

Environmental Sciences education under the microscope

Do graduates promote a societal change
towards sustainability?



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Impressum

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1 INTRODUCTION

This report summarises the major findings of regular evaluations and special studies on graduates of the Environmental Sciences Department of the ETH. The historical background of the study programme and the evaluation instruments are described in the introductory section. The graduates' careers, their positions and occupational areas, including their perceived contributions to sustainable development, are subsequently presented. The third section offers the perspective of external experts on the impact of the graduates on Swiss economy and society. Finally, the performance of the study programme is discussed on the basis of the outcome indicators of the Swiss Federal Statistical Office and of the perceived qualifications of the graduates.

1.1 Historical background

In the late eighties, accidents like Chernobyl and Schweizerhalle demonstrated that intensive economic and technological anthropogenic activities create environmental problems of increasing complexity and that society fails in adequately dealing with them. The lack of and need for experts in analysing, understanding and handling these problems motivated the introduction of the Environmental Sciences curriculum at ETH Zurich in 1987. In contrast to traditional natural sciences which aim at theory development in single disciplines, the new programme was intended to be practice-oriented and to follow a holistic approach with a focus on the environment as a system. Students were meant to acquire skills to understand, handle and solve real-world problems and hence promote sustainable development^{1,2}.

However, at the time when the programme started, the concept of environmental problem solving competence was not well-established, and the new format of university education initially lacked an elaborate and clear profile. Lecturers with traditional natural sciences backgrounds had to reform science teaching and develop an integrative curriculum that imparted the aspired skills to the students:

- A basic training in mathematics and all major natural sciences was followed by an interdisciplinary education with a focus on a specific natural system and its complex processes.
- Classes in social sciences, humanities and environmental technology addressed the interactions between nature and civilisation.
- A new didactic approach - namely, the transdisciplinary case study - was introduced to evolve from understanding and applying scientific methods to tackling and solving real world problems and to train communication skills.
- Finally, a compulsory practical work experience at the end of the programme aimed to further

enhance the students' cooperation skills and their understanding of how environmentally compatible solutions are developed and implemented in practice.

The new educational unit was faced with considerable scepticism from within and outside of the ETH. Since a distinguished professional field was not yet established, it was unclear whether the educational programme would open up sufficient occupational options for the graduates. Even though environmental problems such as deforestation of the rainforest or water and air pollution were evident, the prospective demand for environmental scientists on the labor market was put in doubt. In addition, critics questioned the probability of a successful generalist education and dismissed the design of the curriculum as inadequate for a sound natural science education. Critics further suggested that an educational programme in a traditional discipline complemented with a post graduate environmental curriculum would be a more appropriate approach to achieve the educational goals. The ETH Environmental Sciences founders were confronted with comments that their programme would cover "psycho-socio-ethno-chemistry" and train environmental activists "who talk about everything and know nothing" and are thus unable to contribute to solving existing problems.

Against this background, a comprehensive quality control and evaluation of the success of the curriculum was considered essential from the very beginning. A continual evaluation system was implemented and further supplemented through various specific evaluation projects running in parallel.

1.2 Formative evaluation system

During the last 23 years, the evaluation activities of the department have focused on two key aspects:

- Assessment of the skills imparted to students and the resulting qualification profile of the graduates, in order to develop and adapt didactical methods and to continuously improve the structure and content of the curriculum.
- Analysis of the professional situation of graduates (e.g. percentage of employed people, income, personal satisfaction with professional activity) and the qualifications required on the job market, to enable further refinement of the profile of an environmental scientist.

These activities are embedded in a continuous process of assessment, reflection and improvement of the quality of the programme (Figure 1). The management system takes into account various instruments for evaluating different curriculum aspects and allows discussion and interpretation of results in diverse reflective boards.

The establishment of this system led to in-depth investigations of several research questions which produced results that have been integrated in the evaluation process.

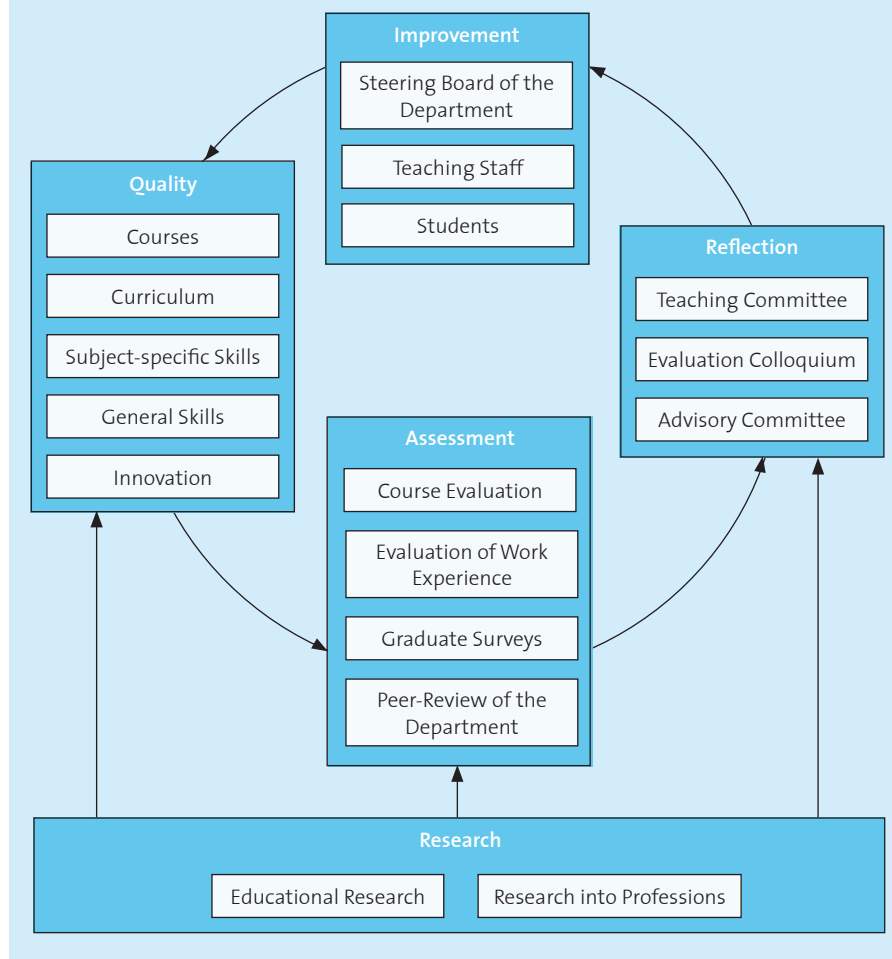
Reflective boards

The evaluation system of the department involves students, graduates, assistants, professors, didactical experts and external stakeholders such as employers and professional organisations as

1 Müller-Herold U. (1990). Umweltnaturwissenschaften: Erfahrungen mit einem neuen multidisziplinären Studiengang an der ETH Zürich. In Mainzer K (ed.): *Natur und Geisteswissenschaften. Perspektiven und Erfahrungen mit fachübergreifenden Ausbildungsinhalten*. Berlin, Springer Verlag.

2 Gigon A, Frischknecht PM, Scherz B. (1993). Umweltnaturwissenschaften – der neue Studiengang an der Eidgenössischen Technischen Hochschule Zürich. In Pfadenhauer J (ed.): *Verhandlungen der Gesellschaft für Ökologie* 22:365-370.

Figure 1. Management system for assessing, reflecting and improving the quality of the curriculum.



active participants in surveys and as members in specific discussion boards.

An *Evaluation Colloquium* that includes professors and staff members of the department as well as external experts and representatives of the department's graduates organisation generally plans evaluation activities and interprets their findings.

The *Teaching Committee* discusses these findings with respect to curricular and didactical implications and conclusions. It is chaired by the department's Study Director and composed of the representatives of professors, assistants and students in equal parts. There is a partial overlap between the members of the Teaching Committee and the Evaluation Colloquium to ensure mutual flow of information.

The *Advisory Committee* was founded in 1995 to institutionalise the perspective of leaders of the Swiss economy and public administration.

Suggestions resulting from discussions in these groups allow the Steering Board of the department to integrate a broad range of perspectives before decisions are taken and changes to the curriculum are implemented.

Continuous evaluation instruments

As in all other departments at ETH Zurich and in many other universities, Environmental Sciences students provide bi- or triennial *single course evaluations* to give feedbacks to the lecturers on the strengths and weaknesses of their classes. The quantitative ratings and individual qualitative comments of the standardised questionnaire are compulsorily discussed by the lecturers and students. This evaluation tool provides feedback on the relative performance of different curricula at the ETH level as well as on the relative performance of single courses within a programme.

Since 1994, the department has also conducted *evaluations of the work experience* that is compulsory for all Environmental Sciences students. The qualification-oriented questionnaires are answered by the students as well as by their supervisor in the host organisation and therefore allow an analysis of the curriculum component from different perspectives. Results of the surveys are used to evaluate the extent to which the work experience contributes to the students' problem solving competence.

The major continual evaluation instruments are *surveys of the graduates* on their first professional experience (conducted two years after graduation) and on subsequent career stages (conducted biennially six or seven years after graduation). As these surveys began with the first graduating class in 1992, by 2009 the dataset encompassed the first career steps of more than 1200 graduates (16 graduating classes from 1992 to 2007) and the further professional activities six to seven years after graduation of 12 graduating classes (graduates from 1992-2003). The first survey is an especially powerful instrument not only in evaluating the graduates' success on the job market but also in investigating the links between professional activities and the curriculum: The questionnaire addresses the qualification profile that graduates require in their current position as well as the skills they acquired during their studies. Thus, the graduates inform on crucial aspects of environmental problem solving competence and whether these have been imparted through the programme.

1.3 Specific evaluation study

The departments of the ETH are evaluated on a regular basis by applying international standards for scientific and teaching excellence. In view of the upcoming evaluation of the Environmental Sciences Department in 2010, a particular interest was to find out whether the establishment of the initially controversial teaching programme had met the aspirations of its founders. Therefore, a comprehensive study has been carried out on the pivotal question of whether graduates of Environmental Sciences are able to handle complex environmental problems in a way that supports

societal change towards sustainability. The general concept of the study is shown in Figure 2.

The first step was an expert workshop where a dual approach to the study was designed:

- (1) An *input-output analysis* on the success of Environmental Sciences as a teaching programme. This study aimed to cover the full educational cycle: Maturanden (Swiss high school graduates) - graduates - doctoral students - post docs. The focus was meant to lie on a quantitative career analysis.

- (2) An *impact analysis* with key companies and public institutions in Switzerland. The main instrument was to be an expert workshop with representatives of Swiss society and its economy. The analysis as well as the group of experts intended to cover the core Swiss social system: Economy – Politics/Public administration - Civil Society - Science.

The **second step** comprised the analyses of career development³. 808 graduates from 1992 to 2005 were invited via email to complete an extensive web-based questionnaire. 70% responded at least to the first question, and 55% completed the entire questionnaire. Information was elicited on the following:

- professional activities since graduation (e.g. income, position, size of company/organisation, field of activities) and advantages of their Environmental Sciences education for these activities;
- engagement in sustainable development through these professional activities in general and by means of two examples of best practice;
- the assessment of the best practice example with regard to (1) the integration of the ecological, economic and social dimensions of sustainability; (2) conflicts between these three dimensions; and (3) evaluation or monitoring of the achieved effects. The concept of sustainable development was not introduced by definition, but rather was investigated on the basis of the 15 goals stated in the Swiss Strategy for Sustainable Development as defined by the *Schweizerischer Bundesrat*⁴;

In an additional image study, the expectations, interests and professional objectives of high school students that intended to enrol in the curriculum were elicited⁵. Moreover, a survey amongst former doctoral students, postdocs and senior researchers was carried out to record their academic careers⁶.

The third step was the impact analysis⁷. To prepare the expert workshop, interviews with experts and representatives of three Swiss social systems were conducted: Economy - Politics / Public Administration - Civil Society. Science as a social system was not included, since in 2010 international research experts intensively evaluated the scientific impact.

The main input for the expert workshop consisted of four statements about the impact of ETH Environmental Sciences on Swiss economy and society. The invited experts and decision makers had to reflect on and supplement the statements. In addition, they had to quantitatively assess the impacts.

The fourth and final step was the discussion and approval of the study results by the Advisory Committee of ETH Environmental Sciences.

³ Hansmann R, Mieg HA, Frischknecht P. (2010). Survey of Graduates of Environmental Sciences from 1992 to 2005: Analysis of their Careers and their Contributions to Sustainable Development. Zürich: ETH Zürich D-UWIS.

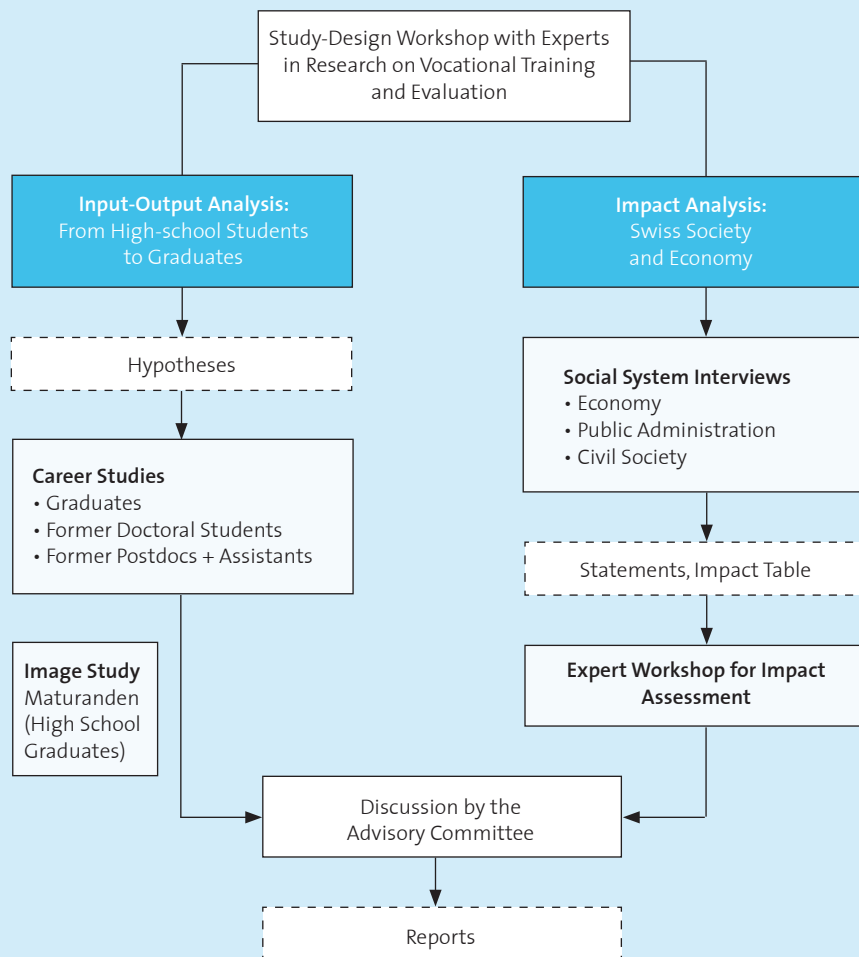
⁴ Schweizerischer Bundesrat. (2002). Strategie Nachhaltige Entwicklung. Bern.

⁵ Hansmann R, Mieg HA, Frischknecht P. (2009). Ergebnisse einer Internet-Befragung von Maturandinnen und Maturanden zur Analyse des Images von Umweltwissenschaften sowie des Zusammenhangs zwischen persönlichen Interessen und Überlegungen hinsichtlich eines Studiums. Zürich: ETH Zürich D-UWIS.

⁶ Unpublished result

⁷ Mieg HA. 2010. The Impact of the Establishment of Environmental Sciences at ETH on Swiss Economy and Society: An Evaluation Study. Berlin, Zürich: Humboldt-Universität zu Berlin, Geographisches Institut, ETH Zürich D-UWIS.

Figure 2. Concept of the specific evaluation study on the impact of Environmental Sciences graduates on Swiss economy and society.



2 THE SUCCESS OF GRADUATES ON THE JOB MARKET AND IN PROMOTING SUSTAINABLE DEVELOPMENT

Results from graduate surveys demonstrated that Environmental Sciences graduates have an excellent acceptance on the job market. They succeeded in accessing a broad variety of professional fields, especially in the private sector, and in reaching income levels comparable to or higher than people in the same position with other educational backgrounds, even though salary was not mentioned as the main criterion for career decisions. In addition, the graduates significantly contributed to sustainable development in all four societal sectors. Their perceived influence on sustainable development increased with career advancement, and some individuals successfully integrated sustainability in professional fields weakly related to the issue.

2.1 Performance on the labour market

In 2009, on average six years after graduation, 96% of the survey participants were professionally active. This employment rate⁸ is considerably higher than in comparable age groups of the Swiss general population (87%)⁹ and similar to the rate of other Swiss university students five years after graduation (95%)¹⁰. The regular graduate surveys from the past 11 years showed that the rate is slightly lower two years after graduation (on average 92%, Table 1). However, this is in line with surveys amongst graduates of all Swiss universities which generally show an increase in the number of employed persons in the course of the first five years after graduation¹⁰. Overall, our findings showed satisfying employment rates suggesting that the professional market for environmental scientists is not particularly or strongly influenced by fluctuations in the economy.

Table 1. Employment situation of graduates 1997-2007.

Year of interview	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Year of graduation	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2006
Employed	97%	83%	94%	94%	96%	95%	100%	87%	91%	87%	87%
Seeking employment	1%	13%	4%	3%	2%	2%	0%	9%	7%	11%	8%
Number of job-seeking people	1	8	4	2	1	1	0	4	3	6	7
Number of interviewed people	74	63	94	72	51	40	26	45	44	55	86

8 Outcome indicator 1 of the BSF: employment rate of the graduates.

9 Bundesamt für Statistik (BFS). (2009). Arbeitsmarkindikatoren 2009. Neuchâtel: BFS.

10 Bundesamt für Statistik (BFS). (2008). Hochschulabsolventen und Hochschulabsolventinnen auf dem Arbeitsmarkt: Erste Ergebnisse der Längsschnitbefragung 2007. Neuchâtel: BFS.

The graduates work in all four societal sectors: the private sector (~50%), public administration and education (~25%), the scientific sector (~20%) and civil society (NGOs, ~5%). Table 2 shows that the most prominent fields of professional activity are environmental planning and consulting, public administration and universities. A high percentage of graduates also work in banks and insurances, in positions with attractive income prospects and special possibilities for contributing to sustainable development. Further activities are dispersed over a broad range of professional fields and reveal a variety of career opportunities for environmental scientists that exceeds the expectations of the founders at the inception of the programme¹¹.

Table 2. Fields of professional activity with median incomes and their relation to sustainability (N = 520, on average approximately 6 years after graduation).

Fields of professional activity	Fraction of graduates employed [%]	Median annual income [CHF]	Relation of field to sustainability ^{a)}
Environmental planning & consulting	15	94'000	3.7
Public administration	15	116'000	3.4
Universities	13	95'000 ^{b)}	2.7
Banks & insurances	10	130'000	2.2 ^{c)}
Education	8	110'000	2.6
Research outside universities	7	100'000 ^{b)}	3.3
Environmental NGOs	5	100'000	4.0
Financial & management consulting	4	150'000	2.8
Health sector	3	110'000	2.4 ^{c)}
Energy & water supply	3	130'000	4.2
Other industry	2	125'000	3.3
Transport	2	119'000	3.2
Media	2	96'000	2.8
Chemical industry	2	150'000	3.3
Commerce	1	90'000	3.7
Farming/forest/garden	1	88'000	3.8
Construction industry	1	91'000	3.2
Other public services	4	116'000	2.0 ^{c)}
Other	2	100'000	2.7

a) Scale: 1 = no relation, 2 = rather no, 3 = rather yes, 4 = yes, 5 = yes, very strong relation of professional activity to sustainability; values < 2.5 denote no or very little relation to sustainability.

b) When excluding graduates currently working on their PhD: Universities Md = 105'000 CHF, Research outside universities Md = 103'000 CHF.

c) Fields weakly related to sustainability.

11 Müller-Herold U. 1990. Umweltnaturwissenschaften: Erfahrungen mit einem neuen multidisziplinären Studiengang an der ETH Zürich. In Mainzer K (ed.): *Natur und Geisteswissenschaften. Perspektiven und Erfahrungen mit fachübergreifenden Ausbildungsinhalten*. Berlin, Springer Verlag.

In 2009, the median annual income¹² of the survey participants amounted to approximately 92'000 CHF (on average 6 years after graduation). The salaries increased over time (Md = 100'000 CHF after 8 years and 130'000 CHF after 15 years) and with greater managerial responsibility. Both advancements in income and in the managerial position were predominantly achieved through continuous engagement within one organisation. At times, changing the organisation was linked to gaining a higher salary, but it did not generally increase or decrease the degree of managerial responsibility, as the latter is strongly tied to a fidelity bonus. The salary increase was most probably a reward for the professional experience *per se* that generally increases over time.

In most professional fields, the income level of the graduates is comparable to that of people in the same position with other educational backgrounds. As is generally true in Switzerland¹³, jobs in the chemical industry, banks and insurances, and energy/water supply are best paid (Table 2). In several fields (e.g. chemical industry, financial management and consulting, energy/water supply, etc.), the salary of the graduates even exceeds the median income of people with other educational backgrounds but the same managerial responsibilities. This might reflect a demand for special qualifications of environmental scientists within these working areas. Notwithstanding, the large number of people working in the field of environmental planning and consulting reduces the overall income level. Due to structural reasons, a future increase in this level can presumably not be expected. Still, positions are generally much better paid than what the Swiss Federal Statistical Office (BFS) reports as median incomes in comparable sectors such as the construction industry (Md = 76'000 CHF)¹⁴.

2.2 Perceived contributions to sustainable development

The graduates reflected and assessed their influence on sustainability based on their best practice examples of contributions to sustainable development. Overall, 672 examples were provided, and these again reflect the broad range of professional activities of environmental scientists. However, the majority can be assigned to 3 typical groups¹⁵: (1) environmental centred activities, often in nature conservation or natural hazard management, (2) activities promoting innovation towards sustainable use of natural resources, (3) activities in environmental education and communication (see Box 1).

¹² Outcome indicator 2 of the BSF: income of the graduates.

¹³ Bundesamt für Statistik (BFS). 2009. Schweizerische Lohnstrukturerhebung 2008. Wichtigste Ergebnisse. Neuchâtel: BFS.

¹⁴ The BFS statistics do not capture Environmental planning & consulting as own fields of professional activity. Therefore no general median income of this field has been assessed and can serve for comparison.

¹⁵ These three groups correspond to results of a component analysis of the interrelationships between the 15 sustainability aspects of the Swiss strategy on the basis of their coverage through the examples.

Box 1. Examples of best practice contributions to sustainable development.

The first three examples represent rather typical activities. Examples four and five give an impression of the wide range of activities in various professional fields, and examples six and seven show contributions in branches weakly related to sustainability.

1) *Nature and protection*

As an employee of a large company, an environmental scientist leads noise-abatement reconstruction projects of public infrastructure in Switzerland. In a recent project the living quality along highly trafficked railway lines was improved without disturbing or reducing refuge areas of domestic reptiles.

2) *Product and process development*

An environmental manager employed in industry in Germany showed through an eco-balance of a specific mobile phone that its charger has major negative environmental impacts when it is plugged in. As a consequence of technology improvements and user information, the environmental burden could be significantly reduced.

3) *Education and communication*

After having worked as a consultant, one former D-UWIS student launched and wrote, as a freelancer, a guide of environmentally friendly hotels in Switzerland. Already published in the fourth edition, the guide helps to sensitise people and supports an ecological hotel industry.

4) *Technology*

An employee of a huge solar company founded his own subsidiary aiming at establishing solar energy and advancing peripheral energy supply in Italy. Now in the position of the CEO, he develops, finances and constructs solar projects, e.g. photovoltaic installations.

5) *Politics*

An environmental/financial consultant advised the Croatian Ministry of the Environment on the implementation of a fund for environment and energy efficiency. In consequence, the government invested large amounts of money, especially in the area of waste disposal.

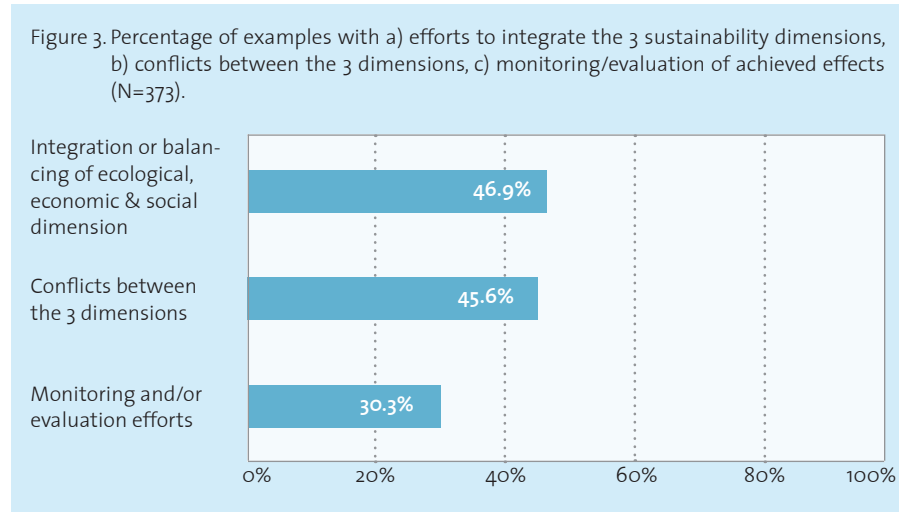
6) *Health sector*

An employee of a large company (approximately 50'000 coworkers) developed and implemented a holistic operational health management. He created intra-organisational structures and functions to enable employees to maintain and improve their health in sustainable ways.

7) *Banks and insurances*

A consultant works in a department of a financial consulting company that gives feedback to firms regarding their sustainability achievements based on the results of a sustainability index.

As could have been expected, the main orientation of the activities was often on ecological aspects; nevertheless, economic and/or social aspects were also addressed in the majority of the examples. Nearly half of them involved efforts to systematically integrate or balance the three dimensions, but a conflict between the dimensions occurred in almost as many (Figure 3)¹⁶. In approximately one third of the examples, the achieved effects were evaluated or monitored (Figure 3). These latter examples are of a special quality, since assessing short- and long-term effects of measures is crucial for an effective regulation of human-environment systems.



Based on the graduates' evaluation of their careers and best practice examples, the perceived influence of Environmental Sciences graduates on sustainability could be assessed and confirmed by the three hypotheses.

1. Hypothesis: Graduates who fill managerial positions contribute particularly strongly to sustainable development.

Former students who attained managerial positions perceived stronger effects of their best examples of contributions to sustainable development (Table 3). They addressed more of the objectives of the Swiss sustainability strategy and more frequently obtained a systematic integration of ecological, economic and social aspects of sustainability. The perceived overall achievements of graduates in upper-level managerial positions were significantly higher than those in lower level positions, and they also perceived more substantial increases in their influence on sustainable development during their career. This can be explained by those graduates accruing professional experience

¹⁶ An analysis of the two latter aspects revealed that they are positively interrelated. Thus, either initial conflicts led to efforts to balance different interests or the conflicts arose subsequent to the integration of different dimensions. However, both explanations suggest that resolving conflicts is essential when balancing the three sustainability dimensions.

over time and acquiring positions that involve responsibilities and decision competencies advantageous to influencing important developments. Accordingly, graduates show continuous engagement in sustainability over time and do not forget their "roots" during the advancement of their careers.

Table 3. Relation between the managerial position of graduates and the perceived impact on sustainable development: best case contribution, personal overall contribution, increase in influence during career.

Managerial position ^{a)}	Characteristics of best contribution			Professional personal contribution		
	Strength of effect ^{b)}	Integration of dimensions	N	Overall ^{b)}	Increase during career ^{b)}	N
No	2.8	41%	140	2.9	2.4	171
Lower level	2.9	43%	68	3.0	2.6	74
Medium level	3.1	53%	48	3.1	2.7	61
Upper level	3.6	67%	24	3.5	3.1	28
Highest (e.g. CEO)	3.6	63%	27	3.2	2.9	37
<i>Spearman r</i>	0.22 ⁺⁺⁺	0.16 ⁺⁺	307	0.12 ⁺	0.17 ⁺⁺⁺	371

a) Self-employed graduates are not covered in the table.

b) 1 = no, 2 = rather small, 3 = rather strong, 4 = strong, 5 = very strong contribution to sustainable development.

⁺p < 0.05, ⁺⁺p < 0.01, ⁺⁺⁺p < 0.001

2. Hypothesis: Graduates make worthy contributions to sustainability in all professional fields.

The broad range of fields in which graduates currently work entails the possibility to contribute to sustainable development in most societal and economic sectors. Table 2 shows that, *in most professional fields, graduates perceived their activity as fairly to strongly related to sustainability (values > 2.5)*. Jobs in energy and water supply, NGOs and environmental planning and consulting in particular were strongly oriented towards sustainability, as well as activities in farming and forestry and commerce. Fields such as universities, education and the media are in an intermediate range (values > 2.5 and < 3.0).

3. Hypothesis: Even in fields where professional activities are usually only marginally related to sustainability, important contributions are made.

In banks, insurance companies, in the health sector and in other public services, which are classified as having a weak relation to sustainability (Table 2), there are some *graduates whose work is closely related to sustainability. Their perceived personal influence has significantly increased in the course of their careers* (Table 4). Two illustrations of best contributions made in these branches are given in Box 1 (example 6 and 7).

Table 4. Increase of the perceived personal influence on sustainable development (SD) during the career of graduates working in: professional fields weakly related *versus* strongly related to SD (see Table 2).

Relation of professional activity to sustainability	Increase in the personal influence on SD during career ^{a)}			
	Fields weakly related to SD		Fields strongly related to SD	
	Mean	N	Mean	N
No/in tendency no	1.8 ⁺⁺⁺	51	1.8 ⁺⁺⁺	103
In tendency yes - very strong	3.0 ⁺	24	3.1 ⁺⁺⁺	247

a) 1 = no increase, 2 = rather none, 3 = rather yes, 4 = yes, 5 = very strong increase

⁺p < 0.05, ⁺⁺⁺p < 0.001; significant deviations of the means of the increase of influence on SD from 2.5 (i.e. halfway between 2 = rather none and 3 = rather increased).

3 THE IMPACT OF ENVIRONMENTAL SCIENCES GRADUATES ON SWISS ECONOMY, PUBLIC ADMINISTRATION AND SOCIETY

An impact analysis showed that environmental scientists were successful in transmitting the sustainability issue to the professional sphere. The degree of the impact varied between different social systems and was higher in the private sector and comparatively lower in politics. The most important impact mechanisms were identified as networking, dissemination of standards and the qualifications of graduates.

3.1 Four statements on the impact of Environmental Sciences graduates on Swiss economy, public administration and society

The results from the social-system interviews and the discussions in the expert workshop can be summarised in four statements¹⁷.

1) Internalisation: Originally, industrial and service companies employed external environmental experts to handle environmental issues and regulations. Step by step, these duties and responsibilities have been embedded in the working process of operating units. The graduates of Environmental Sciences have acted as important promoters of this change.

2) Networking and standardisation: Environmental scientists form a growing network that enhances intersectoral communication. The penetration of well-educated professionals in the labour market stimulates the demand for professional environmental advice and services and promotes their standardisation. Considering the spectrum ranging from industry to NGOs, this facilitates the discussion of environmental issues within and between organisations and supports their integration into companies' daily business.

3) Services for the globalised knowledge-based economy and for Swiss small and medium sized companies (SME): Global companies (e.g. banks and insurances) look for people with strong analytical qualifications, excellent communication skills, and a willingness to constantly and fundamentally refine themselves professionally. Swiss SMEs are interested in specialised professionals with sufficient practical experience. Graduates of Environmental Sciences were appreciated in both sectors.

4) Development of a profession: Industry and society perceive Environmental Sciences as an educational programme but not as a unified scientific discipline. On the long run this could impair

¹⁷ A more detailed report by Mieg (2010) describes the original seven statements which have been partially merged here.

the full acceptance of environmental sciences as a new profession, given that empirical evidence suggests that the development and maintenance of a profession is strongly linked to the existence and perception of a corresponding scientific community. This should be taken into consideration and improved upon in communications with the public.

Figure 4. Position of the Environmental Sciences programme within Swiss economy, public administration and civil society: representatives' perceptions of the graduates' qualifications and important impact mechanisms.

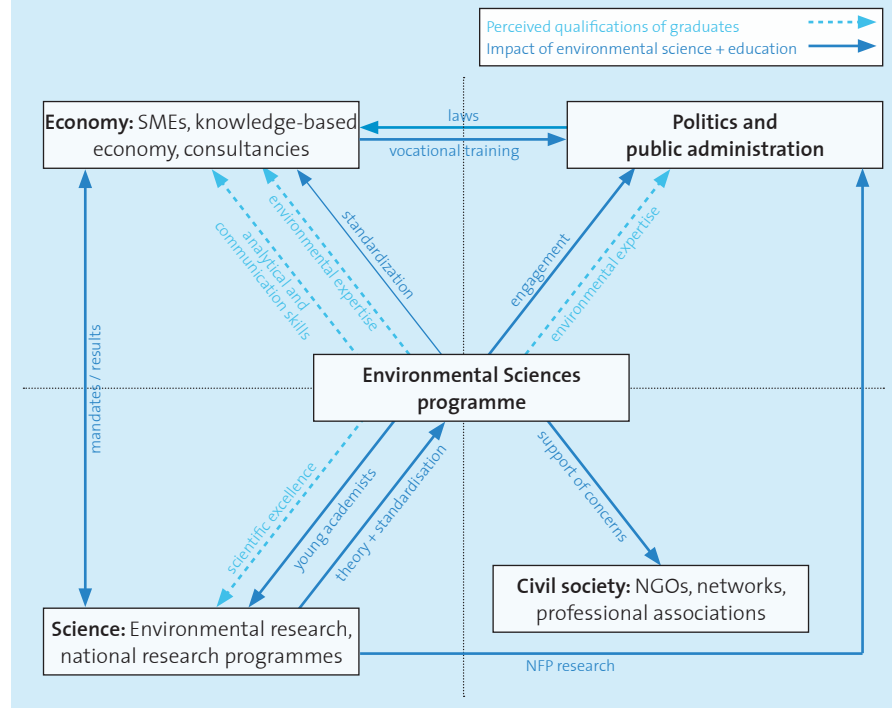


Figure 4 shows the position of the Environmental Sciences programme within Swiss society, public administration and economy based on practical impacts of environmental science and the corresponding education and qualifications of graduates as perceived by representatives of the social systems:

- **Economy:** Depending on their orientation, economic players perceive and appreciate different skills of the graduates (Statement 1 and 3). A standardisation within the private sector is achieved through increased networking of highly skilled environmental scientists (Statement 2).
- **Politics and public administration:** Public administration requires the environmental expertise of graduates, and environmental scientists engage in political functions and debates. In this sector, Swiss National Research Programmes (NFP) serve as important transmitters of environmental science into politics. Resulting indirect impacts are increasing standardisation, vocational training

offerings offered to economic players or the enactment of environmental laws.

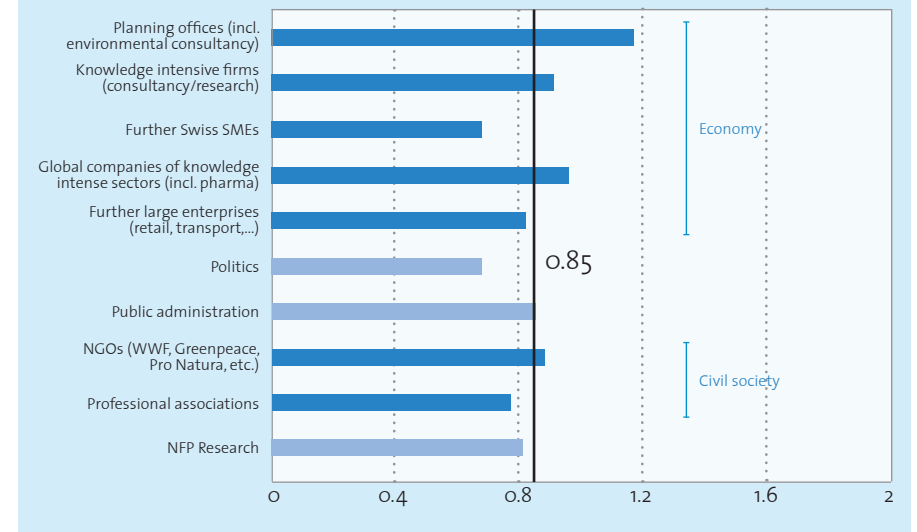
- **Civil society:** NGOs and professional associations are supported by members and the faculty of Environmental Sciences through engagement, scientific knowledge and practical advice as well as ideological support. However, it was shown that most players of civil society do not consciously note environmental scientists as a separate group having a distinguished qualification profile. The NGOs had existed and functioned well before the new curriculum was initiated and therefore had not explicitly waited for experts able to tackle environmental questions. Common ideologies amongst the members are more important than a common and specific education.
- **Science:** The science sector profits from young academics and is predominantly interested in their scientific excellence. The research conducted at the department defines standards used in the study programme, thus conveying them to the graduates, and provides results for specific mandates to the economy.

Overall, Figure 4 demonstrates that the social systems predominantly perceive ETH Environmental Sciences through graduates working or engaging in the different sectors. The graduates bring along applicable skills that the players of the social systems impute to the education.

3.2 General impact on integrative sustainability

The focus of the experts' quantitative impact assessment was on integrative sustainability, i.e., on the question of whether a balance of the ecological, economic and social aspects of sustainability could be implemented in selected fields of the social systems. The corresponding impact was rated

Figure 5. Impact of Environmental Sciences (graduates) on integrative sustainable development of social systems in Switzerland (-1 = negative impact, 0 = no impact, 1 = positive impact, 2 = distinct positive impact).



based on the quality and the strength of the effect of the activities performed by the graduates in a sector as well as of the ideas transferred to the public.

On a scale from -1 (negative contribution) to 2 (large contribution), the average impact over all sectors was rated 0.85 (Figure 5). A comparatively high impact resulted for environmental consulting and planning offices (1.2), whereas a lower impact was found in politics (0.7) and Swiss SMEs (0.7).

4 ENVIRONMENTAL SCIENCES EDUCATION AND CAREER

The Environmental Sciences education provides a broad background, in-depth knowledge of specific systems and guidance and experience in deepening one's own knowledge in exemplary contexts. This education was useful in most of the graduates' professional activities and enabled them to tackle various employments at interfaces to different disciplines in which they managed to develop their specific competencies. The curriculum imparts a distinguished qualification profile to the students that allows for a future development of an environmental profession. Yet the department not only prepares graduates for applied occupations but also successfully promotes academic careers.

4.1 General assessment of the Environmental Sciences education

The Swiss Federal Statistical Office (Bundesamt für Statistik, BFS) annually assesses the achievements and the quality of the Swiss university system through graduate surveys. Six outcome indicators are defined that link the education to the labour market and that evaluate to what extent graduates profit from the acquired competencies in their professional activities¹⁸:

1. Employment rate of the graduates
2. Income of the graduates
3. Rate of entry into the job market since graduation
4. Qualification profile demanded by employers
5. Correspondence between required and acquired competencies
6. Satisfaction of graduates regarding the contribution of their studies to their success on the job market

The BSF assesses these indicators separately for six major study sectors (see Figure 4/5). Since the regular graduate surveys of the department of Environmental Sciences entail the same or similar questions, the Environmental Sciences background can be compared to other university educations (with the exception of indicator 6, which is not evaluated by D-UWIS). As employment rate and income level of the D-UWIS graduates has been discussed above (see Chapter 2.1), the subsequent section details results from such a comparison for indicators 3 - 5.

Outcome indicator 3: Rate of entry into the job market since graduation

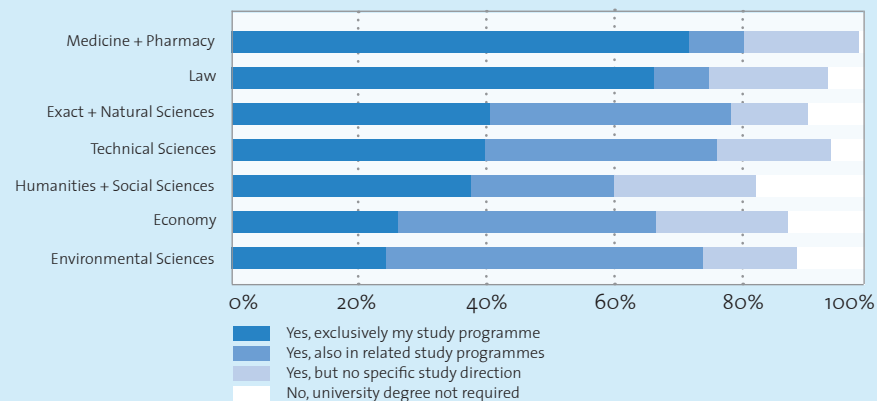
Differently to indicator 1 (employment rate of the graduates), this indicator contains a qualitative aspect. It measures the entry into a qualified professional activity where a university degree is necessary. In 2008, 72% of the Environmental Sciences graduates from 2006 were in positions having this requirement, which is equivalent to the rate of 72% averaged over all study programmes¹⁸.

¹⁸ <http://www.bfs.admin.ch/bfs/portal/de/index/themen/15/06/key/ind1.html>

Outcome indicator 4: Qualification profile demanded by employers

Figure 6 shows that graduates of study programmes which are strongly linked to a profession, e.g. medicine and law, undertake employments with very specific qualification requirements¹⁸. In contrast, environmental scientists engage in professional activities that typically require a university degree but where approximately only 25% demand a degree exclusively in Environmental Sciences. This pattern is similar to that perceived by graduates of other generalist studies, in particular economics. In fact, Environmental Sciences graduates named around 60 different types of alternative curricula that could have potentially prepared them for performing their current professional activity¹⁹. This variety reflects the broadness of professional fields into which the graduates entered. The Environmental Sciences education seems to impart skills to the students that are useful for working at diverse interfaces to other disciplines. On the job, the graduates were evidently able to deepen their basic knowledge in a specific area and to develop as experts equal to graduates from specialised study programmes.

Figure 6. Qualification demands of employers 5 year after graduation* (Was a university degree required for your position?).

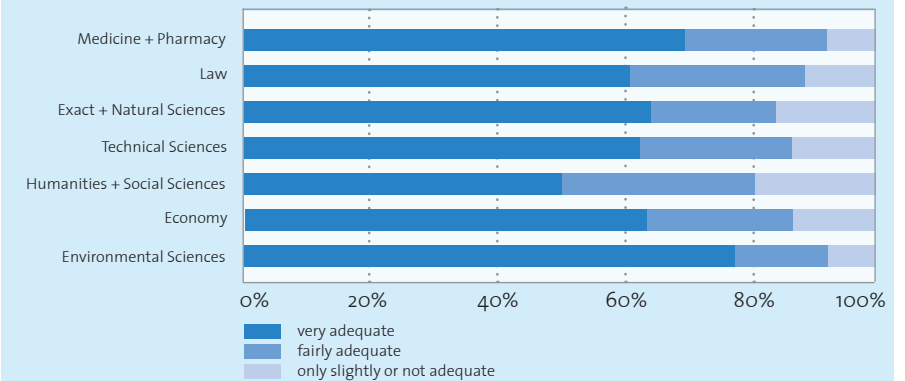


* Data for graduates from 1998/1999 for Environmental Sciences and for graduates from 2002 for all other study programmes.

Outcome indicator 5: Correspondence between acquired and required skills

Despite the fact that a majority of the graduates do not necessarily require the Environmental Sciences education on the job (Figure 6), 78% of them perceive their current activity as very appropriate¹⁹ to their qualifications²⁰. This is a very high percentage compared to other disciplines and substantially exceeds the average of 60% over all university programmes (Figure 7)¹⁸. It thus seems that the graduates were able to usefully implement their acquired skills in their careers and were very often content with their educational background.

Figure 7. Correspondence between acquired skills and those applied in the job* (Do you have a professional activity adequate to your education?).



* Data for graduates from 1998/1999 for Environmental Sciences and for graduates from 2002 for all other study programmes.

4.2 Environmental Sciences education and professionalization

Figure 8 shows that Environmental Sciences graduates have a very strong qualification surplus with respect to modelling environmental systems and a considerable surplus in natural scientific analysis²¹. With a view only on an optimisation of the curriculum, the programme should decrease training in these skills in the future in favour of more practice-oriented competencies such as the development of concrete solutions. However, a major motivation of the founders of the Environmental Sciences Department was that they perceived a societal need for *environmental experts* (see Chapter 1.1) and thus wanted to provide an education that allows the development of a *profession*²². Until now, such a distinguished field of environmental professional activity has not been established in Switzerland or Europe. Nevertheless, the graduates' assessment of the imparted skills shows that the curriculum generally allows for the process of a *professionalization*²³: A qualification surplus, such as graduates have in quantitative modelling of environmental systems, is essential for the public perception of the education²⁴. On the long term, these special competencies can build a distinguished profile for a profession that is anchored in society and on the labour market: If established, the graduates' expertise in system knowledge would then be solicited in all activities regarding "integrative assessment of nature and environmental systems" and be deemed as the standard. Thus, the graduates' competencies, even if not completely adapted to current demand on the job market, assign a professional profile to ETH Environmental Sciences.

19 Hansmann R, Mieg HA, Frischknecht P. (2010). Survey of Graduates of Environmental Sciences of the Years 1992 to 2005: Analysis of their Careers and their Contributions to Sustainable Development.

20 The original survey contained a five-point scale. To be able to compare the results with the BFS statistics, the two lowest and the two highest scales were summarised to each one category.

21 Summary of yearly graduate surveys of the Department of Environmental Sciences from 1999-2004 and 2006.

22 A profession is an organisation of experts that successfully occupy and to a certain degree monopolize a certain professional field. Amongst others, an academic education is one of the preconditions for the development of a profession (Mieg, 2001).

23 An academic education is only one precondition for a successful professionalization. For more details see Mieg (2001).

24 Mieg HA. (2001). Umwelt und Profession – ein Status-Bericht aus der Schweiz. GAIA 10: 182-189.

This is an important feature of a university education in contrast to the educational programmes at technical colleges, which are much more oriented towards the demand of the job market.

In point of fact, the graduates perceived most of their subject-specific and general skills as not adequate enough for practical application (Figure 8). Two reasons can explain this: First, a lot of knowledge is only acquired in practice. Second, graduates are often unable to completely perceive the quality and quantity of their knowledge, especially regarding procedural knowledge. This is supported by the survey regarding the work experience. Generally, the students rate their qualifications lower than do their supervisors. It thus seems that the students are very critical regarding their own skills, even if their performance could convince external professionals (Figure 9).

Figure 8. Graduates' ratings on subject-specific and general skills acquired during the curriculum and demanded in actual professional activities (N between 330 and 341, 1 = low level ... 5 = high level)

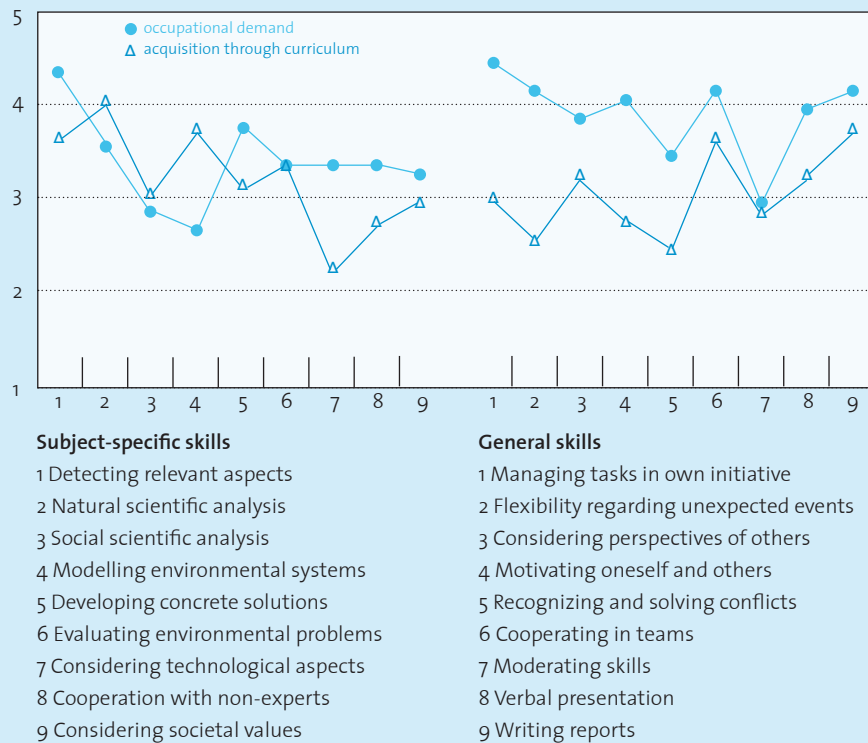
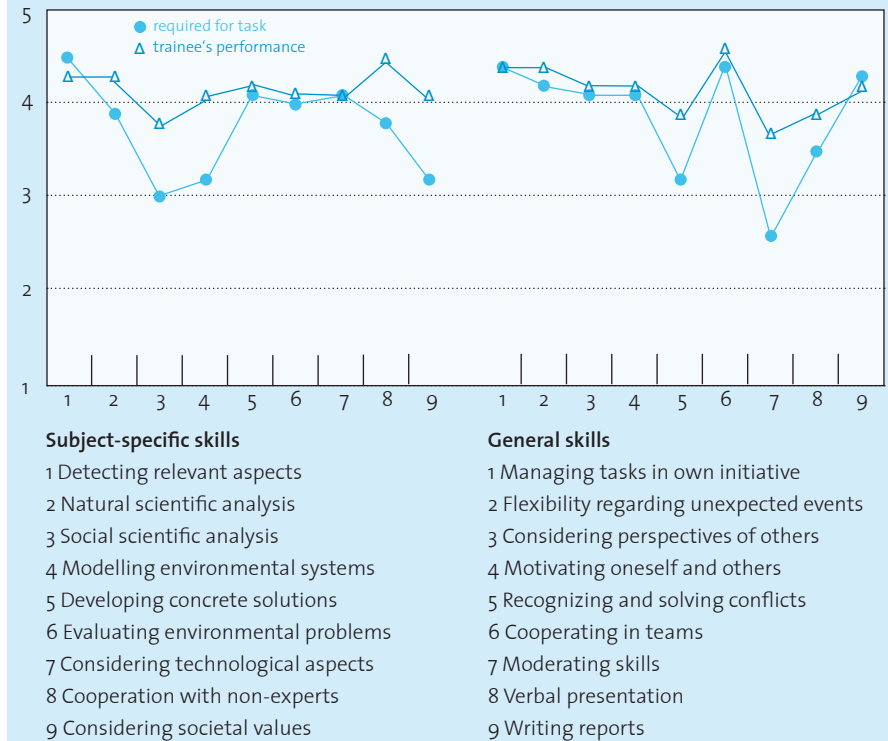


Figure 9. Assessment of the master students' subject-specific and general skills by supervisors of the work experience (N = 75, 1 = low level ... 5 = high level)



4.3 Further academic education and academic careers

The percentage of Environmental Sciences graduates who successfully completed a doctorate is, with 23%, considerably lower compared to natural science graduates. However, 54% have completed additional alternative education programmes. The most frequent amongst these are management educations (e.g. MBA or leadership training) and teaching or didactical studies, followed by other post-graduate studies and additional full university programmes. No significant effect of further education on the orientation of the professional activity to sustainable development or on the income level was found. Presumably, the reason for this is that graduates who do not attain a doctorate enter the private sector or public administration earlier and therefore have more time to ascend to leadership positions. Exceptions are graduates completing a supplementary education in management, who earned on average 15'000 CHF more than others (controlled for seniority). In some cases enrolling in, for example, an MBA might have first laid the foundation for higher incomes, while in other cases graduates already in leadership positions in a company might have

later received management educations. It seems clear that obtaining a leadership position plays an intermediary role here.

An option for doctoral students is to follow an academic career. More than 10% of former PhD students of the department and almost one third of postdocs have been subsequently appointed as professors (Table 4). In the case of senior researchers, more than half of the former employees eventually held a professorial position. This is an impressive achievement and testimony to the professional skills of ETH Environmental Sciences' staff and professors, at least at the European level.

Table 4. Academic careers of former scientific staff of D-UWIS (aggregated from 27 professorships^{a)}).

Position of former staff member at D-UWIS ^{b)}	Number of former staff members	Number of former full professors	Number of former associate professors	Number of former assistant professors	Number of former titular professors	Number of former members now appointed as at technical colleges	Percentage with academic career
PhD	427	15	10	12	4	4	10.5%
Postdoc	141	16	13	11	3	0	30.5%
Senior researcher	82	18	10	6	9	1	53.7%

a) Includes estimated data of all professors who were active at D-UWIS between 2004 and 2009.

b) For people having held several positions at D-UWIS, the highest one was taken into account.

4.4 Survey amongst high school students

In 2009 D-UWIS conducted an online survey to assess the image of Environmental Sciences held by high school students and to map their personal interests. From the 307 participants, a majority (88%) declared knowing – at least approximately – what Environmental Sciences imply. However, only one fifth additionally indicated a more accurate understanding of the term. Of those 88% more or less familiar with the field, nearly 80% called Environmental Sciences rather interesting or even very interesting or mega-cool, respectively. Thus, the study revealed a pleasingly positive image of Environmental Sciences amongst high school students.

36% considered it possible or probable for them to enrol in Environmental Sciences. In a cluster analysis, 18 different personal interests were related to the affinity for choosing an Environmental Sciences education. Two groups of students are particularly attracted:

- Those with a strong interest in natural sciences and no other attributes.
- Those with a strong interest in natural sciences and in addition in nature and protection of the environment, sports and animals and pets.

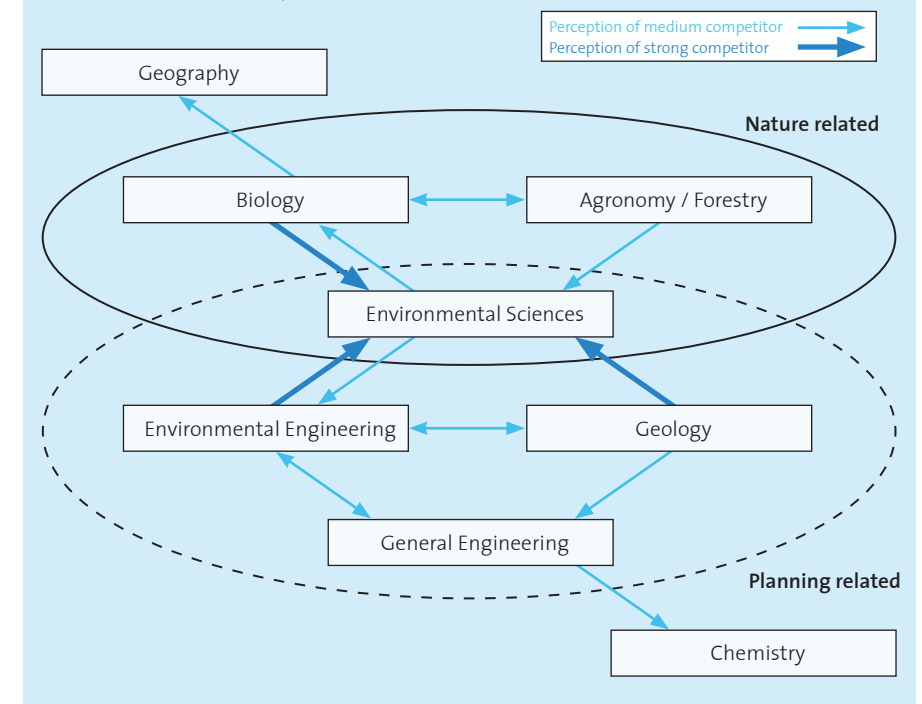
Hence, the survey showed that the department curriculum appeals to two important subgroups of high school students.

5 RESEARCH IN THE CONTEXT OF THE FORMATIVE EVALUATION SYSTEM

Data produced by the various continual evaluation instruments elicited research activities in two fields:

- (1) *Educational research* deals with the skills imparted to students and the resulting qualification profile of the graduates. Typical examples are:
 - Links between the components of a university programme and the qualification profile of graduates (Hansmann, 2009)
 - Transdisciplinary case studies as a means of sustainability learning (Scholz et al., 2006)
 - The role of internships in higher education in Environmental Sciences (Scholz et al., 2004)
 - Assessment of undergraduate examinations (Alean-Kirkpatrick, 1998)
- (2) *Research into professions* covers, for example, the following subjects:
 - The epistemic structure of professional activities in the market of professional environmental services in Switzerland (Mieg, 2001; Mieg, 2002)

Figure 10. Perceived competition between graduates of different study programmes in the Swiss market of professional environmental services.



- Professional identities of environmental experts (Mieg, 2008)
- A cluster analysis of the Swiss market of professional environmental services as a test for the Driving force-Pressure-State-Impact-Response (DPSIR) model (Mieg, in press)
- Competition in the Swiss market of professional environmental services (Mieg & de Sombre, 2007).

For instance, a national survey on competition in the market for professional environmental services (Mieg & de Sombre, 2007) revealed the following (see Figure 10):

- First, there are two areas of competition therein, one related to nature and the other to planning.
- Second, D-UWIS graduates were already perceived as the core competitors since 2001.

A comprehensive list of publications is given in the bibliography of this report.

6 CONCLUDING REMARKS

During their first ten years, the Department and the Study Programme of Environmental Sciences were regularly called into question within the ETH. The excellent students who enrolled every year were the most important guarantee for a successful continuity of the curriculum. Now - almost 25 years later – both the department and the study programme enjoy broad acceptance within the ETH. As shown in the impact study, the Swiss society, public administration and economy pay an equal regard to ETH Environmental Sciences. Three peer review committees (in 1996, 2004 and 2010) have recognised the high quality of research and education.

In 2003, the Department of Environmental Sciences introduced the Bologna teaching system, with a bachelor programme designed to be completed within three years (180 credit points ECTS) and a master's programme of two years (120 credit points ECTS). The language of instruction at the master's level is generally English, indicating the increasing internationalisation of the master's students. This reorganisation took great efforts but was implemented without any significant difficulties. The graduate surveys considered in this report could not yet focus on the new programme. However, the central idea and the core elements of the former diploma programme were kept, even though the Bologna Process motivated the reconsideration of the aim of the programme, the structure of the curriculum and the content of each individual course. Initial feedbacks from students and from people outside the ETH indicate that the change has maintained and further improved the quality of the education. The department will count on the established procedure of assessing, reflecting on and improving this quality to guarantee the continuous development of the bachelor/master's system.

7 BIBLIOGRAPHY

7.1 Quality management

Specific evaluation study

Hansmann R, Mieg HA, Frischknecht P. (2010). Survey of Graduates of Environmental Sciences of the Years 1992 to 2005: Analysis of their Careers and their Contributions to Sustainable Development. Zürich: ETH Zürich D-UWIS.

Mieg HA. (2010). The Impact of the Establishment of Environmental Sciences at ETH on Swiss Economy and Society: An Evaluation Study. Berlin, Zürich: Humboldt-Universität zu Berlin, Geographisches Institut, ETH Zürich D-UWIS.

Hansmann R, Mieg HA, Frischknecht P. (2009). Ergebnisse einer Internet-Befragung von Maturantinnen und Maturanden zur Analyse des Images von Umweltnaturwissenschaften sowie des Zusammenhangs zwischen persönlichen Interessen und Überlegungen hinsichtlich eines Studiums. Zürich: ETH Zürich D-UWIS.

Reports of regular graduate surveys

Hansmann R & Frischknecht P. (2009). Befragung 2007 zu Studium und Berufseinstieg der AbsolventInnen des Diplomstudiengangs Umweltnaturwissenschaften, ETH Zürich, des Jahres 2006. Zürich: ETH Zürich D-UWIS.

Hansmann R & Frischknecht P. (2009). Befragung der Bachelor AbsolventInnen 2009 der Umweltnaturwissenschaften an der ETH Zürich zum Studium und zur weiteren Ausbildung. Zürich: ETH Zürich D-UWIS.

Sutter A. (2008). Befragung der Bachelor AbsolventInnen des Abschlussjahrgangs 2008 der Umweltnaturwissenschaften an der ETH Zürich zum Bachelor-Studium und zur weiteren Ausbildung. Selbständige Arbeit am Departement Umweltwissenschaften der ETH Zürich. Zürich: ETH Zürich D-UWIS.

Hansmann R, Gähwiler M, Frischknecht P. (2007). Eine Befragung zum Studium und Berufseinstieg der ETH AbsolventInnen des Diplomstudiengangs Umweltnaturwissenschaften des Jahres 2004. Zürich: ETH Zürich D-UWIS.

Ruprecht D. (2007). Befragung der Bachelor AbsolventInnen 2007 in Umweltnaturwissenschaften zu Studium und Zukunftsplanung. Eine selbständige Arbeit am Departement Umweltwissenschaften der ETH Zürich. Zürich: ETH Zürich D-UWIS.

Hansmann R & Frischknecht P. (2006). Die erste Karrierephase der Diplomanden und Diplomantinnen des Studiengangs Umweltnaturwissenschaften der ETH Zürich. Ergebnisse einer Zweitebefragung der Abschlussjahrgänge 1998/99 im Jahr 2005. Zürich: ETH Zürich D-UWIS.

Mosimann A & Bähler S. (2006). Studieren nach den Bologna Reformen. Eine Befragung der ersten Bachelor AbsolventInnen in Umweltnaturwissenschaften (Abschlussjahrgang 2006) zum Studium und zur Zukunftsplanung. Eine Semesterarbeit am Departement Umweltwissenschaften der ETH Zürich. Zürich: ETH Zürich D-UWIS.

Hansmann R & Frischknecht P. (2005). Eine Befragung zum Studium und Berufseinstieg der ETH AbsolventInnen der Umweltnaturwissenschaften des Jahres 2003. Zürich: ETH Zürich D-UWIS.

Hansmann R, Frischknecht P & Hug SM. (2005). Studium und Berufseinstieg – Eine Befragung der ETH AbsolventInnen der Umweltnaturwissenschaften des Jahres 2002. Zürich: ETH Zürich D-UWIS.

Hansmann R, Frischknecht P, Zimmermann W, Holdenrieder O. (2004). Befragung der ETH AbsolventInnen der Forstwissenschaften der Jahre 1993 bis 2001 und der Umweltnaturwissenschaften der Jahre 1996/97 und 2001. Zürich: ETH Zürich D-UWIS.

Hansmann R & Frischknecht P. (2002). Zwei Jahre nach dem Diplom - Befragung zur beruflichen Situation und zum Studium. Absolventinnen und Absolventen des Studiengangs Umweltnaturwissenschaften der ETH Zürich. Abschlussjahrgang 2000. Zürich: ETH Zürich D-UWIS.

Stauffacher M & Frischknecht P. (2001). Übergang Hochschule - Beruf: Absolventinnen und Absolventen des Studienganges Umweltnaturwissenschaften der ETH Zürich. Erstbefragung Jahrgang 1999. Zweitebefragung der Jahrgänge 1994/95. Zürich: ETH Zürich D-UWIS.

Stauffacher M & Frischknecht P. (2000). Zwei Jahre nach dem Diplom - Eine Befragung der Absolventinnen und Absolventen des Studienganges Umweltnaturwissenschaften zur beruflichen Situation und zum Studium: Abschlussjahrgang 1998. Zürich: ETH Zürich D-UWIS.

Stauffacher M, Frischknecht P, Woschnack U. (2000). Erste Karrierephase der Absolventinnen und Absolventen des Studienganges Umweltnaturwissenschaften der ETH Zürich. Eine Befragung der Diplomjahrgänge 1992 und 1993. Zürich: Departement Umweltnaturwissenschaften. Zürich: ETH Zürich D-UWIS.

Woschnack U & Frischknecht P. (1999). Umweltnaturwissenschaftlerin und Umweltnaturwissenschaftler - der Übergang in die Erwerbstätigkeit. Oder: Was nach dem Studium kommt (Abschlussjahrgang 1997). Zürich: Departement Umweltnaturwissenschaften. Zürich: ETH Zürich D-UWIS.

Frischknecht P & Bigler S. (1998). Berufschancen der Absolventinnen und Absolventen der Abteilung für Umweltnaturwissenschaften. Eine Umfrage unter dem Abschlussjahrgang 1996 im Vergleich zu Befragungen früherer Jahrgänge. Zürich: ETH Zürich D-UWIS.

Koller B & Frischknecht P. (1997). Berufschancen im Umweltbereich. Eine Umfrage unter den Absolventinnen und Absolventen des Jahrgangs 1995 der Abteilung für Umweltnaturwissenschaften an der ETHZ. Zürich: ETH Zürich D-UWIS.

Koller B & Frischknecht P. (1996). Berufschancen im Umweltbereich. Eine Umfrage unter den Absolventinnen und Absolventen des Jahrgangs 1994 der Abteilung für Umweltnaturwissenschaften an der ETHZ. Zürich: ETH Zürich D-UWIS.

Koller B & Frischknecht P. (1995). Berufschancen im Umweltbereich. Eine Umfrage unter den Absolventinnen und Absolventen des Jahrgangs 1993 der Abteilung für Umweltnaturwissenschaften an der ETHZ. Zürich: ETH Zürich D-UWIS.

Design of the study programme

Frischknecht PM. (2003). Bachelor in Umweltnaturwissenschaften an der ETH Zürich - Teil eines neuen Studienkonzepts für die systemorientierten Naturwissenschaften. *GAIA*, 12(1), 76-77.

Friskhnecht PM. (2000). Environmental science education at the Swiss Federal Institute of Technology (ETH). *Water Sciences and Technology*, 41(2), 31-36.

Friskhnecht PM & Imboden D. (1995). Environmental sciences education at the Swiss Federal Institute of Technology (ETH) Zürich and at other Swiss universities. *Environmental Science and Pollution Research*, 2, 56-59.

Gigon A, Friskhnecht PM & Scherz B. (1993). Umweltnaturwissenschaften - der neue Studiengang an der Eidgenössischen Technischen Hochschule Zürich. In J. Pfadenhauer (ed.): *Verhandlungen der Gesellschaft für Ökologie*, 22, 365-370.

Müller-Herold U. (1990). Umweltnaturwissenschaften: Erfahrungen mit einem neuen multidisziplinären Studiengang an der ETH Zürich. In: K. Mainzer (Ed.): *Natur und Geisteswissenschaften. Perspektiven und Erfahrungen mit fachübergreifenden Ausbildungsinhalten* (pp. 21-67). Berlin: Springer-Verlag.

Müller-Herold U. (1988). Umweltnaturwissenschaften: Das erste Jahr. Bericht des Leiters der Lehrgruppe über das akademische Jahr 1987/88. Zürich: ETH Zürich Laboratorium für Physikalische Chemie [Archiv D-UWIS].

7.2 Research

Educational research

Gasser M. (2009). Die didaktische Ausbildung in Umweltlehre der ETH Zürich - Eine Einschätzung durch die Absolventen/innen und Studierenden. Eine selbständige Arbeit am Departement Umweltwissenschaften der ETH Zürich. Zürich: ETH Zürich D-UWIS.

Hansmann R. (2009). Linking the components of a university programme to the qualification profile of graduates: The case of a sustainability-oriented Environmental Science curriculum. *Journal of Research in Science Teaching*, 46(5), 537-569.

Mittler M. (2006). Unterrichtsevaluation an der ETH - Sind deren Aussagen vom Zeitpunkt der Befragung abhängig? Eine Semesterarbeit am Departement Umweltwissenschaften der ETH Zürich. Zürich: ETH Zürich D-UWIS.

Huber E. (2006). Unterrichtsevaluation - Zusammenhang zwischen Prüfungsnoten und Einschätzung durch Studierende. Eine Semesterarbeit am Departement Umweltwissenschaften der ETH Zürich. Zürich: ETH Zürich D-UWIS.

Scholz RW, Lang DJ, Wiek A, Walter AI & Stauffacher M. (2006). Transdisciplinary case studies as a means of sustainability learning: Historical framework and theory. *International Journal of Sustainability in Higher Education*, 7(3), 226-251.

Stauffacher M, Walter A, Lang D, Wiek A, & Scholz RW. (2006). Learning to research environmental problems from a functional social-cultural constructivism perspective: The transdisciplinary case study approach. *International Journal of Sustainability in Higher Education*, 7(3), 252-275.

Scholz RW, Steiner R, & Hansmann R. (2004). The Role of Internship in Higher Education in Environmental Sciences. *Journal of Research in Science Teaching*, 41(1), 24-46.

Kaufmann-Hayoz R, Bürgenmeier B, Brandl H, Burger P, Eichenberger S, Friskhnecht P, Gülden-zoph

W, Hammer Th, Lindemann Matthies P, Schmid B & Schneider G. (2003). Die Umsetzung der Erklärung von Bologna in interdisziplinär-ökologischen Studiengängen. *GAIA*, 12(2), 153-158.

Steiner R & Friskhnecht P. (2001). Berufspraxis in der Hochschulausbildung: Effiziente Vermittlung von arbeitspraktischen Qualifikationen, *GAIA*, 10(1), 74.-77.

Friskhnecht P & Lindemann-Matthies P. (1999). Hochschulausbildung im Umweltbereich werden immer ausgereifter. Aber sind sie auch praxistauglich? – Befragungen von Absolventinnen und Absolventen umweltwissenschaftlich orientierter Studiengänge an den Universitäten Bern, St. Gallen und Zürich sowie der ETH Zürich im Vergleich. *GAIA*, 8(1), 75-78.

Steiner R. (1999). Praxisorientierte Hochschulausbildung im Umweltbereich: Erste Bewährung im Berufspraktikum. In J. Pfadenhauer (ed.): *Verhandlungen der Gesellschaft für Ökologie*, 29, 637-642.

Alean-Kirkpatrick P, Friskhnecht PM, Utelli AB. (1998). Examining the examinations: Assessment of undergraduate examinations in the Department of Environmental Sciences, ETH Zürich. *GAIA*, 7(1), 73-78.

Defila R, Brandl H, Dyllick T, Friskhnecht P, Hussy C, Koller T, Lenzen C, Lindemann-Matthies P, Schneider G, Vonmont P. (1998). Die Koordinationsstellen an den Schweizer Universitäten Motor für die Förderung interdisziplinärökologischer Lehre und Forschung. *GAIA*, 7(2), 144-158.

Oberle BM, Scholz RW, Friskhnecht PM. (1997). Ökologische Problemlösefähigkeit - Eine Herausforderung für die Ausbildung von UmweltnaturwissenschaftlerInnen. *GAIA*, 6(1), 73-78.

Vonmont P, Brandl H, Defila R, Friskhnecht P, Schneider G. (1997). Praxisorientierte Hochschulausbildung zwischen wissenschaftlichen Traditionen und berufspraktischen Ansprüchen - eine Herausforderung auch für Umweltstudiengänge, *GAIA*, 6(3), 231-238.

Defila R, Brandl H, Friskhnecht P, Schneider G, Vonmont P. (1996). „Umwelt für alle“ in der Ausbildung - zum Stand der Endogenisierung. *GAIA*, 5(3-4), 193-199

Müller-Herold U & Neuenschwander M. (1992). Vom Reden zum Tun: Die Fallstudie in den Umwelt-naturwissenschaften, *GAIA*, 1(6), 339-349.

Research into the environmental professions

Mieg HA. (im Druck). La dynamique du marché des services environnementaux: le cas de la Suisse. En F Bost & S Daviet (editeurs), *Entreprises et environnement: quels enjeux pour le développement durable?* Paris: PUF

Mieg HA. (2009). Two factors of expertise? Excellence and professionalism of environmental experts. *High Ability Studies*, 20(1), 91-115.

Mieg HA. (2008). Professionalization and professional identities of environmental experts: The Case of Switzerland. *Environmental Sciences*, 5(1), 41-51.

Mieg HA & de Sombre S. (2007). The knowledge base of professional work. In M. Chaponnière, Y. Flückiger, B. Hotz-Hart, F. Osterwalder, G. Sheldon & K. Weber (Hrsg.), *Bildung und Beschäftigung, Band 2* (S. 407-425). Zürich: Rüegger.

Friskhnecht P & Hansmann R. (2004). Umweltwissenschaften/Ökologie an Schweizer Hochschulen. (K)eine Stelle nach dem Studium? - Arbeitsmarktchancen von Umweltnaturwissenschaftlern

werden durch die konjunkturelle Situation kaum beeinflusst. *GAIA*, 13(1), 77-78.

Mieg HA & de Sombre S. (2004). Wem vertrauen wir Umweltprobleme an? Gefragt sind Generalisten mit akademisch-abstraktem Wissen (NFP43, Synthesis 17). Bern: Schweizerischer Nationalfonds.

Mieg HA. (2003). Professionalisierung als Muster der beruflichen Kompetenzentwicklung bei hochqualifizierten Berufen: Der lange Arm der absolvierten Studienrichtung. *Wirtschaftspsychologie*, 5(1), 59-62.

Woschnack U & Mieg HA. (2003). Fachwissen - Expertise - Schlüsselqualifikationen: Drei Dimensionen eines integrativen Modells der Qualifikation für professionalisierte Dienstleistungen. *ARBEIT*, 12, 54-67.

Mieg HA. (2002). The use of abstract knowledge in professional competition: A study on the Swiss market for professional environmental services. *Schweizerische Zeitschrift für Soziologie / Swiss Journal of Sociology*, 28, 27-45.

Mieg HA & Woschnack U. (2002). Die berufliche Identität von Umweltdienstleistern: Altes, neues oder ohne Berufsbild? *ARBEIT*, 11, 185-198.

Woschnack U & Frischknecht P. (2002). Schlüsselqualifikationen - Vom Arbeitsmarktverlangt! von der Hochschule gelehrt? *Personal*, 10/2002, 26-30.

Woschnack U & Mieg HA. (2002). Erfahrungen wichtiger als Schlüsselqualifikationen. *PANORAMA*, 5, 38-39.

Mieg HA. (2001). Professionalization and professional activities in the Swiss market for environmental services. In Leal Filho W (ed.), *Environmental careers, environmental employment and environmental training* (p. 133-160). Frankfurt/New York: Lang.

Mieg HA. (2001). Umwelt und Profession - Ein Status-Bericht aus der Schweiz. *GAIA*, 10(3), 182-189.

Scholz RW, Flückiger B., Schwarzenbach RC, Stauffacher M, Mieg HA, Neuenschwander M. (1997). Environmental problem-solving ability: Profiles in application documents of research assistants. *The Journal of Environmental Education*, 28(4), 37-44.

Koller BG, Frischknecht PM, Jaeger CC. (1996). Berufschancen im Umweltbereich – Eine Umfrage unter den Absolventinnen und Absolventen des Studiengangs Umweltnaturwissenschaften der ETH Zürich. *GAIA*, 5(1), 35-43.

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