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Comparison of hydrology curricula of different disciplines at German universities

An overview of hydrological study programmes offered by German universities is given. There are only two independent study programmes in hydrology. The majority of study programmes in hydrology is taught within the scope of studies in engineering and geosciences. Similarities and differences in the hydrological curricula of the various disciplines are shown. To this end, a survey among 60 professors from 45 universities has been conducted. The analysis is based on data from 18 universities providing information on 44 different study programmes. The results have shown that structure and composition of these study courses differ significantly in the three disciplines. Both bachelor and master programmes of each discipline have one predominating area of studies. This fact has a major impact on the subsequent knowledge and views of the graduates.

Keywords: bachelor, curriculum, education, hydrology, master

1 Introduction

Hydrology is a highly diversified science. DYCK & PESCHKE (1995) define hydrology as follows: "Hydrology is the science of water, its properties and manifestations on and under the land surface. It deals with the coherences and correlations of the manifestations of water with the surrounding media, the water cycle, its distribution on and under the ertwined with many related disciplines such as meteorology, ecology, hydrogeology, soil science, hydromechanics, geography, etc. Being an applied science, it lays the basis for managing water resources in terms of quantity and quality as well as for dimensioning and assessing hydraulic structures. It aims at reducing water-related risks jeopardising mankind, such as floods, low-flow and water pollution.

As comprehensive as the definitions of hydrology and its relationships with neighbouring disciplines, as varied is the hydrological curriculum. The most suitable type of training for hydrologists has been frequently discussed (DYCK 1990, NASH et al. 1990, UNESCO 1974). Global change on the one hand and new technological achievements on the other hand have rekindled this debate (UHLENBROOK & DE JONG 2012, WAGENER et al. 2012). Training in hydrology differs considerably depending on the university study programme providing it. Basically, three groups of study programmes can be identified: 1) engineering study programmes, 2) geo- and environmental science study programmes and 3) strictly hydrological study programmes. Hydrology taught within the scope of the first group has the classical task of supplying application-oriented fundamentals to solve practical engineering problems. Hence the role of hydrology in engineering sciences is marginal. In the second group, hydrology is primarily meant to describe and explain natural hydrological processes to answer diverse questions of various geoscientific disciplines. Here, hydrology is part of the geosciences, while the latter is generally favoured as an umbrella discipline for the training of hydrologists compared with the aforementioned group (NASH et al. 1990). In some cases, quantitative aspects and analytical mathematical processes are of minor importance. Strictly hydrological study programmes endeavour to provide comprehensive scientific training. On the basis of scientific principles, while considering both theory and practical observation, future hydrologists are to be enabled to develop an understanding of hydrological processes, establish concepts for their quantification and at the same time cope with practical problems such as measuring and forecasting. Surely such a training is ideal, but highly complex und hardly practicable on a larger scale.

This paper aims at outlining the tutorial offered by different hydrology study programmes at German universities and to facilitate comparison. Special emphasis is placed on highlighting and discussing similarities and disparities in the curricula of the three aforementioned disciplines.

2 Methodology

from German universities offering study programmes with a significant hydrological content have been interviewed. As this cannot always be ascertained a priori, an extensive number of universities was contacted in writing. Participation was voluntary.

The curricula of German-language university study programmes both for the bachelor and the master degree have been acquired. International study programmes held in English language have not been included in this survey. The curriculum has been classified into areas of study and further into subjects or subject groups. As regards bachelor degree programmes, a distinction has been made between four areas of study, namely water resources management, geosciences, related disciplines dealing with water, and mathematic-scientific fundamentals. For master programmes, a distinction has been made between three areas of study, i.e. hydrology / water resources management, geosciences and related disciplines (fig. 1)

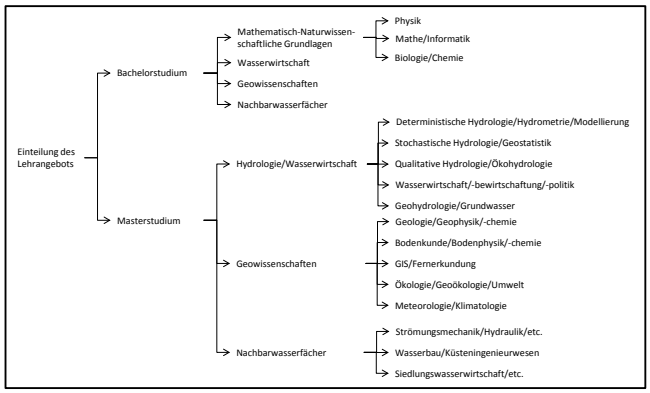

Figure 1
Classification of curriculum into areas of study and subjects or subject groups

The relatively rough subdivision for bachelor programmes is primarily meant to provide an overview on the fundamentals offered because this matters e.g. when changing university or subject between the bachelor and master phases. A more detailed distinction into individual subjects has been made for the master degree programmes, as they usually represent the centre of hydrological education.

In line with this classification, the extent of the potential curriculum in terms of credits has been enquired. The evaluation is not based on a consideration of individual universities or study programmes, but on mean values of the following three disciplines : 1) engineering (ING), 2) geosciences and environmental sciences (GUM) and 3) hydrology (HYD). The focus of evaluation was on analysing the relative share of subject groups resp. subjects in the total amount of study courses offered within and between the three disciplines. As only the potential study course offer has been enquired, it has to be kept in mind that the elective subject offer inevitably overbalances the actually studied contents as a result of this relative consideration.

3 Data

60 lecturers from 45 universities have been contacted. 20 universities replied by sending information on a total of 48 study programmes. The data of some study programmes were incomplete or information on the potential credits offered was lacking. Furthermore, two study programmes in English language were reported, which have not been considered by this study. Following adjustment, comparable data of 18 universities on 44 study programmes were available for evaluation. Table 1 lists the universities included in this survey and shows a classification of study programmes.

Table 1
Universities included in the analysis, detailing the discipline of reported study programmes (ING – Engineering, GUM – Geo- and Environmental Sciences, HYD – Hydrology)

Nr.	Hochschule	B.Sc.	M.Sc.
1	Christian-Albrechts-Universität Kiel	GUM	GUM
2	FH Münster	ING	ING
3	Leibniz Universität Hannover	ING	ING
4	Ludwig-Maximilians-Universität München	GUM	GUM
5	Martin-Luther-Universität Halle-Wittenberg	2 x GUM	2 x GUM
6	Rheinisch-Westfälische TH Aachen	ING, GUM	ING, GUM
7	Ruhr-Universität Bochum	ING, GUM	ING
8	TU Berlin	ING	2 x ING
9	TU Darmstadt	2 x ING	2 x ING
10	TU Dresden	HYD	HYD
11	TU Kaiserslautern	2 x ING	--
12	Universität Bayreuth	GUM	GUM
13	Universität der Bundeswehr München	ING	ING
14	Universität Freiburg	GUM	HYD
15	Universität Potsdam	GUM	GUM
16	Universität Rostock	--	ING
17	Universität Siegen	ING	ING
18	Universität Tübingen	2 x GUM	GUM

As regards bachelor programmes, information on 23 study programmes was reported, with 11 study programmes to be assigned to engineering, 11 to environmental and geosciences and merely the Dresden study programme to hydrology. Data of 21 study programmes are available for master programmes, with 11 to be assigned to engineering sciences and 8 to geosciences and environmental sciences. Two strictly hydrological study courses are offered here, one in Dresden and one in Freiburg. The number of feedbacks indicates that the universities offer hydrologically relevant contents both within the scope of bachelor and master programmes. Solely two universities have a suitable offer just for one of the two degree programmes.

4 Results

The analysis of results is performed separately for bachelor and master programmes. Figure 2 shows a comparison of the curriculum for the 3 disciplines in the bachelor degree programme.

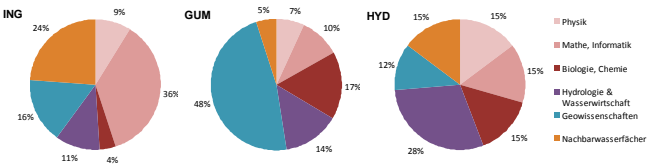

Figure 2
Distribution of curriculum for bachelor programmes according to disciplines: Engineering (left), Geo- and Environmental Sciences (middle) and Hydrology (right)

As regards engineering sciences (ING), mathematics and physics jointly account for approx. 50 % of the study programme, 30 % for hydrology (HYD) and just 17 % in the case of geosciences and environmental sciences(GUM). Biology accounts for approx. 16 % in HYD and GUM, but in the case of ING for just 4 % of the study programme. With 28 %, hydrology has the largest share in the curriculum of HYD, having a far smaller share in the other disciplines, i.e. 14 % in GUM and 11 % in ING. Geosciences account for almost half the curriculum in GUM, with HYD and ING having a far smaller share, but of a comparable size. Most related subjects (due to urban water management) can be found in ING, followed by HYD and subsequently by GUM with a very small share. Overall, the bachelor degree curriculum shows the expected typical differences of the 3 disciplines. Hydrology has the most regular interdisciplinary distribution. Related to the subjects evaluated in this paper, ING students may choose from an offer of 71 credits (LP) on average, GUM students from an offer of 109 LP and HYD students from an offer of 170 LP.

Figure 3 shows a comparison of the curriculum for the three disciplines in the master degree programme, summarized according to disciplines.

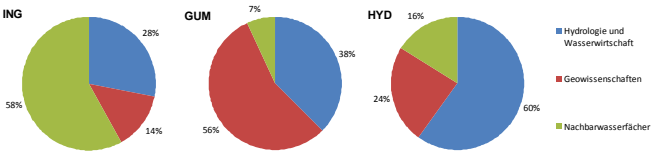

Figure 3
Distribution of curriculum for master programmes according to disciplines: Engineering (left), Geo- and Environmental Sciences (middle) and Hydrology (right)

In obvious conformity, 60 % of the curriculum offered by each discipline consist of the discipline's own teaching contents. At 38 %, the study area hydrology and water management feature second most common in GUM and only then in ING at 28 %. Related subjects dealing with water are scarce in GUM and form the smallest group in HYD. As in the bachelor programmes, hydrology shows the most regular repartition of the three superordinate study areas within the disciplines. For the subjects evaluated within the scope of the master programme, ING students may choose from an offer of 78 credits (LP) on average, GUM students from 105 LP and HYD students from 188 LP.

Figure 4 shows a detailed comparison of the curriculum for master programmes. It depicts mean value and standard deviation of the credits offered for all subjects considered, calculated for the three disciplines engineering, geosciences and environmental sciences as well as hydrology. As regards the training of hydrologists, the master programmes focus on the subjects deterministic hydrology, qualitative hydrology, water management and geohydrology with at least 20 LP each. These are followed by ecology and hydraulic engineering with at least 15 LP. It is striking that the potential curriculum in terms of fluid mechanics and hydraulic engineering is slightly larger for hydrologists than for engineers. However, this is not representative but based on the special position taken by the Dresden hydrology, where a large number of these subjects can be selected from related engineering study programmes dealing with water.

As regards geoscientists, the central focus is on ecology/geoecology/environment. The other subjects within the subject groups hydrology and geosciences show a fairly consistent distribution with 5 to 10 LP on average. With almost 25 LP, urban water management dominates the engineering study programmes, followed by hydraulic engineering with 13 LP and deterministic hydrology offering 8 LP. However, the standard deviation reveals that there is a relatively high variability of the curriculum between the study programmes within the individual disciplines. This is especially pronounced in the "subject" ecology/geoecology/environment. Given that merely two hydrology study programmes are being considered, the standard deviation is not sound in terms of statistics. But one can see that there are strong distinctions between these two study programmes in some cases, which will be discussed hereinafter.

Figure 5 shows a comparison of the relative curriculum in the individual subjects.

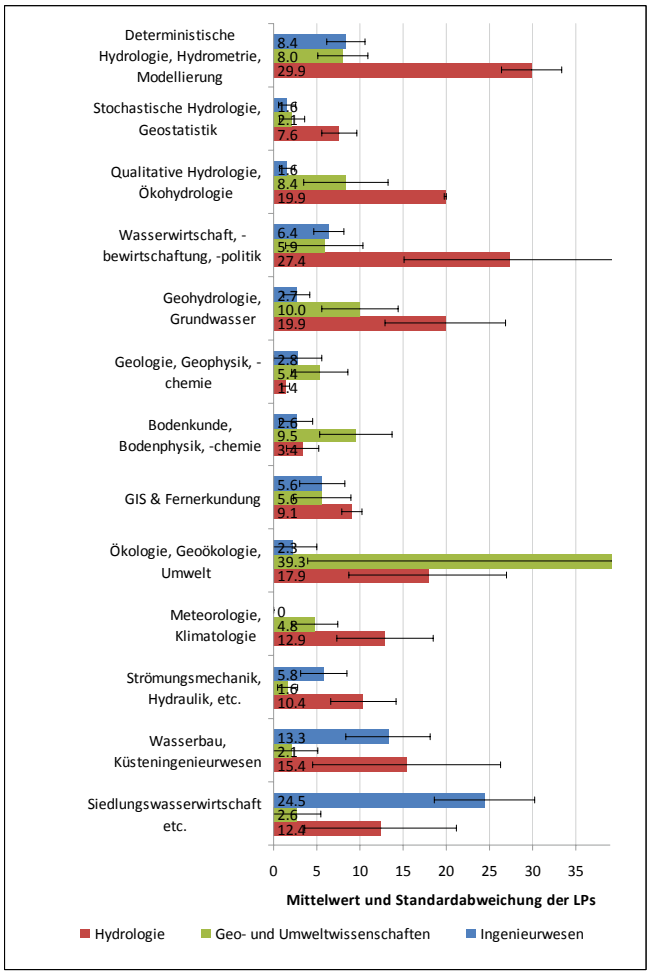

Figure 4
Comparison of mean and standard deviation of credit points offered for master programme according to disciplines: Engineering, Geo- and Environmental Sciences and Hydrology

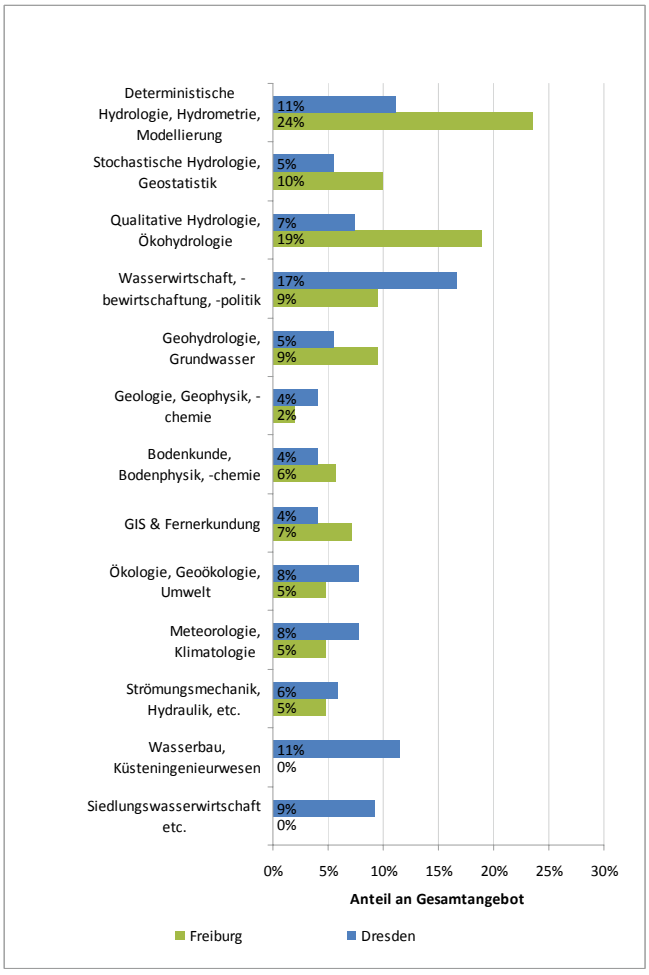

Figure 5
Distribution of curriculum among the two hydrology master programme at Dresden and Freiburg

The curriculum offered at Freiburg university contains a significantly higher share of the subjects deterministic hydrology, stochastic hydrology and qualitative hydrology. The Dresden curriculum is dominated by water management, hydraulic engineering, and urban water management. This reveals a stronger orientation of hydrological studies in Dresden towards engineering sciences whereas the master programmes in Freiburg tend to focus on the geoscientific side. However, it has to be kept in mind that Dresden offers a bachelor programme in hydrology supplying a large share of hydrological fundamentals, while the Freiburg master programme builds on a general bachelor in environmental sciences. The potentially large share of eligible related water subjects in Dresden is due to the availability of these subjects from several master programmes in the water range offered in parallel. The distinctions between both study programmes for the remaining subjects in the geoscientific range are less striking. The relative share calculated in this report results from a potential curriculum of 106 LP in Freiburg and a potential curriculum of 270 LP in Dresden. These strong distinctions may entail that the ranking of the teaching scope for some subjects varies between Dresden and Freiburg, depending on the fact whether relative share or actual LP are being considered.

5 Summary and conclusions

An overview of the hydrological study programmes offered by German universities programmes, i.e. engineering, geosciences and environmental sciences or hydrology. Strong distinctions were found in the composition of the tutorial of these three disciplines both in terms of bachelor and master studies. Both bachelor and master programmes of each discipline have one predominating area of studies. Mathematics and related hydrosciences dominate the engineering bachelor programmes, while geosciences, biology and chemistry are the dominant subjects in geosciences and environmental sciences. Hydrological studies are the only ones showing a relatively balanced distribution of subjects. In terms of master studies, as expected, hydrologists' study programmes are dominated by hydrology and water resources management, while geosciences prevail in the study programmes of geo- and environmental scientists, and related hydrosciences in engineering studies. A direct comparison of the hydrology master programmes offered by the Dresden and the Freiburg universities shows a stronger concentration on engineering in Dresden, and on geosciences in Freiburg.

Hence the choice of the university study programme has a major impact on the subsequent knowledge and views of the graduates. Ensuring a broad-based practical training with a sound theoretical basis for future hydrologists would require an increasingly interdisciplinary approach. In concrete terms, this means a stronger integration of natural sciences and geosciences as regards training in the field of engineering, and increasing the share of subjects with a mathematical-technical content for training in geosciences. Advanced training should take a more important role in future to provide lacking expertise in compliance with the variety of training pathways as well as special, activity-oriented aspects for professionals in practice.

The data serving as a basis for the results presented in this report are to be made available to interested experts via the website of the Deutsche Hydrologische Gesellschaft (DHG). The results of this survey serve as a starting point for further analyses. Above else, the results presented are to stimulate a discussion on a minimum curriculum for hydrological training. The DHG, which plans to establish a relevant working group, offers a platform for this.

It is hoped that the results presented in this report will attract the interest of students, university lecturers and employers.

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