

Improving an international Geo-Information Science curriculum by means of competencies



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Abstract

The Geo-Information Science curriculum of Wageningen University faces the challenge of influx diversity and the wish to implement the competence approach. It is explained how the curriculum is structured with the individual courses and recently formulated exit and entrance competencies are presented. The present diversity in incoming students is described based on cultural differences, type of bachelor education and bachelor domain and analysed in the frame of the competence descriptions. First conclusions are given regarding how to deal with future students on application and during their studies, and problems which will have to be addressed are indicated.

Introduction

In the Netherlands both academic and professional universities are in the process of formulating the competencies they intend to teach their students. The MSc curriculum Geo-information Science is one of the subject fields for which Wageningen University is working towards a description. The competency approach is intended to replace the traditional knowledge and skills approach, since the wishes of the national and international job market are towards the ability to apply knowledge and skills with the right attitude.

The Bologna Declaration about Higher Education (European Ministers of Education, 1999) aims to create more convergence among the education systems in the participating European countries. Wageningen University is presently in the process to operationalize those objectives. With the introduction of the curricula of 2000, the first steps were made to introduce a BSc-MSc system. Since September 2002 Wageningen University offers 16 bachelor and 27 master programmes.

The MSc curricula in Wageningen have a length of two years and intend to prepare the students for academic jobs both in research and in other professions. No separate curricula for international students exist anymore. All teaching in the MSc phase is done in English and the courses and curricula are intended for both Dutch and international students.

The process of development of the competencies for the MSc Geo-information Science curriculum has been described (Rip and Epema, 2004). For Wageningen University with its long experience in international and national education, the challenge is to offer now programmes with exit competencies, suitable for Dutch, other European and international students. The programme Geo-information Science was changed gradually during the last years. In this paper subsequently the following aspects will be discussed: the specific character of the Wageningen University view on geo-information; contents of the courses; competencies of the curriculum; the entrance requirements; the experience with student groups with different background, who followed the last year programmes. Based on this, ideas were developed, how to deal with the variation of entrance and exit competencies.

Geo-information Science in Wageningen

Wageningen view

Characteristic for the Wageningen University (WU) view on Geo-Information (GI) is a focus on tackling complex questions of an environmental nature in an innovative and academic way (Rip and Epema 2004). Geo-information science is in this view devoted to acquisition and processing of geodata for managing our environment. The organizing concept for the Wageningen approach of the geo-information knowledge domain is called the Geo Information Cycle (figure 1).

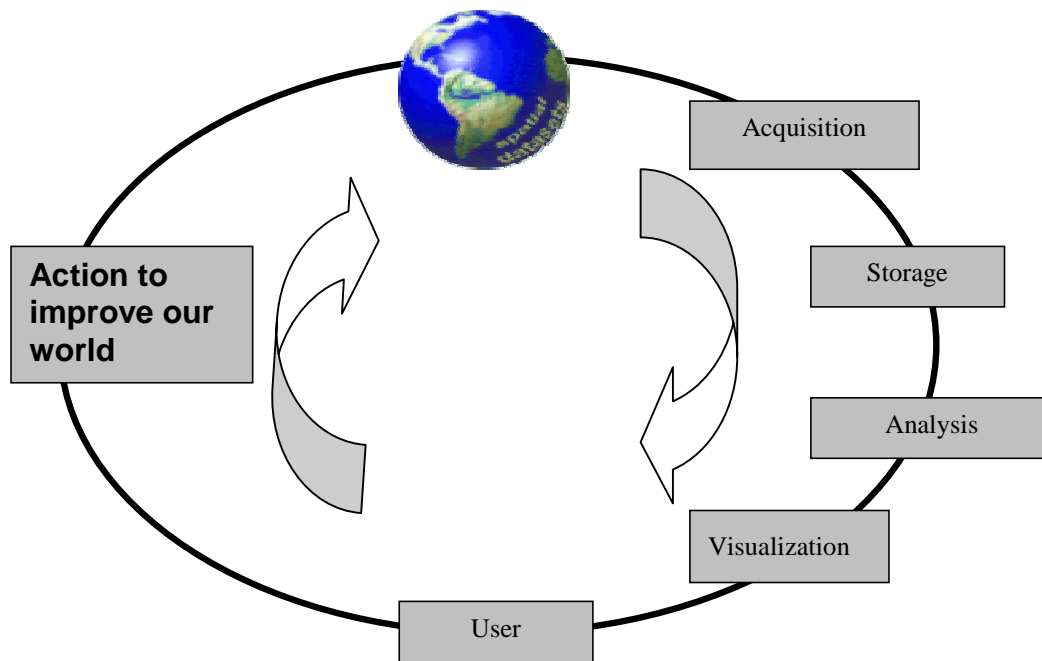


Figure 1 The Geo-Information Cycle. Adapted from: Bregt 1999. "Geoinformatiekunde aan Wageningen Universiteit". Powerpoint slideshow for lecture at Nijmegen University, Dec. 8, 1999

The GI-cycle illustrates, on a high abstraction level, that geo-data are a key element in the way we deal with our planet. Geo-data are collected, processed and visualised to support the needs of engineers, policymakers and others in many knowledge fields. The abilities required doing the things in the right half of the cycle are the competencies that belong to the GI-domain. These abilities imply competence to adequately communicate with various stakeholders and to abstract the problems to tackle with geo-information science.

Influx diversity

Wageningen University does not offer a BSc Geo-information Science. Students are admitted without conditions from a limited number of Wageningen BSc programmes in the broad field of environmental sciences, like forest and nature conservation; landscape, planning and design; international land and water management. In these BSc programmes, topics that deal with our planet are treated, together with basics of Geo-information Science. In view of the BSc-MSc system also students with other backgrounds should have a possibility to follow the MSc Geo-information Science programme.

Curriculum

The Wageningen MSc curriculum Geo-information Science lasts two years (figure 2).

The first year, offering 60 ECTS, is usually devoted to coursework (10 courses of 6 ECTS), while in the second year a MSc thesis and an internship of respectively 36 and 24 ECTS has to be done. A concise overview of the contents of the courses follows here.

The courses can be divided in four groups: (1) basic modules, (2) core modules, (3) specialisation modules, (4) optional modules.

The *basic* modules are courses, that are actually at the level of the second or third year BSc, and are part of the BSc programme of other Wageningen curricula (Introduction Geo-information Science), or can be followed as optional course as part of a minor in the half year free choice (Geo-information Tools and Remote Sensing), or are an integral part of a number of BSc courses (like Research Methods in Environmental Science).

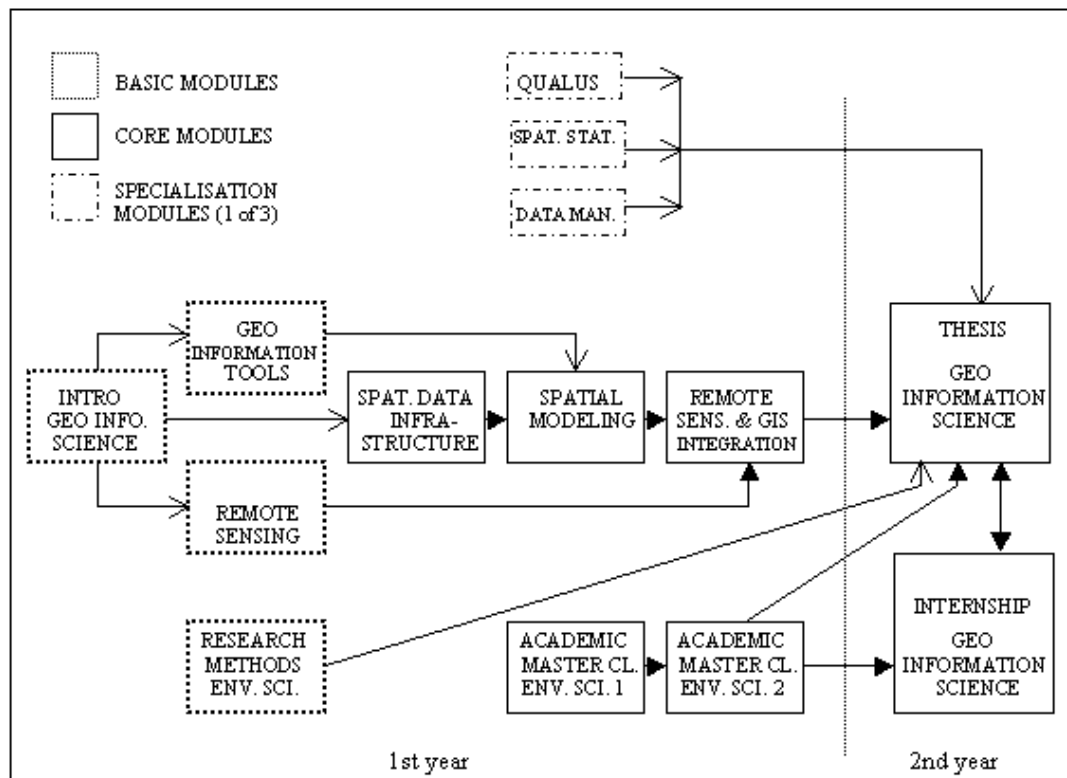


Figure 2 The Curriculum Structure

The *core* modules are meant to teach the domain part of the geo-information cycle: acquisition and storage (Spatial Data Infrastructure), analysis (Spatial Modeling) and visualisation (part of RS and GIS Integration). Integrated in these courses are also training of academic competencies, like writing and evaluating scientific articles, recognition of innovative opportunities within geo-information science in fields like imaging spectroscopy, visualisation, spatio-temporal modeling and geo-data infrastructure as well as conceiving new applications of geo-information science in the environmental sciences

The academic master clusters (AMC's) prepare students for other required competencies of academic jobs. The AMC-1 consists of a selection of two out of four elements: Project Planning and Management; Philosophy and Ethics, Communication Skills Development; and Scientific Writing. In the AMC-2 various competencies have to be developed and applied in dealing with actual cases in an interdisciplinary project setting.

The MSc thesis is an individual research project, which trains the actual research capabilities. Topics can be selected from the research fields of the centre for geo-information:

- providing geo-information for rural areas: making knowledge and information available to underpin policy decisions on natural resources;
- monitoring rural areas; developing GIS-based and RS-based methods for monitoring rural areas, at national as well as global levels;
- quantitative retrieval of geo-biophysical and -chemical variables from spatially distributed data at scales from local to global for environmental management;
- scenario studies: integrating GIS and RS knowledge in process models for planning and scenario studies;
- visualisation and communication of geo-information: using multimedia technology in developing and underpinning policies for the rural areas.

The internship can be followed at different institutions and companies in the Netherlands or abroad.

The *specialisation* modules are meant as possibility for a students to emphasize segments of their competencies. At least one course has to be selected from three options: Data Management, Spatial Statistics or Qualus (quantitative analysis of land use systems). Preferably, the choice is connected to the field of thesis research.

The number of optional courses is different for the various groups and is at maximum 24 ECTS for Wageningen University students, who selected already the basic modules in the BSc. For other students a part of the 24 ECTS can be used to deal with missing competencies. The optional courses can be used to deepen the knowledge in relevant application fields and geo-informatics, or based on the individual needs of the student.

After admission, the study advisor develops together with each MSc student a contract, describing, which courses have to be followed, based on lacking entrance competencies (basic modules), specific existing competencies and wishes for further competence development. This contract is checked by the examination committee.

Competencies

To define competencies for the MSc Geo-information Science, an analysis was made of the types of roles that alumni can fulfil in the context of organizations that deal with geographical questions. This resulted in 5 core competencies for MSc Geo-information Science alumni. In short, the alumni should be able to (Rip and Epema 2004):

- Carry out geo-information research for an external client or for a PhD-thesis
- Leading applied geo-information research projects for external clients
- Develop new geodata processing concepts and implement prototypes
- Bring about geo-information knowledge transfer in educational settings
- Provide geo-information consultancy to management of organisations

These core competencies are split in more detailed sub-competencies. Sub-competencies consist of recognizable knowledge elements, provable skills and manifest attitudes. It is at this level that links can be established between competencies and individual courses in the curriculum and also with the learning objectives for a course. This process is beyond the scope of this article. Essential is the description to which level these competencies have to be fulfilled. For instance a fresh alumnus does not usually have the competence to be a general manager right after graduation, however he should have an idea how management works, and have the attitude to develop these competencies during his career.

As an example the description of the first research competence is given (table 1). The others are given in Rip and Epema (2004).

Table 1 Sub-competencies of research

<p>Overview</p> <p><i>Core competence-1 of a Wageningen GI-Master is, that the graduate is able to act as an Applied Researcher in projects for external clients, and carry out research on an integrated/innovative level. The graduate is able to co-ordinate operational and tactical matters regarding the applicability of GI-knowledge in Rural Areas. For this purpose, the graduate can apply the GI knowledge domain (the geo-information cycle). He/she will do this based on knowledge about and experience with software tools, in combination with the ability to develop an independent vision on the research question. He/she derives a GI approach by abstracting problems in the domains of application, by discussing with clients and domain specialists, and by studying parts of the domain problems. For this type of work, the GI-Master is able to formulate a research proposal, co-ordinate and lead the research project, and communicate about the research in an adequate way.</i></p> <p><i>The following Sub Competencies describe the competence in more detail. The graduate is able to...</i></p> <p><i>IA: Recognise the interfaces between GI and domain of application;</i></p> <p><i>IB: Formulate a feasible research proposal and discuss it with a client;</i></p> <p><i>IC: Co-ordinate by organising tasks in a project and lead its execution;</i></p> <p><i>ID: Perform the partial tasks, using the GI software-tools and available geo-data;</i></p> <p><i>IE. Communicate the results to the client and if relevant, to a broader audience.</i></p>

After establishing the list of competencies, the curriculum committee has invited a group of leading persons, providing geo-information science jobs. They were asked to give their opinion about the list. In general they were positive about the competencies approach. They considered the type of jobs related to the competencies as relevant but very ambitious. One should however consider the fact that academic competencies are not just based on the two year programme, but on the BSc as well and that in the

description the competencies are fulfilled to a certain degree, and that individual students will score different for the various competencies.

Entrance Requirements

In order to have criteria for admitting BSc students and other candidates to the MGI curriculum, Wageningen University Education Institute of Environmental Sciences has described the general characteristics for their exit level in BSc and MSc studies (after Rip and Epema 2004) (table 2). The BSc exit competencies have to be compared with the entrance competencies of the various applicants.

The application of these criteria is preceded by a check of general admissibility to WU MSc curricula in general.

Table 2. Exit level abilities for environmental BSc and MSc phases at Wageningen University

	BSc	MSc
1. Domain	<i>Has an overview of the knowledge of the domain; is able to take in basic disciplinary knowledge and skills, to distinguish between components of a research cycle and/or design cycle, to elaborate, analyse and interpret.</i>	<i>Is able to do research or to design; can become a specialist in a specific domain; is able to make an original contribution to a discipline; is able to evaluate and has a critical attitude; is able to find solutions</i>
2. Problem complexity	<i>Is able to apply knowledge of the domain to problems in practice</i>	<i>Has exercised in complex real world situations; is able to distinguish aspects of a problem and formulate problem perception from other professional roles.</i>
3. Degree of independence	<i>Is able to perform research when coached or supervised, to follow specific guidelines, to apply existing methods and ways of problem solving independently.</i>	<i>Is independent and autonomous to a large extent in work and research. Is able to develop protocols and methods;</i>
4. Co-operation	<i>Is able to co-operate within own domain of training; is able to formulate roles for disciplinary, interdisciplinary and inter cultural aspects of research and design as well as to formulate those roles for societal problems.</i>	<i>Is able to co-operate in both mono-disciplinary and in multidisciplinary context; can assess necessity and surplus value of co-operation with other disciplines, can judge and value intercultural input and co-operation.</i>
5. Autonomy, context awareness & innovation	<i>Has learned to be open minded with respect to new ideas and approaches; is able to quickly learn new ways of doing things; is aware of societal aspects.</i>	<i>Is able to perceive new problems by him/herself and apply existing knowledge in a new context; is able to invent new methods and directions and engage in societal debate.</i>

To obtain unconditional admission to enter the MGI curriculum, a BSc level and a curriculum with geo-spatial elements is a prerequisite. Crucial is the decision how deficiencies will be handled: within the program or before admission to the MSc.

In general, students applying for entering an MSc curriculum at Wageningen University should comply with a number of requirements. They must:

- Have passed the examinations for a BSc curriculum (or higher level);
- Come from a previous curriculum which, in terms of content, matches or is adequate for the MSc curriculum;
- Be able to finish the MSc curriculum with reasonable effort in 24 months;
- Have an adequate grade point average, or class division. Presently a grade point average (GPA) score of at least 70 % is required, an ECTS mark has to be determined; individually if circumstances provide sufficient cause students can be admitted with lower scores;
- Have a solid motivation for this MSc curriculum;
- Have sufficient command of the English language based on a IELTS or TOEFL test (reading, speaking, writing);

- Have a critical attitude, relevant experience in a job or from other activities, ability for B/γ integration.;
- Possess sufficient knowledge of the specific domain.

Based on the requirements, the Environmental Sciences admission committee decides about admission, for each applicant individually.

Experience with various student groups

Student groups vary according to:

- cultural differences
- type of bachelor education (professional versus academic)
- domain background

These subjects will be looked at in the following paragraphs. It has to be stressed that general observations are given and that individual students may deviate from the general trends.

Cultural Differences

During the period 1998-2003, 61 % of the 173 students who participated in Wageningen MSc Geo-information Science Curriculum were not Dutch. All in all, 29 different nationalities were represented. Out of these 105 international students, most of them came from Ethiopia (22), China (17) or Spain (15). This MSc programme reflects the competencies, which are felt important for an international setting (of course, that is as seen from a Dutch point of view). Therefore students in Wageningen will experience this approach in an international student setting. It is believed that this setting is an enrichment for both Dutch and international students, giving ability to function in a more and more international world. An extensive description of cultural differences and their effects on education can be found in Hofstede (1986, 1991) and many subsequent publications.

Culture is a phenomenon, which is induced by the collective programming of the mind which distinguishes the members of one group or category of people from another. The contrasting cultural values can be described according to Hofstede (1991) in five dimensions: (1) Power Distance; (2) Individualism/Collectivism; (3) Masculinity/Femininity, (4) Uncertainty Avoidance; (5) Long-term versus Short-term orientation. It turned out that people from different countries score quite different in these dimensions. This affects attitude to many aspects, including education. Some striking features are given based on Hofstede (1991) and some observed phenomena for our MSc students are added. It must be noted that these phenomena are rather accidental observations, not based on systematic research. Also individuals may differ considerably from the average. Table 3 presents dimension scores of those countries that represent majority of our student's countries of origin.

Table 3 Scores for selected countries, based on Hofstede's dimensions (Kossen, 2002)

<i>Country</i>	<i>Power Distance</i>	<i>Individualism/Collectivism</i>	<i>Masculinity/Femininity</i>	<i>Uncertainty Avoidance</i>	<i>Long-term/Short-term</i>
<i>Argentina</i>	49	46	56	86	
<i>Austria</i>	11	55	79	70	
<i>Belgium</i>	65	75	54	94	
<i>China</i>	80	20	50	60	118
<i>Czech Republic</i>	62	40	60	65	
<i>Ethiopia</i>	64	27	41	52	
<i>France</i>	68	71	43	86	
<i>Germany</i>	35	67	66	65	31
<i>Ghana</i>	77	20	46	54	16
<i>Greece</i>	60	35	57	112	
<i>India</i>	77	48	56	40	61
<i>Kenya</i>	64	27	41	52	25
<i>Spain</i>	57	51	42	86	
<i>the Netherlands</i>	38	80	14	53	44
<i>Sweden</i>	31	71	5	29	33
<i>UK</i>	35	89	66	35	25
<i>USA</i>	40	91	62	46	29

The *power distance* measures how subordinates, in this case students, respond to power and authority of teaching staff. Countries like the Netherlands, UK, Germany, Austria and the USA have a relatively low-power distance. High-power distance countries are most Asian and African countries and in Europe countries like France, Greece and Spain. In low-power distance countries, teacher expects the students to initiate communication, find their own paths, contradict and criticize teachers.

It is observed for our students that in the formulation and sharpening of the research proposal for their MSc thesis and its execution, students from countries with a high power distance have relatively more problems in coming up with new ideas, which differ too much from the original proposal brought by the staff. The same is valid for problem-based learning courses. In the programme it is shown and explained that a critical and independent attitude is important. Still, differences in attitude remain. Since scientific independency is judged positive and reflected in the final mark, attitude could affect the final mark of some students.

In countries, which score high on the *individuality* index, like many West-European countries, Scandinavia and the USA, people are expected to take care for themselves. They will for instance more easily react in class in response to a general invitation by the teacher, they like challenges, and expect that they are taught how to learn. They also consider acquiring competencies of more importance than getting certificates. Students from collectivistic cultures (most of the countries located in Asia and Africa) have a contrasting approach. They prefer to learn how to do things and strive to achieve higher marks.

The competencies of the MSc Geo-information Science curriculum typically emphasizes individualism but include working in small groups. To judge students adequately, they have to be assessed in the different working forms. It is observed that disagreement on marks between staff and students occurs more often with students from collectivistic countries, probably because these student are more keen on higher marks. Another cause may be that these students judge some competencies as less relevant.

In *feminine* societies like countries in Scandinavia and the Netherlands, people like to cooperate well with each other and are less competitive. Teachers tend to use average students as the norm, and students practice mutual solidarity. The education system would usually like to reward also social adaptation, for instance how to work with each other and not only academic performance. Also employers in these countries appreciate alumni with these competencies.

One of the problems which are faced by the introduction of competencies in Wageningen University is how to judge and reward these “soft” values.

When *uncertainty avoidance* is strong, cultures see uncertainty as threatening. In countries where avoidance is weak (Netherlands, USA, UK and Scandinavia) students are able to work with rather unstructured learning situations (like problem-based learning courses), and broad assignments. In these countries teachers interpret intellectual disagreement as a stimulating experience.

It was observed that MSc Geo-information Science students from countries with a strong uncertainty avoidance prefer courses like Geo-information Tools, where students learn to solve problems accurately and structurally. It is remarkable, that they often judge this course, in which they learn many skills, as more academic than more unstructured courses, where students have to develop their own ideas of tackling problems. These last type of courses however are - at Wageningen University - considered essential for developing academic competencies.

The Netherlands has an intermediate position in between *short and long-term orientation*. The MSc Geo-information Science promotes both fast results and perseverance.

We observed that for instance Chinese students, having a long-term orientation, spend much more time in studying, both in the class and outside, than students from Europe. In judgement of the thesis, the time spent is however not judged, which occasionally leads to some disagreements with students. Finishing a thesis in time determines only a small part of the mark. This aspect of thesis evaluation has to be reconsidered.

Differences in culture affect expectations of students, judgement of parts of courses and to a certain extent performance. However the various courses and overall programme are judged as very positive by different groups, probably because a lot of knowledge and skills are offered adequately in the programme, which can be used in any future job setting. Most students also appreciate that they better understand other cultural attitudes, which make them more competent in respecting, dealing and understanding people from other cultures. Moreover quite a few competencies are not culturally dependent. Although the Geo-information Science curriculum is from Wageningen perspective a more practical one along the academic part, still some students indicate that they like to educate even more about how to do things.

Different types of Bachelor Education

Students of the MSc Geo-information Science presently vary in the type of bachelor education, being scientifically oriented for universities bachelors and more professionally oriented for students from universities of professional education and polytechnics. However universities in Europe vary considerably, some are comparable to universities of professional education while others are very academic. Also the difference between various polytechnics can be considerable.

For Wageningen University as a whole, differences in performance between students with a university BSc and a professional bachelors ("HBO" in Dutch, meaning: higher professional training) have been studied. Average overall course marks, and final thesis marks hardly differ, but for courses, followed by both type of students, students with a university BSc do score better. This indicates that for the present programmes, allowing students to take BSc courses as supporting courses, a considerable part of the HBO students is able to adapt to academic competencies. Since the number of supporting courses will be limited, HBO students will in future probably have to follow a preparation programme or specific supporting courses before admission to MSc.

The difference between Wageningen University BSc and van Hall-Larenstein bachelors on entering the Wageningen MSc's is studied for two curricula, Forest and Nature conservation and Environmental Sciences (Epema, 2004).

Comparing the domain no large differences were found, but when comparing competences especially academic competences, differences were prominent. Also students with a bachelor from the HBO, following MSc's in Forest and Nature and Environmental Sciences turned out to have more problems in abstract thinking. Based on this a preparation programme as minor in the HBO bachelors is developed of maximum 30 ECTS having courses as mathematics and statistics and courses where various academic competences are trained within regular courses. In this way more equal entrance level for academic competence is achieved and only supporting courses up to a maximum of 18 ECTS have to be followed. Students with background in environmental sciences and forest and nature studies also apply for and follow a MSc Geo-information Science. Experience is comparable to the general findings for the university. In thesis work they tend to select more technical oriented thesis topics, but they perform comparable to other groups of students.

In the new situation following one of these minors as preparation for their MSc seems suitable. Alternatively they can follow the basic courses Geo-Information Tools and Remote Sensing in the HBO, like students from Wageningen University are advised to follow in the optional part of the BSc. HBO students usually have the knowledge of the introductory course Geo-information Science. Vital remains, that they also in the new situation take the course "Research Methods in Environmental Sciences" as part of their MSc, where they learn how to set-up scientific research proposals. In the Academic Master Cluster they preferably should not select subjects like Project Planning and Management and Communication Skills Development, but Philosophy & Ethics, and Academic Writing. The advantage of a preparation programme is that HBO students, like the Wageningen BSc students, will have the possibility to select ample optional courses in their MSc. In this way they not only achieve the minimum competencies offered by the compulsory part of the programme, but they are also able to perform at a higher level for the competencies or profile themselves by a minor in another domain.

For BSc students from other universities in the Netherlands differences in academic competencies with Wageningen are relatively unimportant. These students are well able to follow the MSc Geo-information Science programme. For admission to the programme in the new situation, mainly the domain is of importance. This will be treated in the next section.

Students from universities outside the Netherlands vary considerably. It is difficult to make general statements about performance and admissibility, since variations between universities are large, individual students deviate from the mean, students develop different during their studies and cultural differences are present. This pleads for an individual assessment of the students by admission committees to see if they can be admitted directly, or should follow a preparation programme or better to be turned down. It also pleads after admission for an individual programme to establish a good choice in the optional part of the curriculum.

Domain Knowledge

In the past years bachelor students with different backgrounds have followed the MSc Geo-information Science programme: environmental sciences, geo-informatics and social sciences.

Characteristic for Wageningen University is a focus on tackling complex questions of an environmental nature in an innovative and academic way (Rip and Epema 2004). Geo-information

science is in this view devoted to acquisition and processing of geodata for managing our environment. The original programme is for the domain part, based on BSc's in the broad field of environmental and natural sciences, with geographic aspects. The exact background is not very important, it may be narrow or broad, but the student should be willing to integrate his knowledge with other domains by geo-information methodology. Most students have this background and no specific problems occur.

In Wageningen, experience with students with a background in geo-informatics is rather limited. It turned out that these students have a good background in mathematics and statistics, and are very good in the practical parts of courses like geo-information tools and spatial modeling. They are also very well able to get sufficient marks for some other courses. This may partly be due to the fact that the final mark often is a combined score for different parts, where they score quite well for implementation aspects or group work. If they select thesis work, they normally are more in the informatics direction. During the courses and the thesis, they will be confronted with environmental problems and in this way they will to a certain extent be able to acquire the required minimum for the different (sub-) competencies. Still they have on average more problems in understanding environmental scientists to give geo-information scientific solutions. Advisable will be that these students take courses in environmental sciences before or during their MSc programme to be more competitive with other students for jobs like geo-information science consultant.

Also students with a gamma background (policy, social geography) are relatively rare. Students with a pure gamma background normally have a problem in following the technical and modelling part of the study. Actually the admission procedure is presently reconsidered and it probably will be decided only to accept students with a beta-gamma background. This background is comparable to most Wageningen students. Students with a beta-gamma background are very suitable, because they are able to translate policy problems in GIS and still are able to cope adequately with the more technical and modelling part of the study.

In summary, students coming from environmental sciences, geo-informatics and beta-gamma domain, can generally be admitted. They should be treated individually both on admittance and during their studies to take care that the competencies will be mastered. After admission students should carefully select a programme in cooperation with the study advisor to score better for the different competencies or to broaden their competencies.

Conclusions

1) The bachelor-master structure is a good start in giving students more flexibility in education. However differences in exit competencies of the bachelor student vary strongly, based on orientation of the bachelor (scientific, professional), cultural differences and domain knowledge. On admission to the MSc programme and during the programme these differences have to be tackled in order to get students with the same range of minimum competencies;

2) Students of the Wageningen MSc Geo-information Science, having at least in common a set of joint competencies, will vary according to personal competencies, the bachelor background and personal choices. These differences should be made clear, so that employees and students are aware of the strong and weak competencies;

3) International curricula, like the Wageningen programmes, are successful as long as knowledge and skills are trained well and respect and understanding of different cultural attitudes is part of the programme. Describing the programme in competencies helps to communicate with international employees, but the valuation of different competencies will depend on the type of job and its cultural setting;

4) The competence approach is a good aid in determining more specific criteria for unconditional admission, determination of the preparation programme and determining the optional part of the MSc Geo-information science. For some broad groups criteria have been developed, but an individual assessment in addition remains crucial.

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