also offers an excellent foundation for continuing further in research by completing doctoral studies in geoinformatics either in Aalto University or elsewhere.

Annually, we reflect our teaching against comments from stakeholders. We have established an advisory steering group for our Master's programme. Each professorship proposes two stakeholder representatives for the steering group. This allows general discussions with the whole group but also professor-oriented discussions in smaller groups. As a result, we are able to deal with both larger issues and professor-specific issues in developing our curriculum.

Our academic advising system ensures that every student gets individual support from a named staff member. There is a biannual opportunity to meet the academic advisor face-to-face and to discuss about studies and future plans. This also serves as an early-warning tripwire when things are not going as they should. Furthermore, it is easy to approach the academic advisor whenever there is a need to discuss or get help.

NORDIC MASTER IN COLD CLIMATE ENGINEERING

Under the umbrella of the Nordic Master in Cold Climate Engineering (<http://www.coldclimate-master.org/>), there is a Space Track. A student accepted in this track may select the Mapping and Navigation focus area. Students in this focus area study one year in the Aalto University and another year in the Technical University of Denmark (DTU). Students can select at which university they want to start their studies. In Aalto University, they mainly study the courses listed in Tables 2 and 3.

Graduation from this curriculum confers a double degree. From Aalto University, students get the degree of Master of Science (Technology), and DTU grants the title of Master of Science in Earth and Space Physics and Engineering.

DISCUSSION

Our Master's programme in Geoinformatics provides high-level teaching in all aspects of geoinformatics. Active contacts with industry, companies, municipalities, mapping agencies, and research institutes, as well as our own research projects keep our teaching up-to-date. Our students learn a broad foundation in geoinformatics which opens many employment opportunities. Currently, the employment rate of our graduates is excellent.

The annual intake of students coming from outside Aalto University is 15-20. The applicants need to have a Bachelor's degree or a degree from a university of applied sciences from a field related to geoinformatics. In some cases, we accept also students who have a strong programming background even if their prior knowledge of geoinformatics is insubstantial.

In Aalto University, the programmes at both the Bachelor's and Master's levels have no tuition fee for students coming from the EU or EEA countries. However, the university collects a tuition fee from students coming from countries outside the EU and EEA. In the academic year 2018-2019, the tuition fee was 15 000 € per year. The Aalto University Scholarship Programme offers scholarships of 100 % and 50 %. The full scholarship is usually available only for one or two students per Master's programme. Therefore, the majority of non-EU and non-EEA students need to pay either the full tuition fee or half of it.

CONCLUSIONS

Aalto University's Master's Programme in Geoinformatics is a fairly new two-year curriculum which provides courses in geoinformation technology, geodesy, photogrammetry, laser scanning, and remote sensing. Since all teaching is in English, it is well suited for international students. Also the students of the Nordic Master in Cold Climate Engineering Space Track have access to our courses.

Aalto University is an internationally recognized university, and we put great emphasis on giving high-quality teaching. We aim to assist our students to develop into skilled academic professionals in geoinformatics. We gladly welcome talented students in the Master's Programme in Geoinformatics or to the Nordic Master in Cold Climate Engineering.

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