Analysis of the Degree Programmes in the Field of Food Science and Technology Offered by Swiss Universities and Universities of Applied Sciences

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D MTEC
Chair of Education Systems

CES

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Master of Advanced Studies (MAS) in Management, Technology, and Economics

Analysis of the degree programmes in the field of food science and technology offered by Swiss universities and universities of applied sciences

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Master's thesis

Zurich, July 2021

Chair of Education Systems, D-MTEC, ETH Zurich

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Abbreviations

BFH	Berner Fachhochschule
BFS	Bundesamt für Statistik
BSc	Bachelor of Science
CAS	Certificate of Advanced Studies
CES	Chair of Education Systems
CVC	Curriculum Value Chain
D-HEST	Department of Health Sciences and Technology
D-MTEC	Department of Management, Technology, and Economics
DAS	Diploma of Advanced Studies
ECTS	European Credit Transfer and Accumulation System
EHA	Erhebung bei den Hochschulabsolventen/Innen
EHEA	European Higher Education Area
EPFL	École Polytechnique Fédérale de Lausanne
ETH	Eidgenössische Technische Hochschule
FHNW	Fachhochschule Nordwestschweiz
FIAL	Föderation der Schweizerischen Nahrungsmittel-Industrien
FS	Food Science
FSO	Federal Statistical Office
GDP	Gross Domestic Product
HAFL	Hochschule für Agrar-, Forst- und Lebensmittelwissenschaften
HedA	Higher Education Act
HEI	Higher Education Institution
HES-SO	Haute école spécialisée de Suisse occidentale
HFKG	Bundesgesetz über die Förderung der Hochschulen und die Koordination im schweizerischen Hochschulbereich (Hochschulförderungs- und -koordinationsgesetz)
HIC	High-Income Country
ISCED	International Standard Classification of Education
LABB	Längsschnittanalysen im Bildungsbereich
MAS	Master of Advanced Studies
MSc	Master of Science
PhD	Doctor of Philosophy
SCCRE	Swiss Coordination Centre for Research in Education
SERI	State Secretariat for Education, Research and Innovation
SGLWT	Schweizerische Gesellschaft für Lebensmittel-Wissenschaft und -Technologie
SHK	Schweizerische Hochschulkonferenz
SNSF	Swiss National Science Foundation
SSIC	Swiss Science and Innovation Council
SVIAL	Schweizerischer Verband der Ingenieur-Agronomen und der Lebensmittel-Ingenieure
UAS	University of Applied Sciences
UTE	University of Teacher Education
VET	Vocational Education and Training
ZFH	Zürcher Fachhochschule
ZHAW	Zürcher Hochschule für Angewandte Wissenschaften

Abstract

Universities and universities of applied sciences educate qualified professionals for the economy, academia, and society. Due to the continuously changing needs of the labour market, educational institutions have to develop their degree programmes in a constant and circular process, the curriculum value chain (Renold, et al., 2015). In this thesis, I systematically examine the degree programmes in food science and technology offered by Swiss universities of applied sciences and the federal institute of technology. The method presented here converts the qualitative statements of the course descriptions into a quantitative and comprehensive evaluation on specific aspects of the curriculum. Thereby, I identify the main differences in the structure and content of their curricula. The analysis shows that the curricula of the federal institute of technology and the universities of applied sciences differ mainly in the share of basic science and additional subjects, such as economics and law, and only marginally in the share of the food science subjects. While the teaching at the federal institute of technology is strongly oriented towards imparting theoretical knowledge and scientific practices, the curriculum at the universities of applied sciences includes a lot of practical application, aiming for a clear professional profile. Differences between the educational institutions are also evident in the competencies fostered and in the assessment of the competencies. Many of the differences in the curricula are based on institutional factors, which are listed here for the level of the entire educational institution and the individual degree programmes. In addition, I use the results of a survey conducted by D-HEST ETH Zurich in 2020 among professionals and ETH graduates to elicit the outcome of the degree programmes BSc and MSc in Food Science at ETH, which exemplarily closes the curriculum value chain. In combination with additional studies, the results of this analysis provide the data basis to examine the link between the education and employment system in the field of food science and technology. Furthermore, the approach presented here can be applied to other educational institutions and degree programmes and provide the basis for upcoming curriculum reforms.

1 Introduction

1.1 Motivation

1.1.1 Food Science Initiative

The training and provision of qualified professionals who perform important functions in the economy and society is a central task of the tertiary education level in Switzerland. Graduates of tertiary education programmes are expected to meet the diverse needs of the labour market. However, these needs are subject to constant change due to the dynamics of the economy, politics, and society. In addition to the growing level of knowledge, the changing needs of the labour market are the important driver for the further development of the content and orientation of degree programmes at higher education institutions. If the education system fails to achieve this goal and graduates are not equipped with the required competencies, the labour market will have an unfavourable outcome, which is particularly evident in the employment system in the form of youth unemployment and skills mismatch (Rageth & Renold, 2020). To prevent such and unfavourable outcome, an exchange between the education and the employment system is necessary throughout the entire curriculum value chain (Renold, et al., 2015). For the area of vocational education and training (VET), L. Rageth and U. Renold (2020) state that the two systems are highly linked in the optimal case and actors of both systems influence the contents of the training programmes. To a certain extent, this also applies to the tertiary education level, although it also wants to consider other interests, such as academic research, in addition to the labour market.

The Food Science Initiative is based on these considerations and aims to take a closer look at the interaction between the higher education and the labour market in the field of food science and technology in Switzerland. The central question is whether today's degree programmes offered by Swiss universities and universities of applied sciences (UAS) meet the needs of the Swiss labour market. To answer this question, different aspects of the education and the employment system have to be analysed.

The Food Science Initiative is modular (**Figure 1**), with each module addressing a specific aspect of the overarching question. The individual modules use different analytical methods and data sources (**Table 1**). When the findings from the individual modules are combined, a holistic picture emerge and the answer to the overarching question can be framed.

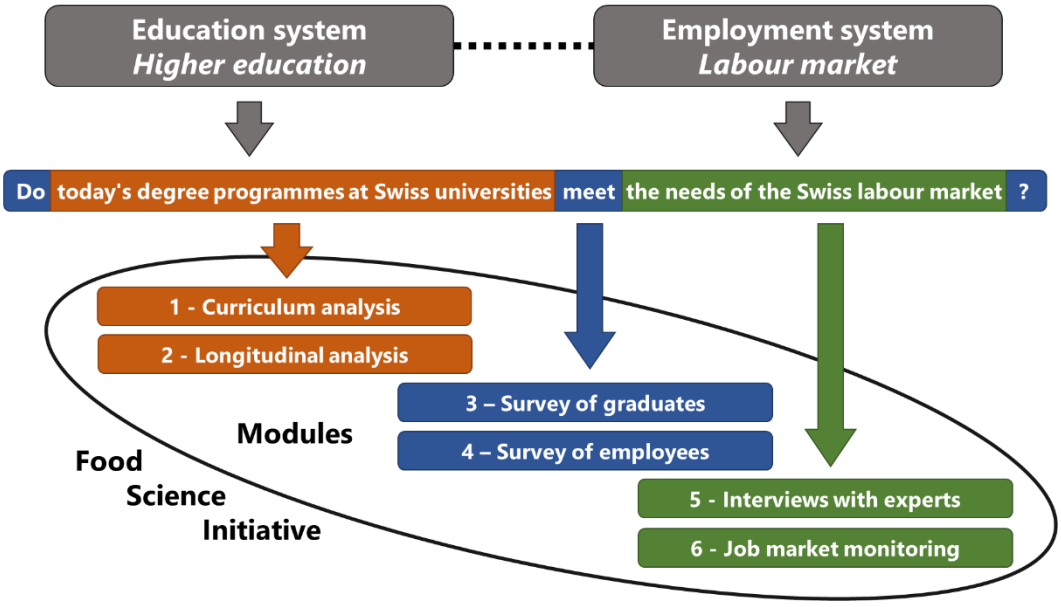

Figure 1: Overview of the Food Science Initiative.

The Food Science Initiative was initiated by the Swiss Association of Agricultural and Food Engineers (SVIAL), the Swiss Society of Food Science and Technology (SGLWT) and the Federation of Swiss Food Industries (FIAL). It is intended to conduct the study in cooperation with higher education institutions that offer a degree programme in the field of food science and technology. Thereby, both sides, the education and the employment system, would be involved in the study. The Chair of Education Systems (CES) led by Prof. Dr. Ursula Renold at the Department of Management, Technology, and Economics (D-MTEC) at ETH Zurich has elaborated the scientific approach of the study and will carry it out operationally. This thesis is part of the Food Science Initiative and comprises Module 1 (**Figure 1** and **Table 1**).

Table 1: Modules of the Food Science Initiative.

Module	Method	Aspect in focus
1	Analysis of the institutional factors and the curricula of the degree programmes	Degree programmes
2	Longitudinal analysis in education (LABB)	Degree programmes and educational trajectories
3	Survey of university graduates (EHA)	Educational trajectories and labour market situation
4	Survey of employees (alumni)	Labour market situation
5	Interviews with employers and experts	Competencies
6	Job market monitoring	Labour market situation and competencies

1.1.2 Scope of the thesis

In Switzerland, the Swiss Federal Institute of Technology in Zurich (ETH Zurich) and several universities of applied sciences offer degree programmes in the field of food science and technology at Bachelor's and Master's level (**Table 2**).

Table 2: Degree programmes in food science and technology at Swiss universities and UAS.

Institution	Level	Degree programme (title)
University		
ETH Zurich	Bachelor	BSc ETH in Food Science
	Master	MSc ETH in Food Science
University of Applied Sciences		
ZHAW	Bachelor	BSc ZFH in Food Technology
	Master	MSc ZFH in Life Sciences with specialisation in Food and Beverage Innovation
BFH-HAFL	Bachelor	BSc BFH in Food Science
	Master	MSc BFH in Life Sciences - Food, Nutrition and Health
HES-SO	Bachelor	BSc HES-SO in Life Technologies with specialisation in Food Technology

Module 1 of the Food Science Initiative aims to investigate the differences between these degree programmes and the institutions offering them. Module 1 is the scope of this thesis and consists of three parts:

1) **Analysis of institutional factors**

   I will elucidate the differences in the institutional factors among the educational institutions and their influence on the curricula of the degree programmes. The institutional factors specific for the university form the framework conditions for the degree programmes and include, for example, the orientation of the university and the composition of the faculty, but also the link with the economy and the study rules for the students. The analysis of the institutional factors provides the context for the curriculum analysis.

2) **Analysis of the curricula**

   The curriculum analysis examines the structure and content of the individual degree programmes. To certain extent, the pedagogical methods are also considered. All this information is prepared in such a way that general statements can be made about the degree programmes. With the help of the curriculum analysis, tendencies in the

orientation of the degree programme towards research or application, the proportions of theoretical knowledge transfer and practical exercise, as well as the composition of the competencies imparted are to be analysed.

3) **Analysis of graduates' and professionals' feedback**

   As part of the efforts to reform the curriculum of the Food Science programme at ETH Zurich, the Department of Health Sciences and Technology (D-HEST) conducted a survey among ETH graduates and professionals in the field of food and nutrition about their experiences during their studies and in the job market. The D-HEST provided me access to this data, which I partially analysed in this study. In particular, the data will possibly underpin the conclusions from the curriculum analysis and provide hints for further improvements of the degree programmes. I did not have access to a similar data set from the UAS.

Thus, I formulated an independent research question for Module 1 and this thesis: How do the degree programmes in food science and technology offered at ETH Zurich and the universities of applied sciences differ in structure and content, and how do institutional factors influence any differences?

1.1.3 Approach

To shed light on the research question, a heuristic approach is applied. The approach orientates on the concept of the curriculum value chain (CVC) that is based on the curriculum theory of A.V. Kelly (Kelly, 2009) and was subsequently further developed (Rageth & Renold, 2020; Renold, et al., 2015). The CVC divides the educational process into three phases that interact cyclically with each other (**Figure 2**). In the curriculum design phase, the structure of the curriculum and the pedagogical methods are regulated. In the same phase, the learning content to be taught and the competencies to be acquired are determined. In the curriculum application phase, training takes place, i.e. the teaching and testing of the learning content to the learners by the teachers. The outcome is apparent in the graduates' transition to the labour market. The experience gained flows back into the educational process in the curriculum feedback phase.

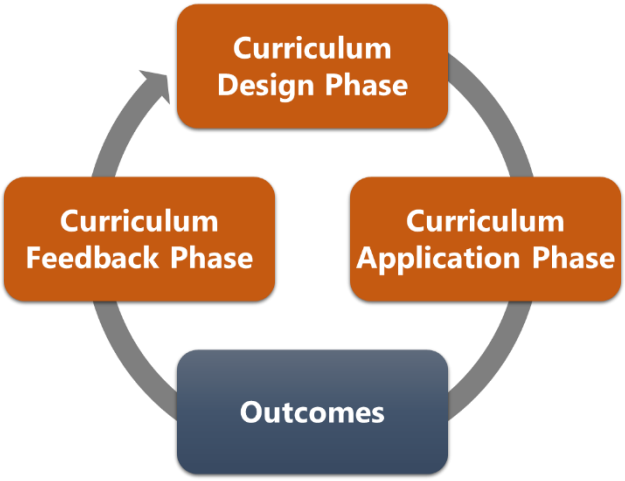

Figure 2: The curriculum value chain (CVC). Source: figure adapted from (Renold, et al., 2015).

Investigation of the whole CVC requires multiple analysis tools and different perspectives have to be taken. Although all modules of the Food Science Initiative are required to get a complete picture, the tools of module 1 already provide information from all phases of the CVC:

- The analysis of institutional factors shows differences between educational institutions and their potential influence on curriculum design and application. I use information from written and online sources for this purpose. In addition, I have conducted semi-structured interviews with the responsible persons of all degree programmes to obtain background information.
- The curriculum analysis uses a systematic approach to examine the content and structure of the curricula, which are defined in the curriculum design phase and delivered to students in the curriculum application phase. I present the structure of the curricula in a uniform way so that a visual comparison is easily possible. The contents of the curricula are categorised according to various criteria. This makes it possible to identify tendencies for the individual curricula and to discuss differences between them. I have sourced the information from the course catalogues, which are available to students online.
- Surveys among graduates and professionals are an effective and popular tool to evaluate and develop curricula. For this thesis, I use two surveys that the D-HEST/Food Science conducted among graduates and professionals at the beginning of 2020. The surveys provide feedback specifically on the ETH degree programmes as well as indicate general requirements for food science graduates.

1.2 Education system in Switzerland

1.2.1 Overview

The Swiss education system is composed of three levels. The primary level begins with the entry into the two-year kindergarten. This is usually followed by six years of primary school. The education of the primary level is compulsory. The secondary level is divided into two parts: the lower- and upper-secondary level. The lower-secondary level is still part of compulsory education, but it is often organised according to learning levels and preferences so that pupils are optimally prepared for the upper-secondary level. The upper-secondary level that is no longer part of compulsory schooling prepares learners either for entry into the labour market or for transfer to the tertiary level of education (**Figure 3**). The baccalaureate enables people to enter a degree programme at universities, the federal institutes of technology (EPFL and ETHZ), or universities of teacher education (UTE). The specialised baccalaureate allows students to transfer to a university of teacher education or a university of applied sciences. An alternative to these two school-based education trajectories is the vocational education and training (VET), which is characteristic of Switzerland as a dual VET system. During their VET, the apprentices learn a profession, both in a company in which they are integrated as workers and at a vocational school, in which they are in a class with other apprentices. Optionally, a vocational baccalaureate can be done during or after the dual VET, which usually extends the VET programme by one year. The vocational baccalaureate allows students to transfer to a university of applied sciences.

The tertiary level in the Swiss education system (ISCED level 6-8) can be divided into two sectors (**Figure 3**): 1) academic education and 2) professional education. The professional education includes the colleges of higher education and the federal examinations of higher education. These examinations offer professional specialisations that result in an advanced diploma (ISCED level 6/7). The academic education includes the cantonal universities, the federal institutes of technology (EPFL and ETHZ), the universities of applied sciences and the universities of teacher education. Their degree programmes are divided into a Bachelor (ISCED level 6) and Master level (ISCED level 7), which are completed with the respective title. The doctorate (PhD) is the highest academic degree (ISCED level 8) that can only be awarded by the universities and the federal institutes of technology in Switzerland.

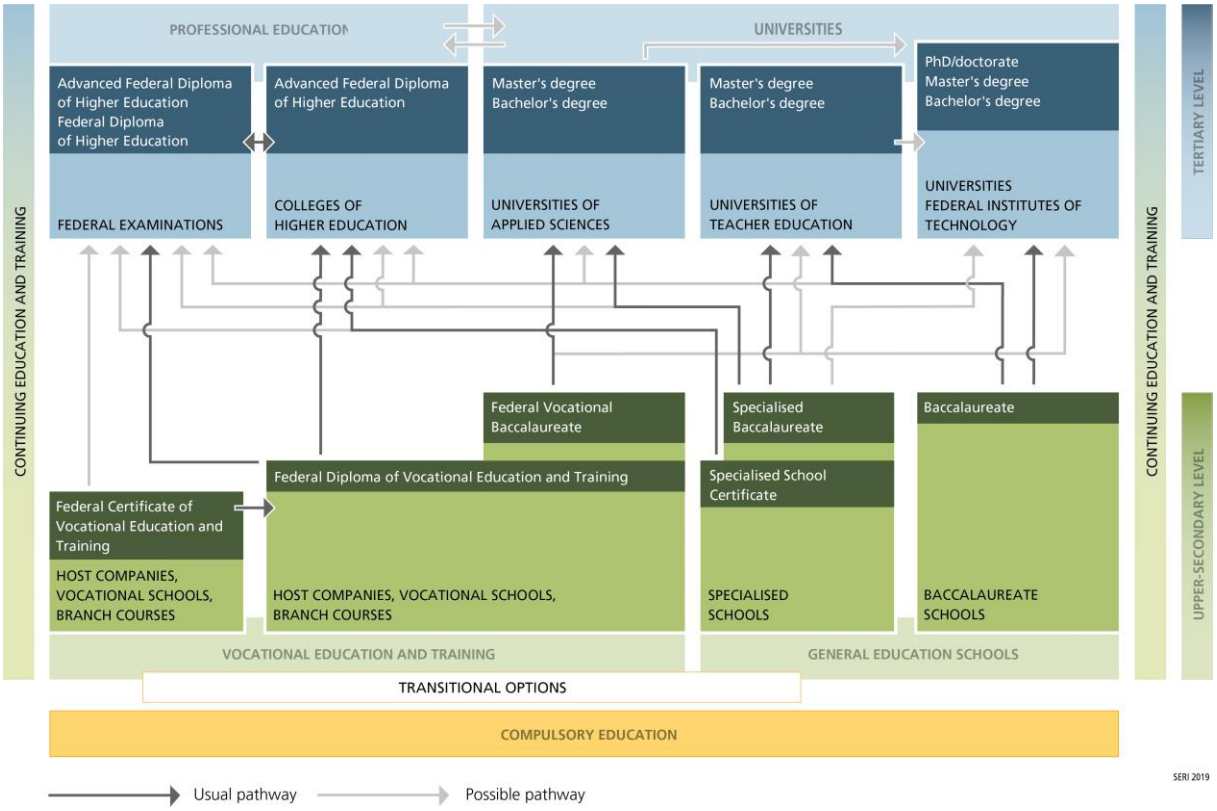

Figure 3: The Swiss education system with focus on the upper-secondary and tertiary level. Source: https://www.sbfi.admin.ch/sbfi/en/home/education/swiss-education-area/swiss-education-system.html# (last visited: 12/06/2021)

According to the Swiss Federal Constitution, the Swiss Confederation and the cantons are jointly responsible for education in Switzerland (BV Art. 61a). However, most competencies and responsibilities lie with the cantons, which, among other things, regulate the entire compulsory education (BV Art. 62, Abs. 1). In most cases, the municipalities operate the schools of the primary and lower-secondary level. Due to the high competencies of the cantons in the education system, there are cantonal differences, especially at primary and lower-secondary level. The amendment of the articles on education in the Swiss Federal Constitution (BV Art. 61a-67) in 2006 led to a harmonization of the education system among the cantons to certain extend (Ehrenzeller, 2007). The Swiss Confederation and the cantons are partners and share responsibility for baccalaureate schools, vocational education and training, and higher education. For example, the cantons run the universities and the Swiss Confederation runs the technical universities in Zurich (ETHZ) and Lausanne (EPFL).

1.2.2 Academic education

According to the Swiss Science Council (SSC), which advises the Federal Government on education, research and innovation, the higher education mainly serves the following superior objectives (SSIC, 2014):

- Optimal use of the entire human potential
- Increasing the competitiveness of the economy at the international level
- Promoting access to the labour market
- Strengthening social integration

The higher education institutions (HEIs) achieve these goals by training qualified professionals and leaders for the labour market, either through an initial or a continuing education programme. Thereby, the aim is to impart an abstract, conceptual, and critical way of thinking. The higher in the academic degree, the students are intendent not only to learn existing knowledge, but also to generate new knowledge through their own research activities.

In 1999, the education ministers of 29 European countries, including Switzerland, have launched the Bologna Process, giving rise to the European Higher Education Area (EHEA). Its overarching goals are the harmonisation of the academic education, promotion of student mobility, and an ongoing quality assurance. Thereby, Europe's competitiveness in higher education should be strengthened. The Bologna model divides academic education into three levels: 1) Bachelor's degree, 2) Master's degree, and 3) doctorate. Credit points are awarded for verified academic achievements. According to the European Credit Transfer and Accumulation System (ECTS), one credit point corresponds to a workload of 25-30 hours. The implementation of the Bologna model for Swiss universities and fort he UAS is regulated in the "Verordnung des Hochschulrates über die Koordination der Lehre an den Schweizer Hochschulen" (SR 41.205.1). Accordingly, the Bachelor's programme comprises 180 ECTS and the Master's programme 90 or 120 ECTS. In contrast, the HEIs themselves determine the scope and structure of the doctorate.

1.2.3 Higher education institutions

In Switzerland, there are two types of higher education institutions (HEIs) offering academic education (ISCED level 6-8): 1) universities including the cantonal universities and the federal institutes of technology (ETH and EPFL), and 2) the universities of applied sciences (UAS) and

the universities of teacher education (UTE). These institutions are embedded in a system that is regulated by federal and cantonal laws. All academic institutions have a responsible body with which they are linked by a target agreement or a service mandate. The Swiss Confederation is the responsible body of the two federal institutes of technology: the ETH Zurich and the EPF Lausanne. On the other hand, the cantons run the universities, the UAS and the UTE. However, the management activities of the responsible body are limited to the strategic level. The operational management lies with the institutions themselves, which can define their own goals and tasks.

According to the Swiss Constitution (BV Art. 63a Abs. 3), the Confederation and the cantons are jointly responsible for coordination and quality assurance in higher education. Based on this constitutional mandate, the Higher Education Act (HEdA) was drafted by the Confederation and the Higher Education Concordat by the cantons, both of which entered into force in 2015. This legal basis regulates the financing of the academic institutions as well as the mechanisms and responsible bodies for coordination and quality assurance in the Swiss higher education area.

Since recently, only the academic institutions as a whole have to undergo accreditation at periodic intervals. The accreditation of individual degree programmes is no longer compulsory, which leads to a greater variety of educational programmes. Because of the HEdA, the UAS in particular have been given more autonomy in the design of their degree programmes.

The HEdA regulates the federal funding for the cantonal universities and the UAS. However, the largest share of their expenditure is financed by the cantons themselves. On the other hand, the Swiss Confederation finances largely the federal institutes of technology. In addition to federal and cantonal funding, the academic institutions are financed to varying degrees by third party funding and tuition fees.

Fundamentally, teaching and research are constitutive for all academic institutions. In addition to preserving and teaching existing knowledge, they must create new knowledge and guide students to participate in scientific research. However, due to their target mandate, the academic institutions differ in their orientation towards research and development. The main activity of the universities is basic research, which aims to advance the state of knowledge in a specific research field. In contrary, the UAS usually conduct research that is often aimed directly at an application. ETH Zurich and EPFL do both basic and applied research, especially in the

field of engineering and applied life sciences. This work may give some indication of the extent to which the orientation in research is reflected in the design of the curricula.

1.2.4 Curriculum

When we were at school, we looked at syllabuses and went through curricula. Although we have encountered these terms, we find it difficult to grasp them. It is easier to describe the term "timetable" because it can be represented on a piece of paper. In education, the timetable regulates the chronological sequence of courses. However, what is a syllabus and what is a curriculum?

A syllabus always refers to a single course. The syllabus provides information on the learning content as well as on the organisational framework of the course. There are several definitions of the term curriculum, which differ in their internal range (Wiles, 2009). In all definitions, the curriculum refers to the entire learning programme that one goes through within a school, apprenticeship, study, or further education (Law & Glover, 2000). In the narrowest and most public definition, curriculum is the collection of all syllabi of the courses in that learning programme (Leyendecker, 2012). This definition can be expanded to include not only the subject matter, but also the experience a student has while in school. This includes, for example, how the subject matter is tested and what students do in extra-curricular activities. A newer understanding of curriculum describes it as a plan aimed at equipping students with knowledge and skills they need for the next step in their educational or professional career (Leyendecker, 2012). The content and activities of the curriculum are aligned with this goal. Many academics see the curriculum as an individual learning trajectory enabling the students with different competencies (Sztajn, Confrey, Wilson, & Edgington, 2012).

The forms of instruction used, the learning content taught, and the competencies sought can be recorded on paper. However, teaching and learning is an individual process that can only be standardised to a limited extent and is personally shaped and perceived differently. Thus, teachers unconsciously convey internalised knowledge and their own experiences to students. This learning content is referred to as hidden curriculum (Barnett, 2000), as it is not recorded in writing in the ordinary curriculum.

The CVC, described in section 1.1.3, forms a dynamic process around the curriculum. In addition to the teaching and learning of knowledge, methods, and competencies (curriculum

application phase), the CVC also includes the development process and the constant feedback-based adaptation of the curriculum (Renold, et al., 2015).

To be able to proceed systematically in the curriculum analysis of this thesis, the curriculum in the following means the totality of all courses of a degree programme with the subject-specific and interdisciplinary knowledge and competencies that are consciously taught, as well as the teaching and examination methods of the degree programme.

1.2.5 Competencies

What exactly are competencies? The scientific literature offers more than one definition, which vary in comprehensiveness (Rychen & Salganik, 2003). However, there is the consensus among them that a competence encompasses more than mere knowledge or a specific skill. In particular, the terms 'skill' and 'competence' are often misused interchangeably. Dominique S. Rychen and Alejandro Tiana distinguish the two terms as follows (Rychen & Tiana, 2004): A skill is "the ability to perform a complex motor and/or cognitive act with ease and precisions". In contrast, a competence is a "complex action system encompassing cognitive skills, attitudes and other non-cognitive components". Ruth D. Crick specifies the 'complex action system' in her definition and describes competence as "a complex combination of knowledge, skills, understanding, values, attitudes and desire, which lead to effective, embodied human action in the world, in a particular domain" (Crick, 2008).

As described in section 1.2.4, a curriculum empowers students with competencies. However, as competencies are expressed in actions in the real world, their development cannot be solely reduced to the educational training but must be considered within a real-world experience (Crick, 2008). It is important that the competencies taught are aligned with the educational objectives of the degree programme as well as the required competence profile of a conceivable professional activity. If this process is done well, it will ensure that students learn competencies that enable them to solve real-world problems in their private and professional life. In addition, competencies are built up in a lifelong learning process that includes all forms of learning (informal, non-formal and formal learning) (Crick, 2008).

In general, employers have a great need to recruit people who have the appropriate competencies to successfully fulfil a certain job (Salvisberg, 2010). However, today's labour market is increasingly looking for people who have versatile competencies. A good match seems more difficult to find. Therefore, the policy bodies and the educational institutions have

elaborated key competencies that are fundamental to individuals successfully performing in various social and professional situations (Rychen & Salganik, 2003; Salvisberg, 2010). To increase the impact, learners need to develop an awareness of their competence development such that they can make them visible to future employers (Volk, Eggs, Salvisberg, & Läge, 2013). These efforts require that competencies are identified, named, and grouped (Roth, 1971; Reetz, 1999). Most concepts assign the individual competencies to the following competence domains: 1) subject- and method-specific competencies, 2) social competencies and 3) personal competencies. Some concepts consider the subject- and method-specific competencies as two separate domains.

1.3 Food industry

1.3.1 Past, present, future

The food industry includes the industrial production of food and beverages (incl. coffee, mineral water, and alcoholic beverages), the production of oils and fats, and the processing of tobacco. It is part of the secondary economic sector and follows the food production in the value chain. The food industry processes raw materials that are produced in the primary economic sector, especially in agriculture and fishery, into refined food products. The wholesale or retail trade that are part of the tertiary economic sector sell the food products directly or via the catering trade to the consumer.

Humans began preserving food from agriculture, hunting and fishing early in their development. Some of these techniques for refinement and preservation of food are ancient. Therefore, it is not surprising that the food industry is an old industry branch. The food industry has a long tradition in Switzerland, especially with the processing of dairy products. The first sources that mention cheese production in Switzerland date back to the Middle Ages (Guzzi-Heeb, 2009). In addition to cheese production, which grew steadily in importance, other food products emerged in the 18th and 19th centuries that are of great importance for Switzerland: chocolate, condensed milk, and milk powder. Many of the companies founded during this period, such as Nestlé and Lindt & Sprüngli, have grown into global corporations to this day. From the second half of the 19th century, industrialisation opened new possibilities in food production. Factories began to produce the first ready-made meals in the form of soups (Maggi, today part of Nestlé) and to fill food in tins (Henckel & Zeiler & Cie., today Hero). In

the 20th century, the number of companies reduced, but the ones that remained became bigger and more international by expansion or merger.

Today, the food industry is still highly important for the supply of food in Switzerland and for the Swiss economy. In 2012, the food industry turned over around CHF 30 billion and thus contributed about 2% to the gross domestic product (GDP), which is the third highest contribution within the industrial sector (Leinert, Brand, & Duma, 2016). The most important sub-sectors in the food industry in terms of turnover are (Leinert, Brand, & Duma, 2016): 1) food products such as chocolate and coffee (35% of the total turnover by the food industry), 2) dairy products (19%), 3) meat processing (16%), 4) baking and pasta production (15%), 5) beverage production (9%), and others (6%). The average growth rate of the Swiss food industry in terms of turnover was 4.3% in the period from 2001 to 2012 and therefore it grew more strongly than the average of all industries in Switzerland (Leinert, Brand, & Duma, 2016).

The food industry in high-income countries (HIC) is currently being shaped by two major trends. Sustainability drives the first trend. Special diets, such as vegetarianism and veganism, require new products, such as artificial and plant-based meat. There is also a need to reduce waste in packaging. Technology drives the second trend. New raw materials, such as genetically modified plants, and new production methods, such as 3D printers, enable new food and beverage products. Overall, these trends demand innovation, which are fostered by new insights from research in food science.

1.3.2 Education and employment system

According to the Federal Statistical Office (FSO), approximately 54'500 people were employed in occupations of the food, beverage, and tobacco industry in 2019, which represents almost 3% of the total workforce in Switzerland (BFS, 2020). In this sector, total 420 companies are registered, of which slightly more than half are declared as multinationals (BFS, 2020). The average monthly wage for an employee without a management function in this industry was CHF 4'952 (BFS, 2020), which is below the average wage of CHF 5'958 in manufacturing.

About two-thirds of employees in food manufacturing occupations have an upper-secondary education (**Figure 4**) (BFS, 2014). About one fifth of employees do not have a post-compulsory education qualification. The remaining 14% have a tertiary level qualification. Interestingly, the proportion of people with a tertiary level qualification is more than twice as high in the

beverage manufacturing occupational field. On the other hand, the proportion of employees with an upper-secondary qualification is significantly lower.

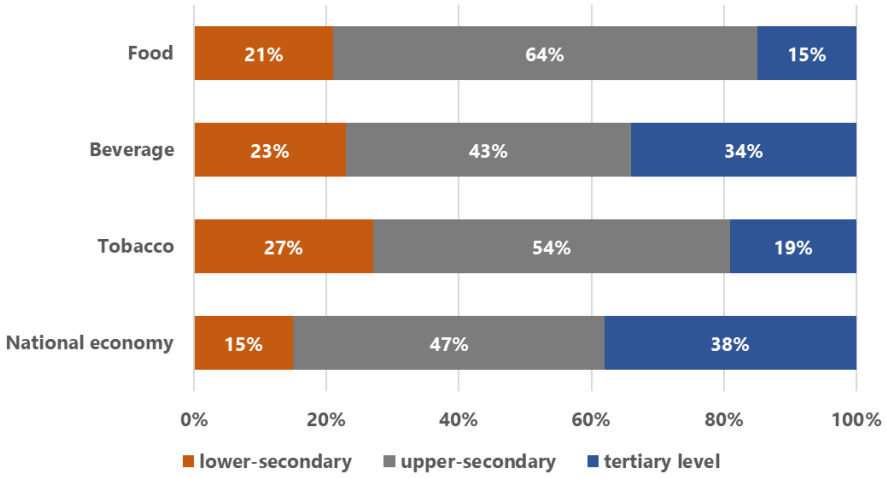

Figure 4: Educational structure in the food and luxury food industry. Source: data from (BFS, 2014) and figure adapted from (Degen, Ragni, Bieri, & Marti, 2014).

The FSO also examined occupational mobility in the period 2012-2014 (**Figure 5**) (BFS, 2014). In food manufacturing, around 64% of employees also learned a profession within this occupational class, which is significantly higher as for the national economy (39%). The value for beverage manufacturing is slightly below the value for the national economy (33%). This means that employees in food manufacturing have a high identity to their profession. The unemployment rate and the vacancy rate are important indicators of the employment system. In 2014, the sector-dependent unemployment rate was 3.0%, slightly below the economy-wide rate of 3.2% (Degen, Ragni, Bieri, & Marti, 2014). In 2014, the job vacancy rate was 1.0%, well below the economy-wide average of 2.1%. All these indicators tend to suggest that the education and employment systems are well linked (Rageth & Renold, 2020).

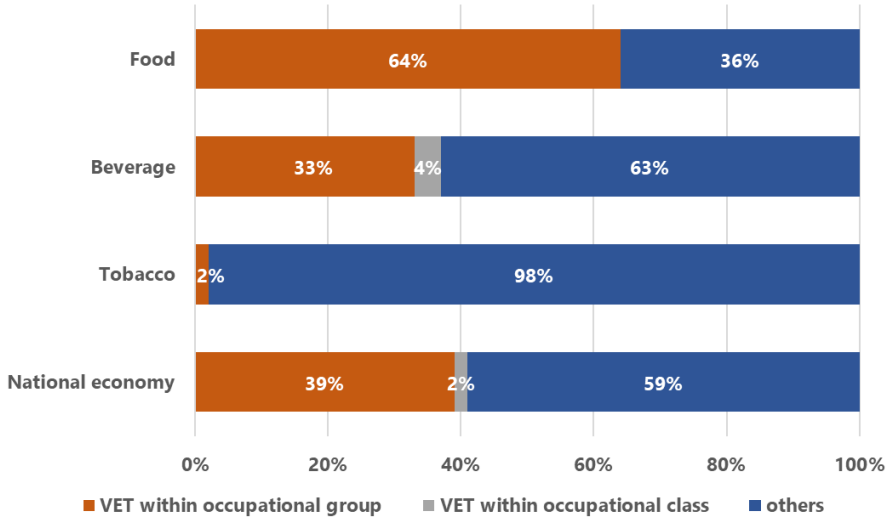

Figure 5: Vocational education and training performed within or outside of the occupational field. The classification of professions is based on the Swiss Standard Classification of Occupations 2000 (BFS, 2000). All occupations (types) are assigned in ascending order to an occupational group, an occupational class, and an occupational division. In the figure, food and beverage manufacturing and processing occupations (code 21) are the occupational class with the three associated occupational groups: 1) food manufacturing and processing occupations (code 211), 2) beverage manufacturing and processing occupations (code 212), and 3) tobacco manufacturing and processing, tasting and related occupations (code 213). Source: data from (BFS, 2014) and figure adapted from (Degen, Ragni, Bieri, & Marti, 2014).

2 Methods

2.1 Compilation of institutional factors

For the contextualisation of the curriculum analysis, I gathered relevant institutional factors that are qualitatively or quantitatively ascertainable for all educational institutions and are relevant to answer the research question. The factors have either an internal or an external source and influence the competitiveness of the higher education institutions (Supe, Zeps, Jurgelāne, & Ribickis, 2008). In addition, some factors relate to the institution as a whole and some only to the specific degree programme. I used different sources to gather the information. In particular, the laws and regulations, the annual reports, and the webpages of the educational institutions served as written sources. In addition, I consulted multiple reports published by governmental organisations, in particular the 'Swiss Education Report' (SKBF, 2018) by the Swiss Coordination Centre for Research in Education (SCCRE), 'Higher Education and Research in Switzerland' (SERI, 2019) by the State Secretariat for Education, Research and Innovation (SERI), and 'The Tertiary Level of the Swiss Education System' (SSIC, 2014) by the Swiss Science Council (SSC).

In addition to the written sources, I interviewed the persons responsible for the degree programmes at the institutions. In these interviews, I validated my knowledge about each degree programme and gathered additional information. The interviews followed a guideline with four parts and several questions (Appendix 7.1 Semi-structured interviews). The information from the interview with the person responsible for the Bachelor's programme in Life Technologies at HES-SO is not used for this study. For the analysis of the degree programme at HES-SO, only information that is publicly available was used.

2.2 Analysis of curricula

In this study, I examined the degree programmes in the field of food science and technology listed in **Table 2**, which are offered at ETH Zurich, ZHAW, BFH-HAFL, and HES-SO. In total, I analysed the curricula of four Bachelor's and three Master's programmes.

For the analysis, I applied a product-based understanding of the curriculum (Wijngaards-de Meij & Merx, 2018). Thereby, the curriculum is viewed as a product offered by the university. The learning experiences of the students are not considered.

The structure (section 2.2.1) and content (section 2.2.2) of the degree programmes are analysed separately. For both, specific aspects were defined that are of interest and can be analysed using a systematic approach. Here, the systematic approach means that a metric was defined for each aspect, which was evaluated either qualitatively or quantitatively and aggregated for the degree programme. It requires that similar information is available for all degree programmes. I used the course catalogues of educational institutions as primary source of information (**Table 3**). I obtained additional information by interviewing the persons responsible for the degree programmes. For all degree programmes, the newest available version of their curricula has been analysed.

Table 3: Version and course catalogue of the degree programmes.

Institution	Degree	Version*	URL† of course catalogue
ETH Zurich	Bachelor	2020-2021	http://www.vvz.ethz.ch
	Master	2020-2021	
ZHAW	Bachelor	2020-2021	https://www.zhaw.ch/de/lsfm/studium/studiweb/bachelor/lebensmitteltechnologie-lm/
	Master	2021-2022	https://www.zhaw.ch/de/lsfm/studium/studiweb/master-ls/modulbeschreibungen/
BFH-HAFL	Bachelor	2021-2022	https://is-a.bfh.ch/imoniteur_OPROAD/PORTAL6S.htm
	Master	2021-2022	https://www.bfh.ch/de/studium/master/life-sciences-food-nutrition-health/
HES-SO	Bachelor	2020-2021‡	https://www.hevs.ch/de/hochschule/hochschule-fur-ingenieurwissenschaften/life-technologies/plan-etude-plein-temps/

* The version indicates the academic year that is analysed.
† The websites were last visited on 12/06/2021.
‡ The BSc programme in Life Technologies at HES-SO was being revised at the time of this study. A new curriculum will be introduced in the autumn semester of 2022. For the completeness of the analysis, the current programme (academic year 2020-2021) was analysed.

2.2.1 Structure of the curricula

To describe and compare the curricula of the different degree programmes, I displayed them in a uniform layout (**Figure 6**). In the graphical representations, the time is segmented in semesters and plotted on the horizontal axis. The vertical axis indicates the categories to which the courses and modules are assigned. Thereby, I have taken the terminology as well as the allocation of courses and modules to the categories from the degree programmes. As a result, the categories differ between the degree programmes. The graphical representation always shows the basic full-time study. In an additional illustration, the number of ECTS that must be

achieved in each category is shown. This provides the proportion of ECTS that is predefined and that can be freely selected.

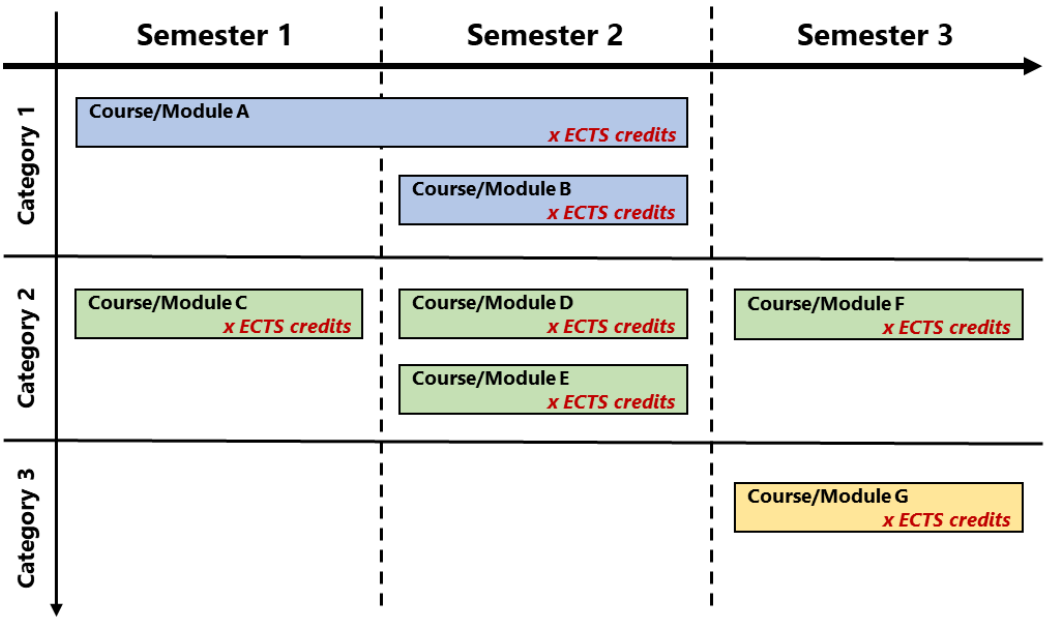

Figure 6: Uniform graphical representation of the curriculum. The horizontal axis is the timeline divided into semesters. The categories are plotted on the vertical axis. Based on the full-time degree programme, the courses, or the modules with the respective number of ECTS credits have been placed in the graph.

2.2.2 Content of the curricula

The analysis of the curriculum's content highly depends on the comprehensiveness of the course description in the sources examined (**Table 3**). Thereby, two different elements play a role. First, the course catalogues of the universities differ in their structure and information value. Second, the lecturers usually enter the content for their courses into the course catalogue. Although there might be some guidelines, this nevertheless creates variability among the descriptions. To consider this variability, the descriptions of the courses were classified using the concept of a Finnish study (Levander & Mikkola, 2009) that was conducted as part of a curriculum development project. They found that the descriptions of the courses particularly differ in two dimensions: 1) extensiveness and 2) explicitness (**Figure 7**, **Table 4**). For simplicity, both dimensions have only two states each: extensive versus brief for extensiveness, implicit versus explicit for explicitness. The combination of the two dimensions then results in the classification of the course in one out of four possible categories: 1) extensive & explicit, 2) brief & explicit, 3) extensive & implicit, and 4) brief & implicit. The shares of categories across the entire curriculum indicate the comprehensiveness of the curriculum documentation. The better the documentation, the more reliable the statements of the curriculum analysis.

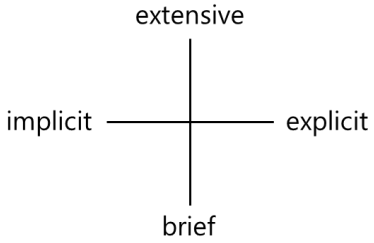

Figure 7: Dimensions of course descriptions. Source: adapted from (Levander & Mikkola, 2009)

Table 4: Dimensions of course description and their attributes.

dimension	state	attributes
extensiveness	extensive	complete and well-formulated sentences
	brief	few generic words
explicitness	explicit	specific and detailed information about concepts and competencies taught key words with explanation
	implicit	unspecific information about upper-level concepts key words without explanation

To analysis the content of the curricula, I evaluated five aspects for each curriculum (**Table 5**). I selected these aspects based on interest, significance, and feasibility. The metrics for each aspect are determined so that an evaluation was possible based on the course descriptions.

Table 5: Aspects of the curriculum analysis concerning the content.

Aspect	Metric for evaluation	Interest
Subject	The course teaches a … ▪ basic science subject ▪ food science subject ▪ additional subject	The evaluation reveals the educational focus of the degree programme.
Theory or practice	The course teaches … ▪ theoretical knowledge ▪ practical applications ▪ both	The evaluation shows how much practical training the students receive during their studies.
Course orientation	The course teaches knowledge and skills that are related to an application in … ▪ science ▪ profession ▪ general	The evaluation indicates whether the degree programme is intended more for an academic or a professional career.
Competencies	The course fosters competencies belonging to the domain of … ▪ subject-specific competencies ▪ method-specific competencies ▪ social competencies ▪ personal competencies Classification of the competencies based on Salvisberg (2010) and ETH competence framework (appendix).	The evaluation reveals the competence domains that are fostered the most and the least or whether they are in balance.
Type of performance assessment	The course content is examined with … ▪ written, oral or online exam ▪ graded or ungraded perf. ▪ written work	The evaluation shows which types of performance assessment are used to examine the course content and the fostered competencies.

To obtain the quantitative data for the content-based curriculum analysis, I read all descriptions (syllabi) of the courses offered in the degree programme and selected for each course the most appropriate metric for each of the five aspects (**Table 5**). In addition, I also assigned a state to each course description for its extensiveness (extensive or brief) and its explicitness (explicit or implicit), which was used to evaluate the comprehensiveness of the course descriptions (**Figure 7** and **Table 4**). In doing so, I received a data table for each degree programme that listed all courses offered in the curriculum and the selected metrics for the aspects as well as the assigned states for the course descriptions (**Table 6**).

Table 6: Exemplary representation of the data table that was obtain for each degree programme.

Course	Category	ECTS	Comprehensiveness of the course description		Aspects of the curriculum analysis concerning the content				
			Extensiveness	Explicitness	Subject	Theory or practice	Course orientation	Competencies	Type of performance assessment
Food 1	Food	4	extensive	explicit	food science	theoretical knowledge	profession	subject	written ex.
Food 2	Food	4	brief	implicit	food science	theoretical knowledge	profession	subject, method	online ex.
Chemistry 1	Basic	4	extensive	implicit	basic science	theoretical knowledge	science	subject	written ex.
Lab 1	Basic	2	brief	explicit	basic science	practical applications	science	subject, method	ungraded sem.
...	...	...	...	...	...	...	...	...	...
BSc thesis	BSc thesis	15	brief	explicit	basic science	both	science	subject, method, social, personal	graded sem.

In a next step, I counted the frequency of the individual metrics within a degree programme, by adding up the ECTS of the courses with the same metrics (**Table 7**). However, the degree programmes offer a varying number of courses, which are grouped in categories. The categories are individual for each degree programme. Usually there is a category for compulsory subjects, specialisation, electives, and theses. In addition, the courses differ in the workload required from the students, which is measured by the ECTS credits. Usually, the degree programmes specify how many ECTS credits the students must complete in each category (compulsory portion). To obtain a correct analysis of the degree programmes, the metric score will be summed up using ECTS credits and weighted according to the compulsory portion of ECTS per category (**Equation 1** and **Table 7**).

Equation 1: Weighting of the metric score.

$$S_{x,i} = \sum_{i=1}^{n} a_i \times \frac{b_i}{c_i}$$

$S_{x,i}$ = total score for metric x [ECTS]
n = number of categories
a_i = amount of ECTS required in category i [ECTS]
b_i = sum of ECTS of courses with metric x [ECTS]
c_i = total amount of ECTS of courses assigend to category i [ECTS]

Table 7: Exemplary representation of the data table that was obtained for each degree programme and each aspect. It shows the calculated metric score for one aspect (here: course orientation) and for one fictive degree programme (here: BSc programme with 180 ECTS required). The sums of ECTS credit points per metric and per category and in total are indicate in blue font. The total ECTS credit points and the required ECTS credit points per category are indicated in black and red font, respectively. The weighted sums, calculated using Equation 1, are indicated in violet font. The total score per metric has a yellow background.

Category	Course orientation **Sum of ECTS per metric**			**total ECTS**	**required ECTS**	Course orientation **Weighted sum of ECTS per metric**		
	Scientific	Professional	General			Scientific	Professional	General
Basic courses	88	5	4	97	97	88	5	4
Excursions	0	3	0	3	3	0	3	0
Electives	0	0	13	13	3	0	0	3
Food science	15	71	6	92	62	9.4	48.8	3.8
BSc thesis	15	0	0	15	15	15	0	0
Total score	**118**	**79**	**23**	**220**	**180**	**112.4**	**56.8**	**10.8**

2.3 Survey among graduates and professionals

In preparation of the planned curriculum reform, the D-HEST/Food Science at ETH Zurich conducted two surveys at the beginning of 2020:

1) Survey among ETH graduates who graduated between 2013 and 2018 about the degree programme Food Science at ETH Zurich and their entry into the labour market (**Appendix Table 11**).
2) Survey among professionals who are members of the SGLWT about Food Science specialists and ETH graduates (**Appendix Table 12**).

The sample size as well as the rate of response and completeness for the surveys are provided in **Table 8**. The response rate among the graduates was just over 50%. In the case of the survey among the professionals, the total number of people reached could not be ascertained, as the

survey was partly sent to e-mail addresses that were inactive in the meantime. Therefore, I was not able to calculate a response rate. Overall, the sample size for both surveys which are indicated for each question in the results section are low and care must be taken when interpreting the results.

Table 8: Participation and completeness of the survey.

Survey among:	**graduates**	**professionals**
Number of questions	27	17
Total responses	103	128
Response rate	52%	n.a.
Complete responses	66	56
Completion rate	64%	44%

The D-HEST/Food Science intended the surveys to elicit the strengths and weaknesses of their degree programmes. In addition, the survey indicates the employability of the graduates and the required competencies in the labour market. The D-HEST/Food Science developed the survey questions based on experience. The survey was conducted on the online platform SurveyMonkey. The D-HEST/Food Science provided the survey data for this curriculum analysis. From the two surveys, I only considered the following questions that are most relevant to answer the research question of this thesis.

Considered questions from the survey among the ETH graduates:

- *Which courses during your study do you find most useful for your job?*
- *What scientific competencies were missing at the beginning of your professional career?*
- *Since your Master's degree, did you follow further educational programmes?*

Considered questions from the survey among professionals in food and nutrition:

- *What are the most typical reasons why you choose a food scientist from ETH Zurich?*
- *What competencies do you expect from a food scientist in general?*
- *What do the candidates from ETH Zurich fulfil well?*
- *What do the candidates from ETH Zurich lack?*

3 Results

3.1 Analysis of institutional factors

Out of the many possible institutional factors (Supe, Zeps, Jurgelāne, & Ribickis, 2008), I have selected those that are relevant for the analysis of the CVC, in particular of its curriculum design phase, and those that are accessible. Furthermore, I have distinguished factors that concern the entire educational institution from those that are relevant at the programme level. The institutional factors at the organisational level are presented in **Table 9** and the factors at the programme level in **Table 10**. The institutional factors that illuminate characteristic differences between the Swiss federal institutes of technology and the universities of applied sciences are listed below.

- **Legislative and strategic orientation**

  Many differences in institutional factors are due to differences in the legislative and strategic orientation of the educational institutions. The HEdA, which came into force in 2015, newly regulates the mechanisms and bodies for the management and coordination of higher education institutions in Switzerland. The Swiss Conference of Higher Education (SHK) is the highest policy body and coordinates the activities of the state and the cantons in the higher education sector. The Conference of Rectors, known as swissuniversities, sets the overarching objectives for the universities, the universities of applied sciences and the universities of teacher education in accordance with the HEdA on behalf of the SHK. Because the state is the responsible body for the federal institutes of technology and based on the ETH Law (SR 414.110), the Federal Council determines the strategic goals for the ETH domain every four years, which the ETH Board and the executive boards of the individual institutions implement.

- **Admission requirements**

  The main admission requirement for Swiss students to the federal institutes of technology is the academic baccalaureate (‘Maturität’), which is acquired through purely academic achievement elements during the upper-secondary level education. In contrast, a key admission requirement to the degree programmes of the universities of applied sciences is a completed vocational education and training and a vocational baccalaureate (‘Berufsmaturität’). Alternatively, students can have completed a general

upper-secondary education with an academic baccalaureate and gained an additional year of work experience in a profession related to the field of study. As a result, students from the federal institutes of technology and the universities of applied sciences differ in their entry competencies. The extent to which this difference is compensated for during the course of studies or even increases depends mainly on the curricula.

- **Education**

  The education at the universities of applied sciences aims at an immediate entry of their students into professional life after graduation. Therefore, the education offered is geared towards mostly the national labour market and an optimal professional career for the students. Teaching is oriented towards practice and professional activities. It often contains a high proportion of practical application.

  Teaching at ETH Zurich is designed to educate professionals in scientific and technical fields. For many degree programmes, the intended professional profile is defined less specifically as it is the case for the UAS. Overall, the Federal Council expects as a strategic goal from the federal institutes of technology an "innovative research-based and competence-oriented education and training of the highest quality" (BBl 2021 1038). Students can exclusively qualify themselves through their own academic work.

- **Research**

  According to the education policy, the universities of applied sciences should conduct application-oriented research that is geared to the needs of the economy and society. In addition, they should provide services in cooperation with business partners or for them. The Confederation has created its own funding instrument, Innosuisse, for the application-oriented promotion of innovation. Innosuisse ensures that the needs of the economy are recognised and supports corresponding research projects.

  The core business of the federal institutes of technology is basic research and the transfer of new knowledge into practice. In principle, basic research should be independent of economic and social interests and serves primarily to expand scientific knowledge. However, the boundaries between basic and applied research are often blurred. In the course of their education, students should make their own research contributions, especially in their Bachelor's and Master's theses. In contrast to the

universities of applied sciences, the federal institutes of technology can educate doctoral students and award the doctorate. The Swiss National Science Foundation (SNSF) promotes basic research in all scientific disciplines on behalf of the federal government.

- **Qualification of professors and lecturers**

  Usually, lecturers at the universities of applied sciences must have a university degree as well as a didactic qualification. Teaching of profession-specific subjects also requires several years of professional experience. Heads of research groups must also demonstrate a research interest and the necessary competencies.

  When recruiting professors, the federal institute of technology usually focus primarily on the academic qualifications of the candidate. In contrast to the universities of applied sciences, no direct reference to practice is usually required. To get the best people in a research field, the federal institute of technology recruit their professors from all over the world.

- **Quality assurance and accreditation**

  The federal institute of technology and universities of applied sciences are obliged to review the quality of their teaching, research, and services, and to ensure long-term quality assurance and development (HFKG Art. 27). The institutions must periodically undergo accreditation in order to use the title 'university' or 'university of applied sciences', to receive federal funding and to accredit degree programmes. The Swiss Accreditation Council is responsible for the accreditation on behalf of the Federal government and the cantons.

  Since the HEdA came into force, however, individual degree programmes no longer have to be accredited individually. This has given educational institutions more freedom in the design of their degree programmes.

Table 9: Institutional factors on the level of the organization.

	Federal Institute of Technology	**Universities of Applied Sciences**		
Institution	**ETH Zurich**	**ZHAW**	**BFH**	**HES-SO**
Organization				
Responsible body	Swiss Confederation	Canton of Zurich	Canton of Bern	Cantons of Jura, Bern, Fribourg, Neuchâtel, Vaud, Geneva and Valais
Strategic management	ETH Board (ETH Rat)	Council (Fachhochschulrat)	Council (Schulrat)	Government Committee (Regierungsausschuss)
Operative management	Executive Board (Schulleitung)	Executive Board (Hochschulleitung)	Executive Board (Fachhochschulleitung)	Rectorate (Rektorat)
Autonomy	High autonomy towards the responsible body	High autonomy towards the responsible body		
Steering instruments	- Performance mandate - Lump-sum credit	- Performance mandate - Lump-sum credit		
Funding				
Funding	1) State 2) Competitively acquired third-party funds 3) Other third-party funds 4) Tuition fees	1) Cantons (intercantonal agreement) 2) State (according to HFKG) 3) Other third-party funding 4) Competitively acquired third-party funds 5) Tuition fees		
Education				
Access after completion upper-secondary level	Baccalaureate	Vocational baccalaureate or academic baccalaureate with professional experience (e.g. internship) (thus professional experience from an apprenticeship or internship is a prerequisite)		
Target group	Persons who strive to a high level of technical and scientific education that will give them access to numerous professional and scientific careers.	Persons who want to specialise further in a technical or industrial profession or who aspire to a management or executive function in a corresponding field.		
Main tasks in education	- Academic orientation in the fields of technical and natural sciences with the aim of developing scientific thinking and intellectual independence. - Development, preservation, and communication of knowledge.	- Application and practice-oriented focus - Preparation for the conception and exercise of clearly defined professional activities		
Degrees awarded	Formal education: Bachelor, Master, Doctorate Informal education: CAS, DAS, MAS	Formal education: Bachelor, Master Informal education: CAS, DAS, MAS		
Research				
Main tasks in research	- Basic and applied sciences - Renewal, broadening and deepening of knowledge - Innovation in science and technology	- Applied sciences - Innovation and development in the respective disciplines - Development of applied technology and problem solving		
Relationship between teaching and research	Direct and concrete connection between teaching and research.	Transfer of research results into teaching. Depending on the institution, research and development may be separate.		

Notes: The content of the table is compiled from the following sources: (SSIC, 2014), (Gyger Gaspoz, 2015), (SKBF, 2018) and (SERI, 2019).

Table 10: Institutional factors on the level of the degree programmes.

Institution	**ETH Zurich**		**ZHAW**		**BFH-HAFL**		**HES-SO‡**
Degree programme	**BSc in Food Science**	**MSc in Food Science**	**BSc in Food Technology**	**MSc in Life Sciences**	**BSc in Food Science**	**MSc in Life Sciences**	**BSc in Life Technologies**
Specialisation	none	4 majors 9 minors	3 options	Specialisation in Food and Beverage Innovation	3 majors 4 minors (optional)	Specialisation in Food, Nutrition and Health	Specialisation in Food Technology
Duration [semester]	6 (full-time)	3 (full-time)	6 (full-time) 8 (part-time)	3 (full-time) 4-7 (part-time)	6 (full-time) 7-10 (part-time)	3 (full-time) 4-6 (part-time)	6 (full-time)
Study effort	180 ECTS	90 ECTS	180 ECTS	90 ECTS	180 ECTS	90 ECTS	180 ECTS
Teaching language	German and partially English in 3rd year	English	German	English	German and French	English	German and French
Tuition fee [per semester]	CHF 730.-	CHF 730.-	CHF 720.–	CHF 720.-	CHF 750.–	CHF 750.–	CHF 500.–
Student body							
Entries per year	60-70	40-50	70-75	12-14	60-65	20-25	n.a.
Tendency	slight decline	n.a.	stable	stable	fluctuating but with slight increase	stable	n.a.
Distribution CH region	n.a.	n.a.	n.a.	75% from German speaking area	evenly with a higher share from the cantons BE, SO, FR	n.a.	n.a.
Proportion of women	high (70%)	high (70%)	balanced (50%)	slightly more women than men	n.a.	high (80%)	n.a.
Proportion of international students	almost none	5-11 students each year	few students from Germany	25% from non-German speaking area	5-10%	60%	n.a.
Faculty							
Academic staff	ca. 200		70-80		42		n.a.
Professors	14 (12 professors and assistant professors, 2 associated professors)		25-30 (persons active in teaching)		13 (persons active in teaching)		n.a.
Curriculum design							
Establishment	established in the 1970s, previously integrated into agricultural sciences		1988	2009	2007	2015	n.a.
Last reform	2003, 2010 and 2016	2006 and 2017	2020	2018 and a few modules in 2021	2014 and 2021	2018	n.a.
Next reform	Start of next curriculum reform in 2021, focus on BSc degree programme		not yet planned	not yet planned	just completed, new curriculum as of autumn semester 2021	Probably in 2 to 3 years from now	planned for 2022

Notes: Information was obtained from the websites of the degree programmes and from the semi-structured interviews.
‡For the Bachelor's programme in Life Technologies at HES-SO, only public-accessible information is shown in the table and used for the analysis of the institutional factors and curricula.

3.2 Analysis of curricula

3.2.1 Formal observations

The depth of a curriculum analysis depends on which documents and sources are consulted (Amundsen, Saroyan, & Donald, 2004; Donald, 1983; Levander & Mikkola, 2009). For this work, I focused on the official publication channels of ZHAW, BFH-HAFL, HES-SO, and ETH Zurich (**Table 3**). However, the course catalogues differ due to the technical implementation and the information content. As previously described (section 2.2.2), I have examined the comprehensiveness of the course descriptions, which reflects the information content to some extent.

The BSc programmes in Food Technology at ZHAW and in Food Science at BFH-HAFL have recently undergone a reform of their curricula (**Table 10**). As a result, some of the descriptions for courses taking place later in the curriculum were not yet available on the online course catalogues. For the BSc programme at BFH-HAFL, I received a preliminary version of the missing course descriptions (approx. 62% of all modules in the programme) from the programme director. Thus, I was able to analyse the entire curriculum. For the BSc programme at ZHAW, I was unable to analyse some of modules taking place in the fifth and sixth semester (approx. 23% of all modules in the programme) because their descriptions were not yet available. Due to the weighting of courses according to the categories, the analysis can nevertheless be considered as representative for the whole degree programme.

I found information on the structure of the degree programmes on the website, in the study regulations, and in the information brochures. The semi-structured interviews with the programme directors verified that I have correctly described the curriculum structures in this thesis. For each degree programme, I have depicted the full-time study, which is the model most often chosen for all degree programmes (information from semi-structured interviews).

I have taken additional information on the recently reformed BSc programme at BFH-HAFL from a publication by Stefan Bürki and Roland Stähli (2021). They describe the historical background and the procedure of the curriculum reform as well as the structure and content of the new curriculum.

3.2.2 Structure of the curricula

3.2.2.1 BSc in Food Science at ETH Zurich

The Bachelor's programme in Food Science at ETH Zurich comprises 180 ECTS and lasts six semesters in full-time study (**Figure 8**). The courses are divided into five categories, whereby more than half of the credits must be completed in the category of basic courses (**Figure 9**). In the first and second semester, the students learn the mathematical and scientific fundamentals. An excursion in the second semester is the only subject related to food science. In the third and fourth semesters, the basic courses still dominate, but the students have a few food science courses and a laboratory course. In the fifth and sixth semester, students choose from general food science courses. At the end, they write a Bachelor's thesis worth 15 ECTS.

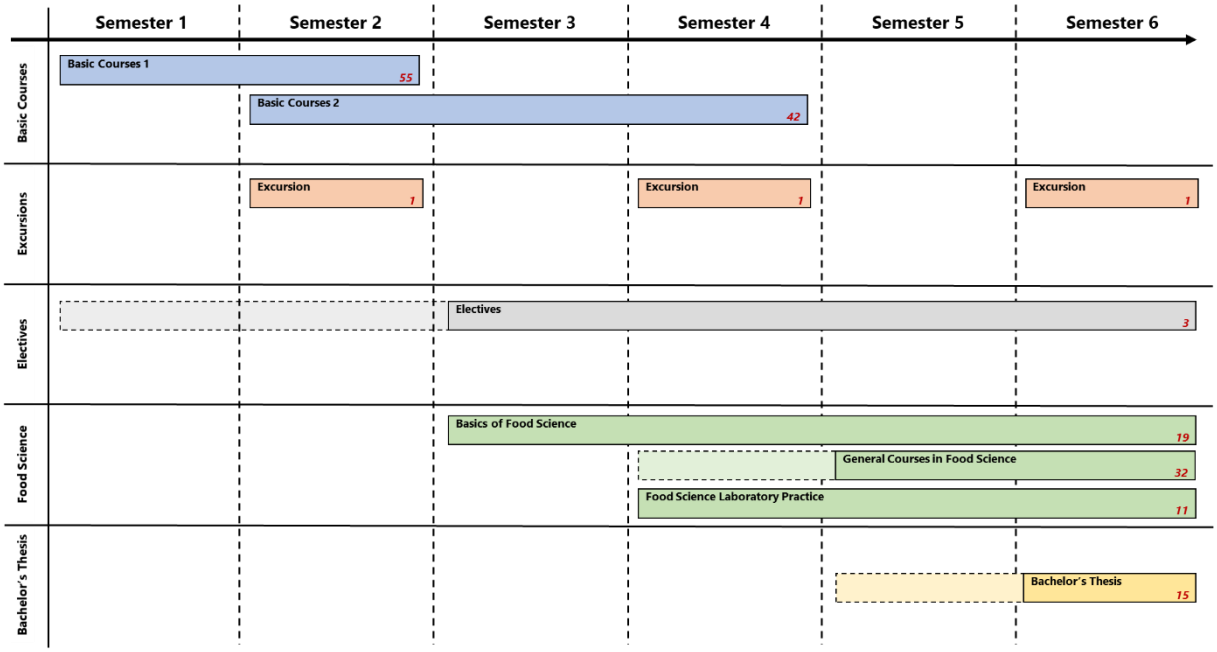

Figure 8: The structure of the BSc degree programme in Food Science at ETH Zurich. The ECTS credits of the course blocks are indicated in red italics. The dashed boxes indicate that courses from these categories can be selected earlier. The categories define 180 ECTS credits of the 180 ECTS credits required for the degree.

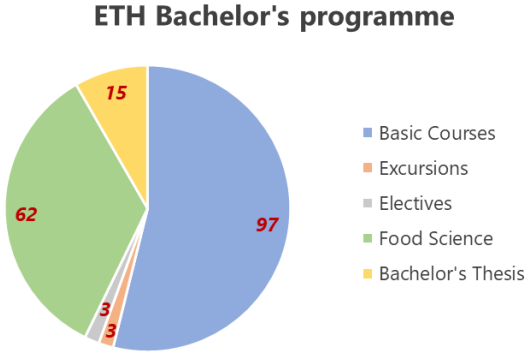

Figure 9: Categories of the BSc degree programme at ETH Zurich. The proportions are given in ECTS. The categories define 180 ECTS credits of the 180 ECTS credits required for the degree.

3.2.2.2 BSc in Food Technology at ZHAW

The Bachelor's programme in Food Technology at the ZHAW comprises 180 ECTS and is designed for full-time study over six semesters (**Figure 10**). The modules are divided into four categories (**Figure 11**). In the first year, the modules are set and deal with the scientific and technical fundamentals as well as with the basics of food production. For the second and third years, students choose one of the following specialisations: 1) Food Management and Sustainability, 2) Food Processing and Automation, or 3) Food Safety and Quality. They can also take modules from the elective area. In the third year, students perform a semester project and write a Bachelor's thesis worth 20 ECTS.

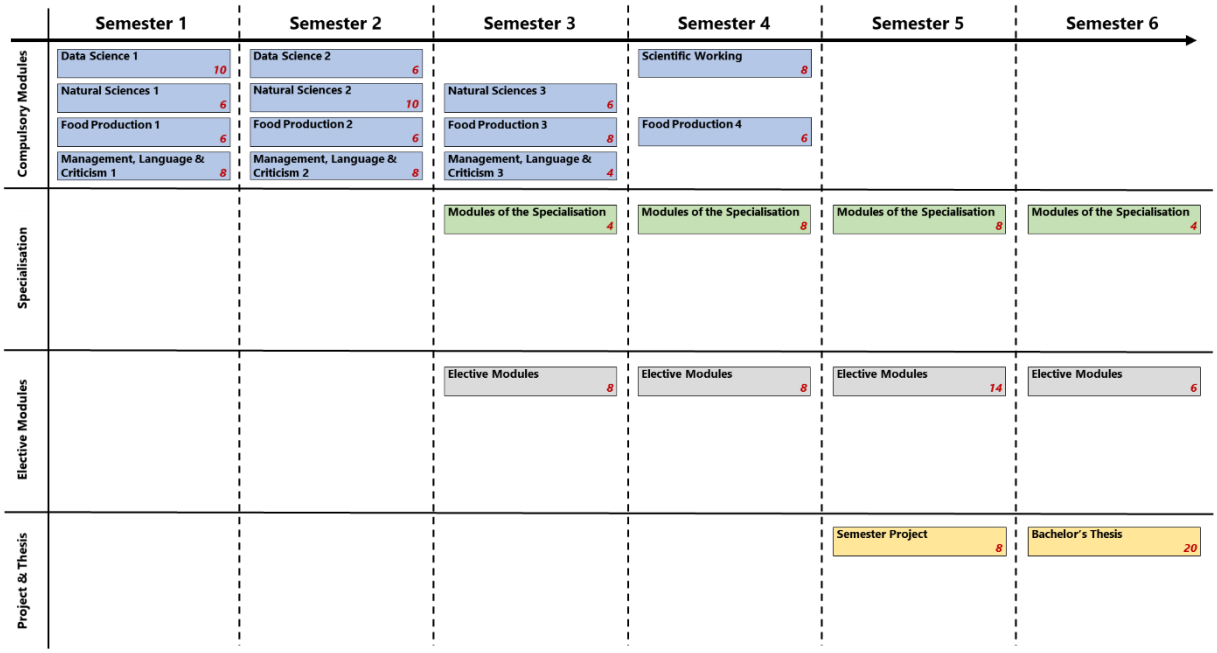

Figure 10: The structure of the BSc degree programme in Food Technology at ZHAW. The ECTS credits of the modules are indicated in red italics. The categories define 180 ECTS credits of the 180 ECTS credits required for the degree.

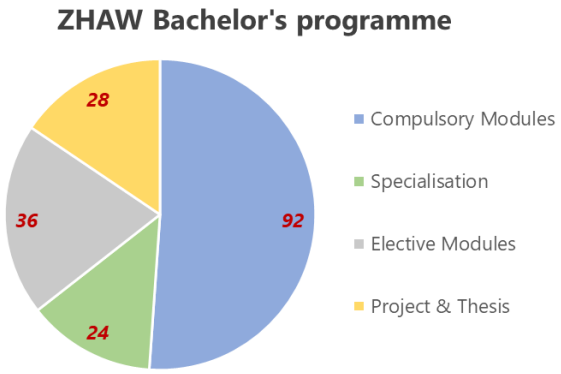

Figure 11: Categories of the BSc degree programme at ZHAW. The proportions are given in ECTS. The categories define 180 ECTS credits of the 180 ECTS credits required for the degree.

3.2.2.3 BSc in Food Science at BFH-HAFL

The Bachelor's programme in Food Science at BFH-HAFL comprises 180 ECTS and takes six semesters in full-time study (**Figure 12**). The modules are grouped into four categories (**Figure 13**). In the first year, the courses are set and deal with the scientific and technical fundamentals, which are often applied to issues from food science. For the second and third year, students select one of the following specialisations: 1) Technology, 2) Food Business, or 3) Consumer Science and Marketing. In addition, they choose elective modules. Overall, the students complete two semester projects and a Bachelor's thesis worth 14 ECTS.

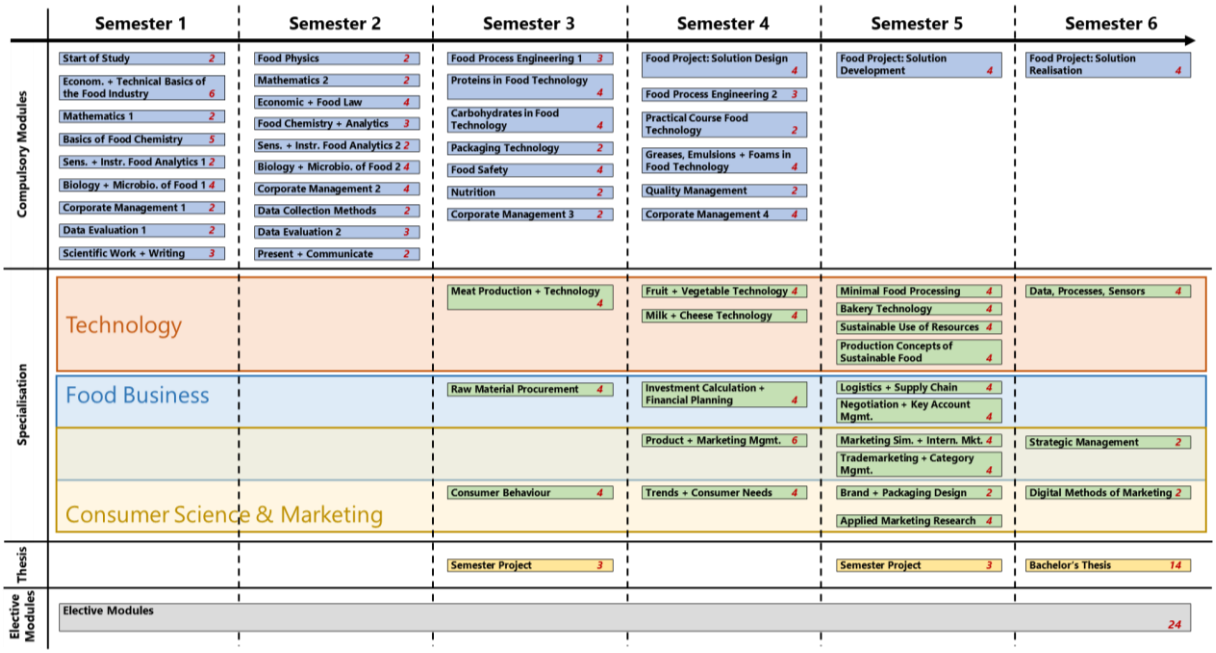

Figure 12: The structure of the BSc degree programme in Food Science at BFH-HAFL. The ECTS credits of the modules are indicated in red italics. The categories define 180 ECTS credits of the 180 ECTS credits required for the degree. The three specialisations (Technology, Food Business, Consumer Science & Marketing) are shown as boxes and enclose the corresponding modules.

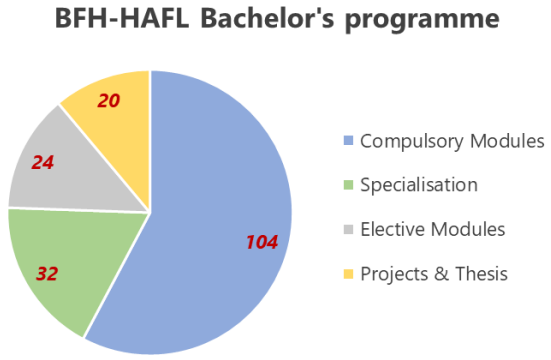

Figure 13: Categories of the BSc degree programme at BFH-HAFL. The proportions are given in ECTS. The categories define 180 ECTS credits of the 180 ECTS credits required for the degree.

3.2.2.4 BSc in Life Technologies with Specialisation in Food Technology at HES-SO

The Bachelor's programme in Life Technologies with the specialisation in Food Technology at the HES-SO Valais comprises 180 ECTS and is designed for full-time study over six semesters (**Figure 14**). All courses are predefined and arranged in five categories (**Figure 15**). In the first year, students learn the basics of mathematics, informatics, and natural sciences. In addition, they train their practical skills in laboratory courses. From the second year onwards, students have subjects from the food technology category. Students complete the programme with a Bachelor's thesis worth 18 ECTS. The degree programme is currently under revision. The new curriculum will be introduced in the autumn semester of 2022. In this study, the curriculum from the academic year 2020-2021 is analysed and presented.

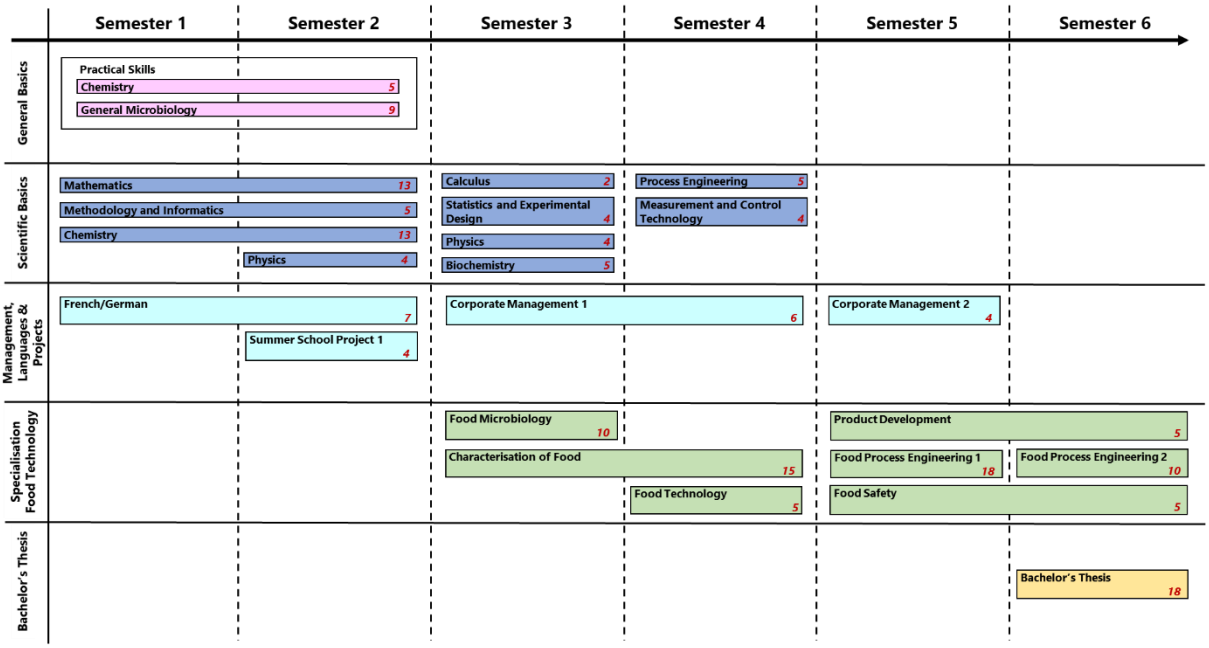

Figure 14: The structure of the BSc degree programme in Life Technology with the specialization in Food Technology at HES-SO Valais. The ECTS credits of the modules are indicated in red italics. The categories define 180 ECTS credits of the 180 ECTS credits required for the degree.

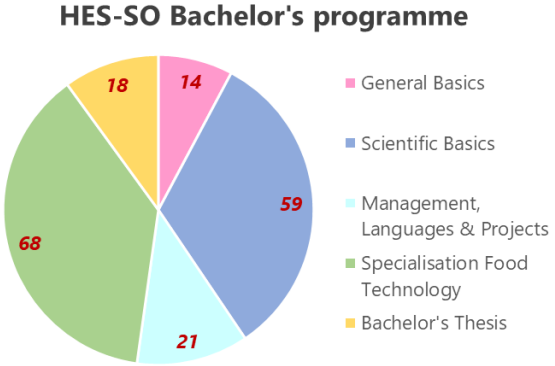

Figure 15: The module categories of the Bachelor's programme at HES-SO. The proportions are given in ECTS. The categories define 180 ECTS credits of the 180 ECTS credits required for the degree.

3.2.2.5 MSc in Food Science at ETH Zurich

The Master's programme in Food Science at ETH Zurich comprises 90 ECTS and usually lasts three semesters (**Figure 16**). Students select a major comprising 40 ECTS and a minor of 10 ECTS (**Figure 17**). Optionally, students choose a second minor or elective courses worth 10 ECTS in total. The degree programme is completed with a Master's thesis worth 30 ECTS. As a voluntary option, students can complete a professional internship, which, if the conditions have been fulfilled, is recognised with a certificate.

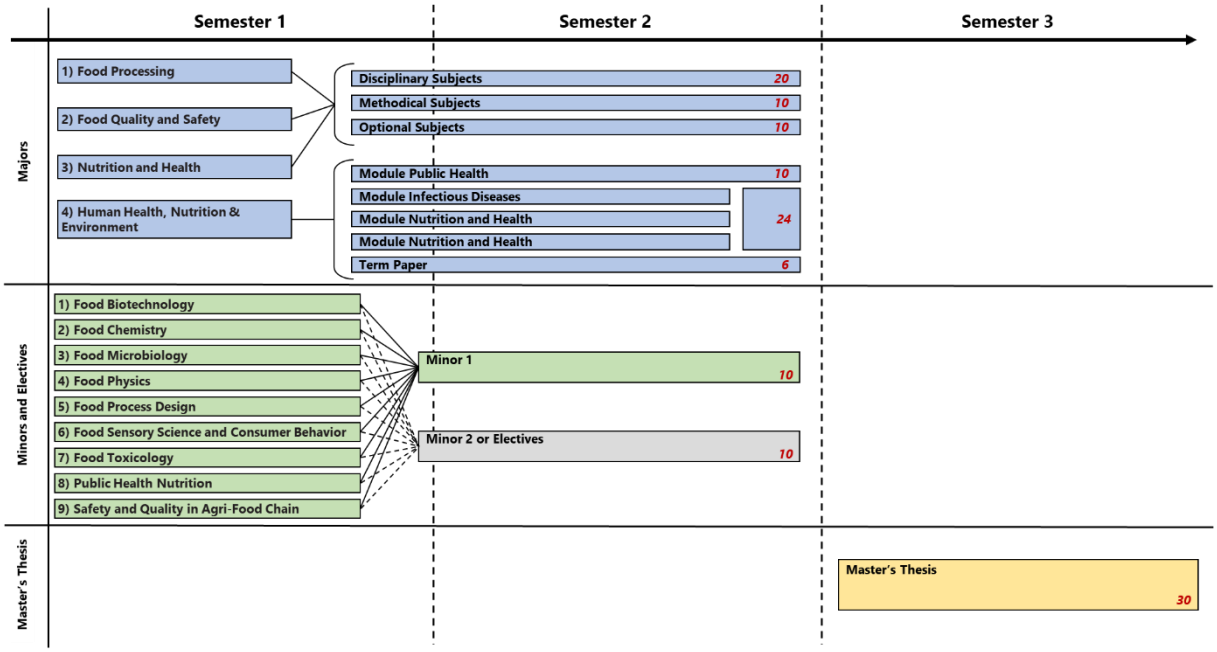

Figure 16: The structure of the MSc degree programme in Food Science at ETH Zurich. The ECTS credits of the courses are indicated in red italics. The categories define 90 ECTS credits of the 90 ECTS credits required for the degree.

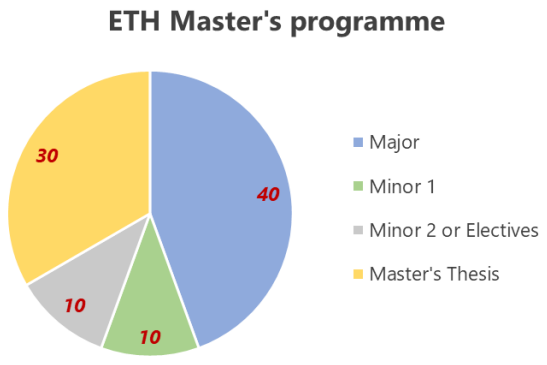

Figure 17: The course categories of the Master's programme at ETH Zurich. The proportions are given in ECTS. The categories define 90 ECTS credits of the 90 ECTS credits required for the degree.

3.2.2.6 MSc in Life Sciences with Specialisation in Food and Beverage Innovation at ZHAW

The Master's programme in Life Sciences with a specialisation in Food and Beverage Innovation at the ZHAW comprises 90 ECTS and takes three semesters in full-time study (**Figure 18**). The modules are divided into three areas of competence: 1) core competencies modules, 2) specialisation modules, and 3) cluster-specific modules. Students must achieve a minimum of ECTS from all three areas (**Figure 19**). The core competencies and cluster-specific modules are offered in collaboration with BFH and HES-SO, while the specialisation modules are taught only at ZHAW. The Master's thesis, which comprises 40 ECTS, is a central element of the curriculum. The topic of the Master's thesis is selected at the beginning of the programme.

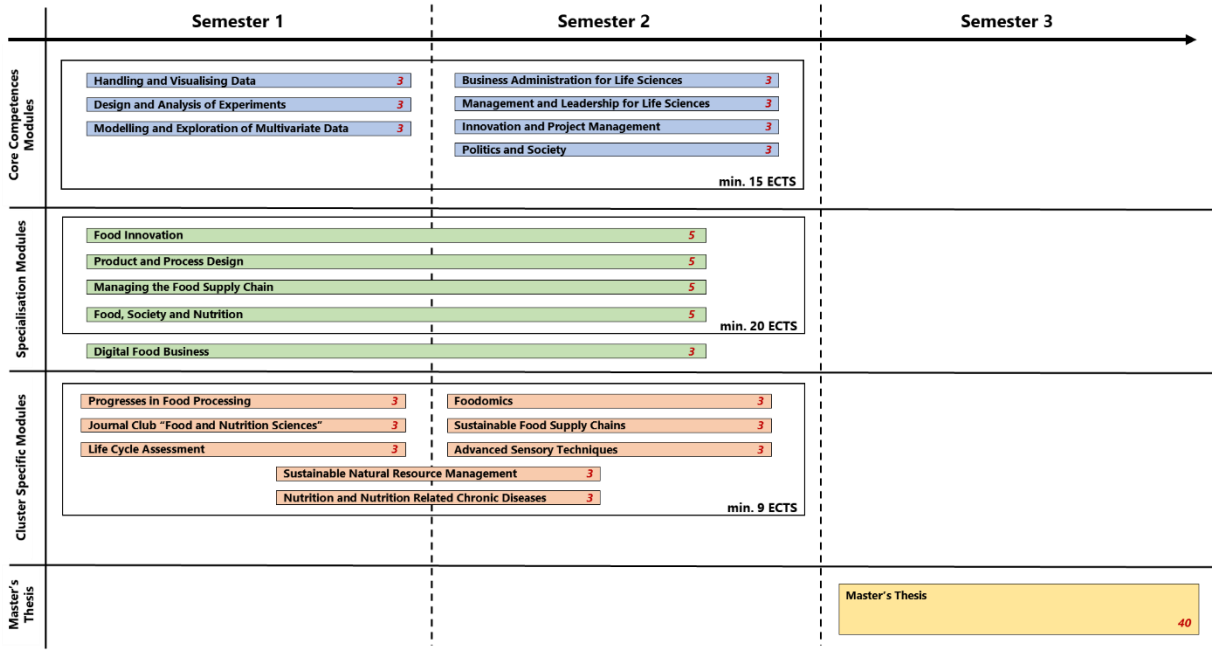

Figure 18: The structure of the MSc degree programme in Life Sciences with specialization in Food and Beverage Innovation at ZHAW. The ECTS credits of the modules are indicated in red italics. The categories define 84 ECTS credits of the 90 ECTS credits required for the degree.

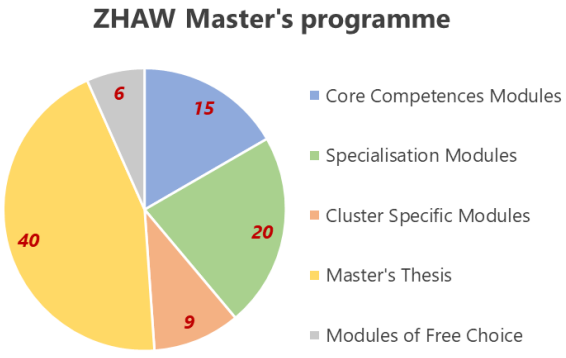

Figure 19: The course categories of the Master's programme at ZHAW. The proportions are given in ECTS. The categories, including the elective courses (fee choice), define 90 ECTS credits of the 90 ECTS credits required for the degree.

3.2.2.7 MSc in Life Sciences with Specialisation in Food, Nutrition and Health at BFH-HAFL

The Master's programme in Life Sciences with a specialisation in Food, Nutrition and Health at BFH-HAFL comprises 90 ECTS and takes three semesters in full-time study (**Figure 20**). The programme is assembled in modules, which are allocated to three areas of competence (**Figure 21**): 1) core competencies, 2) specialisation, and 3) cluster-specific modules. Students must achieve a minimum of ECTS from all areas. The core competencies and the cluster-specific modules are offered in cooperation with ZHAW and HES-SO, while the specialisation modules are only taught at BFH-HAFL. The Master's thesis comprises 30 ECTS and can be completed either at a research group of the UAS or with an external research or industry partner.

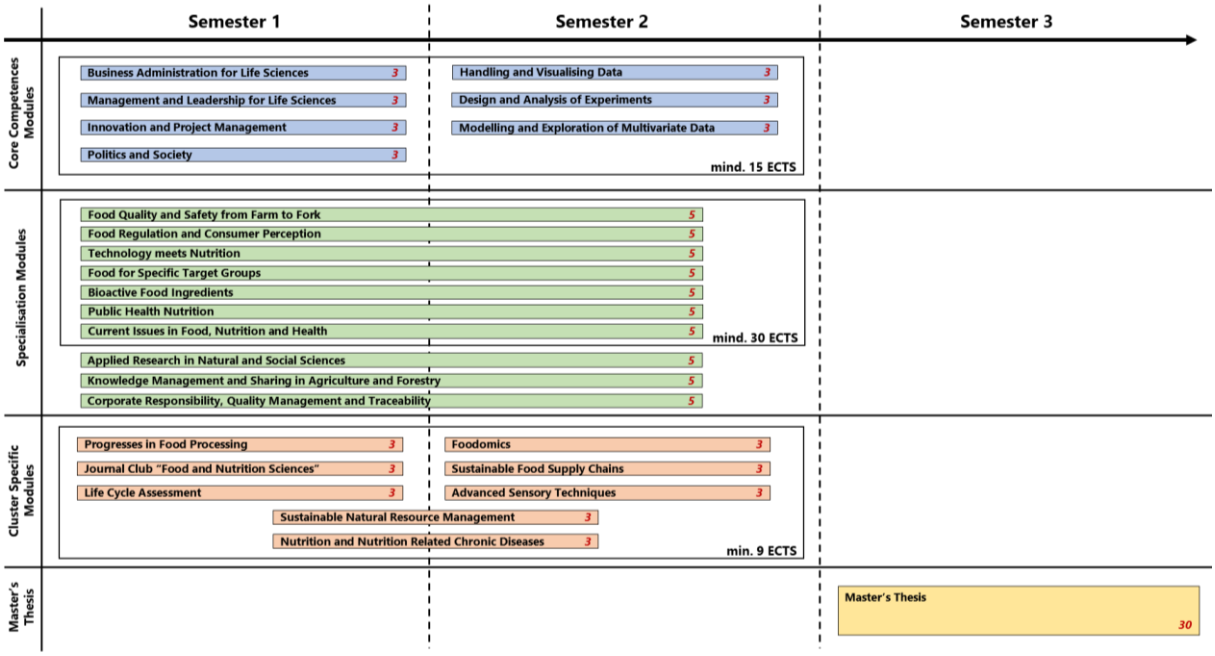

Figure 20: The structure of the MSc degree programme in Life Sciences with specialization in Food, Nutrition and Health at BFH-HAFL. The ECTS credits of the modules are indicated in red italics. The categories define 84 ECTS credits of the 90 ECTS credits required for the degree.

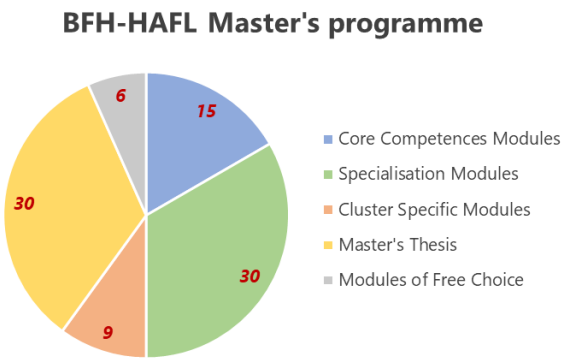

Figure 21: The course categories of the Master's programme at BFH-HAFL. The proportions are given in ECTS. The categories, including the elective courses (fee choice), define 90 ECTS credits of the 90 ECTS credits required for the degree.

3.2.3 Content of the curricula

3.2.3.1 Comprehensiveness of the course descriptions

The comprehensiveness study of the course descriptions shows that more than half of the descriptions in all degree programmes, except for the BSc programme at HES-SO, are explicit (**Figure 22**). The tendency of an implicit formulation is higher when the description is brief. For both, the BSc and MSc programmes, the proportion of brief and implicit descriptions is higher at ETH Zurich in comparison to ZHAW and BFH-HAFL. Considering these universities of applied sciences, the share of implicit formulations is slightly smaller in their Master's programmes than in their Bachelor's programmes, which can be explained by the design of the course description. Because the Master's programmes in Life Sciences are offered by the universities of applied sciences in cooperation, they use the same detailed design for the course descriptions. At HES-SO, most courses are described only with keywords and without an explicit declaration of the course content.

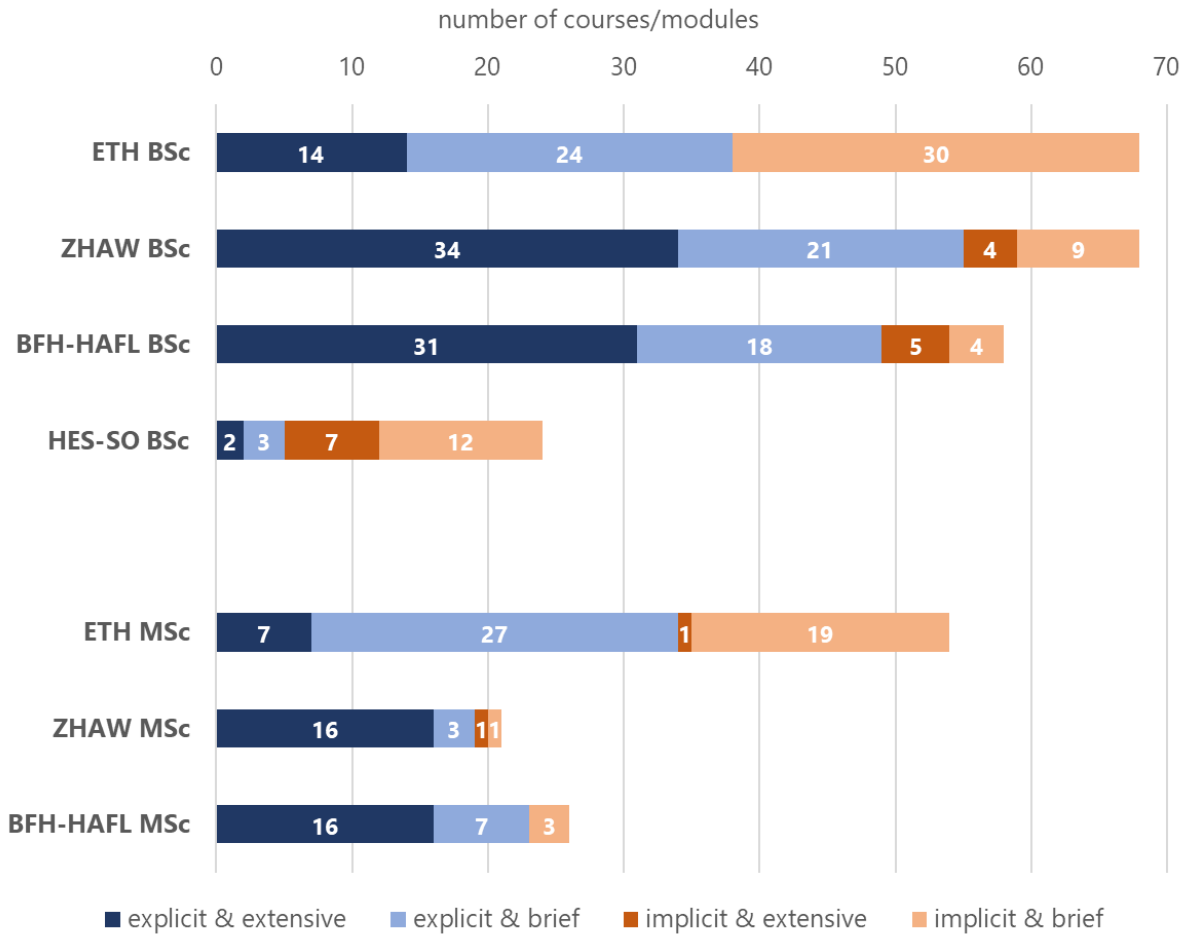

Figure 22: Comprehensiveness of the course descriptions. The courses are assigned according to their descriptions to one out of four groups. Each compulsory or elective course offered in an analysed category was counted once.

3.2.3.2 Course subjects

When comparing the Bachelor's degree programmes, it is evident that the proportion of subjects in food science is similar at ETH Zurich and the universities of applied sciences (**Figure 23**). The programmes differ in the share of basic science and additional subjects. At ETH Zurich, the basic science subjects make up more than half of the study programme. The BSc programme at HES-SO has a similarly high proportion. The degree programmes at ZHAW and BFH-HAFL have fewer basic science subjects but more additional subjects.

The subjects in food science dominate all Master's degree programmes (**Figure 23**). Interestingly, ETH Zurich even has the highest share of those. As with the Bachelor's programmes, the share of additional subjects and subjects that students can choose freely is higher at the universities of applied sciences then at the ETH Zurich.

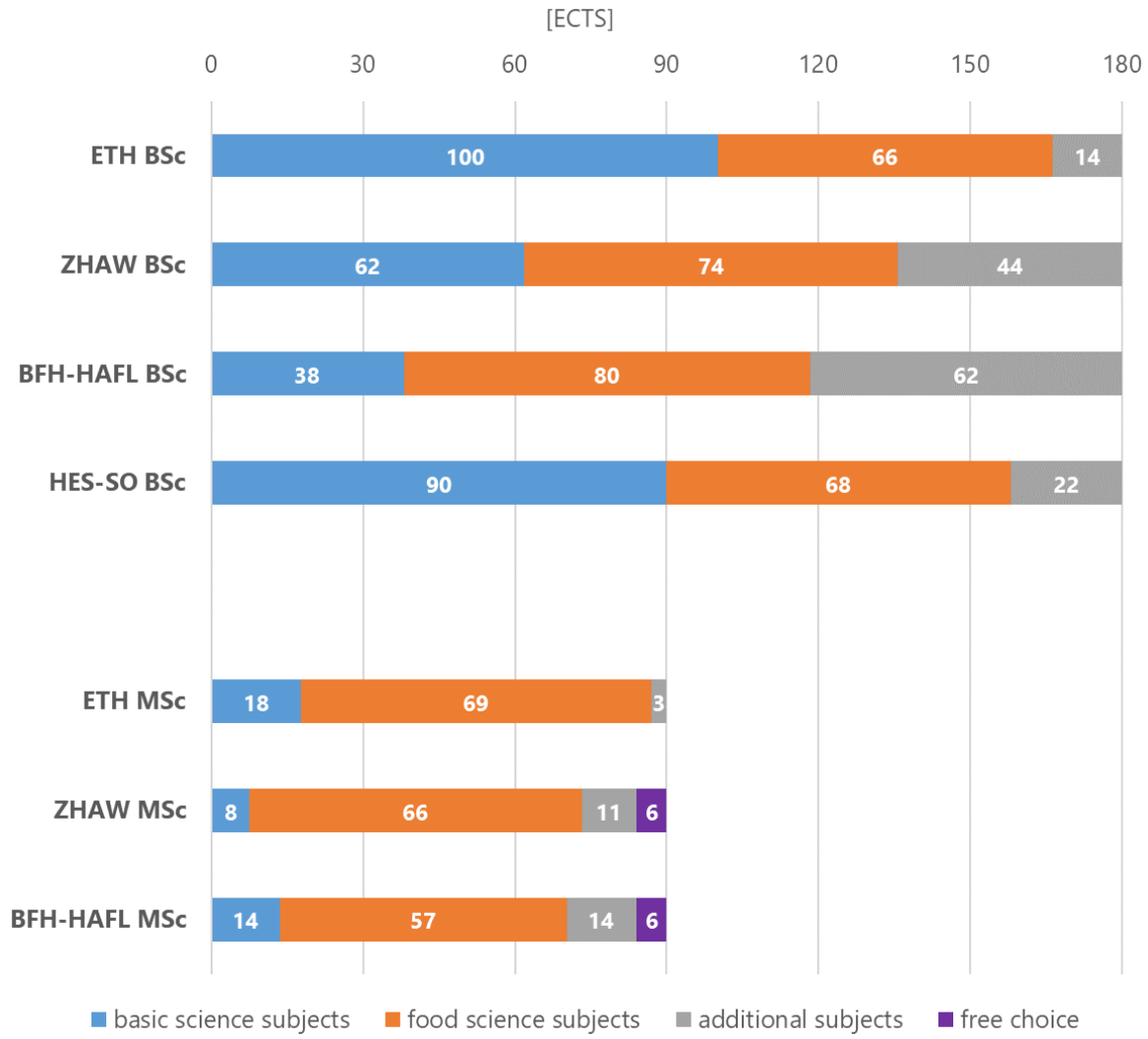

Figure 23: Course subjects. The courses are assigned according to their descriptions to basic science, food science, or additional subjects. Subjects to be freely chosen by the students are grouped in 'free choice'.

3.2.3.3 Focus of the courses

Regarding the focus of the courses, whether theoretical knowledge, practical skills, or a combination of both are taught, there is a clear difference between ETH Zurich and the universities of applied sciences (**Figure 24**). In the Bachelor's and Master's programmes at ETH, almost half of the courses teach theoretical knowledge without direct training of any practical application. This striking contrast is because the courses at ETH are still divided into lectures, exercises, and practical courses, among others. On the other hand, the universities of applied sciences organize their curricula in modules that allow for a much more flexible design. Theory and practice are frequently mixed in the modules. Among all degree programmes, there are only a few courses in which students acquire exclusively practical skills.

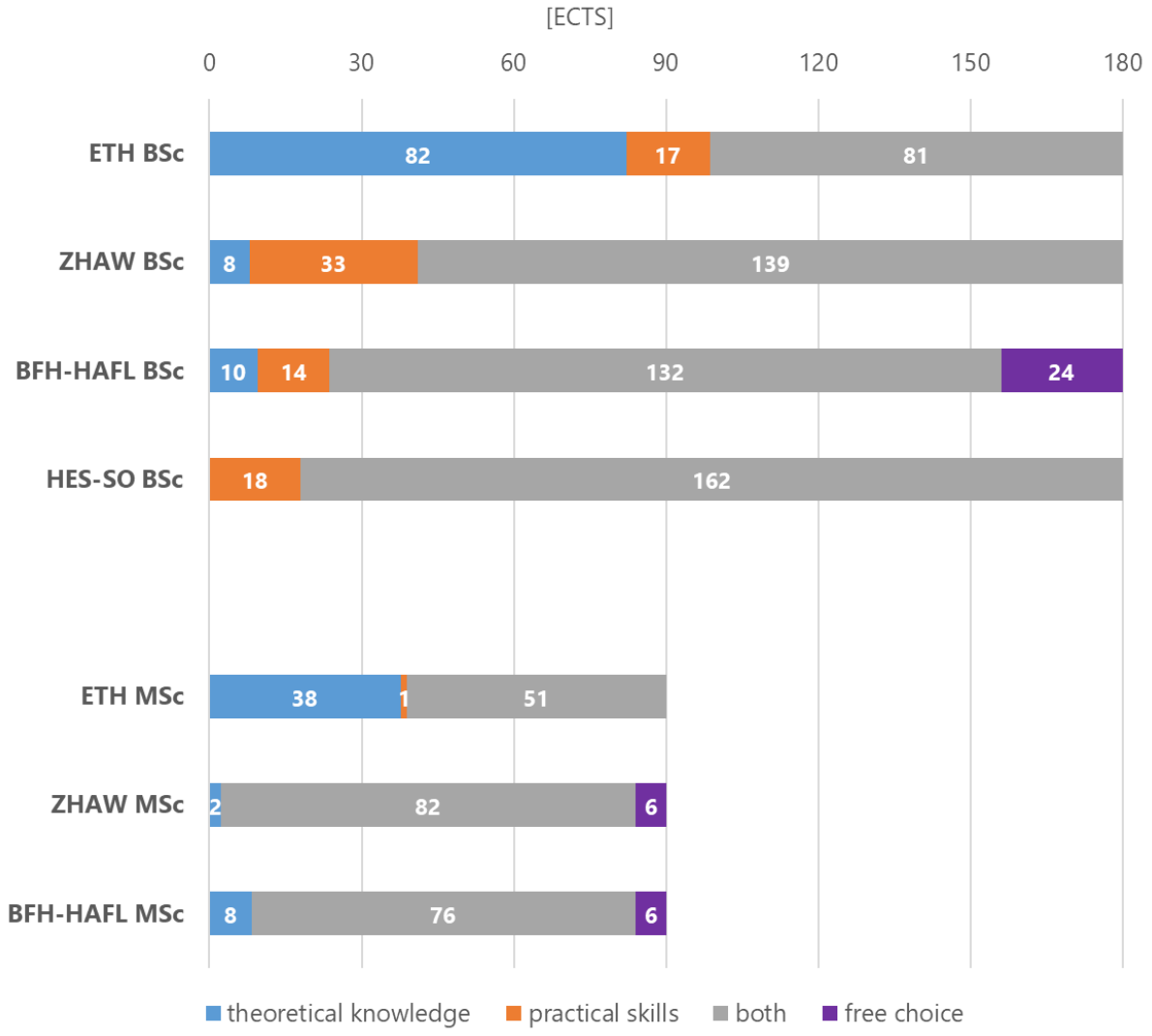

Figure 24: Focus of the courses. The classification of the courses is based on whether the courses teach mainly theoretical knowledge or practical skills or a combination of the two. Subjects to be freely chosen by the students are grouped in 'free choice'.

3.2.3.4 Course orientation

The curricula of the BSc programmes at ZHAW and BFH-HAFL, around half of the courses, are oriented towards a professional application (**Figure 25**). A quarter of the curriculum consists of courses with an orientation towards scientific activity and general knowledge. Surprisingly, the HES-SO deviates from this pattern. There, courses with a scientific orientation make up about half of the curriculum and those with a professional application make up one third. Only the curriculum of the BSc programme at ETH shows an even higher share, about 60%, of courses with a scientific orientation. Courses with a professional orientation make up 30%.

A similar pattern emerges for all Master's programmes (**Figure 25**). The share of curricula with a scientific orientation is that high because I counted the Master's as well as the Bachelor's theses among the courses with a scientific orientation. Of course, students frequently examine topics with a practical relevance in their thesis, which has a scientific framework.

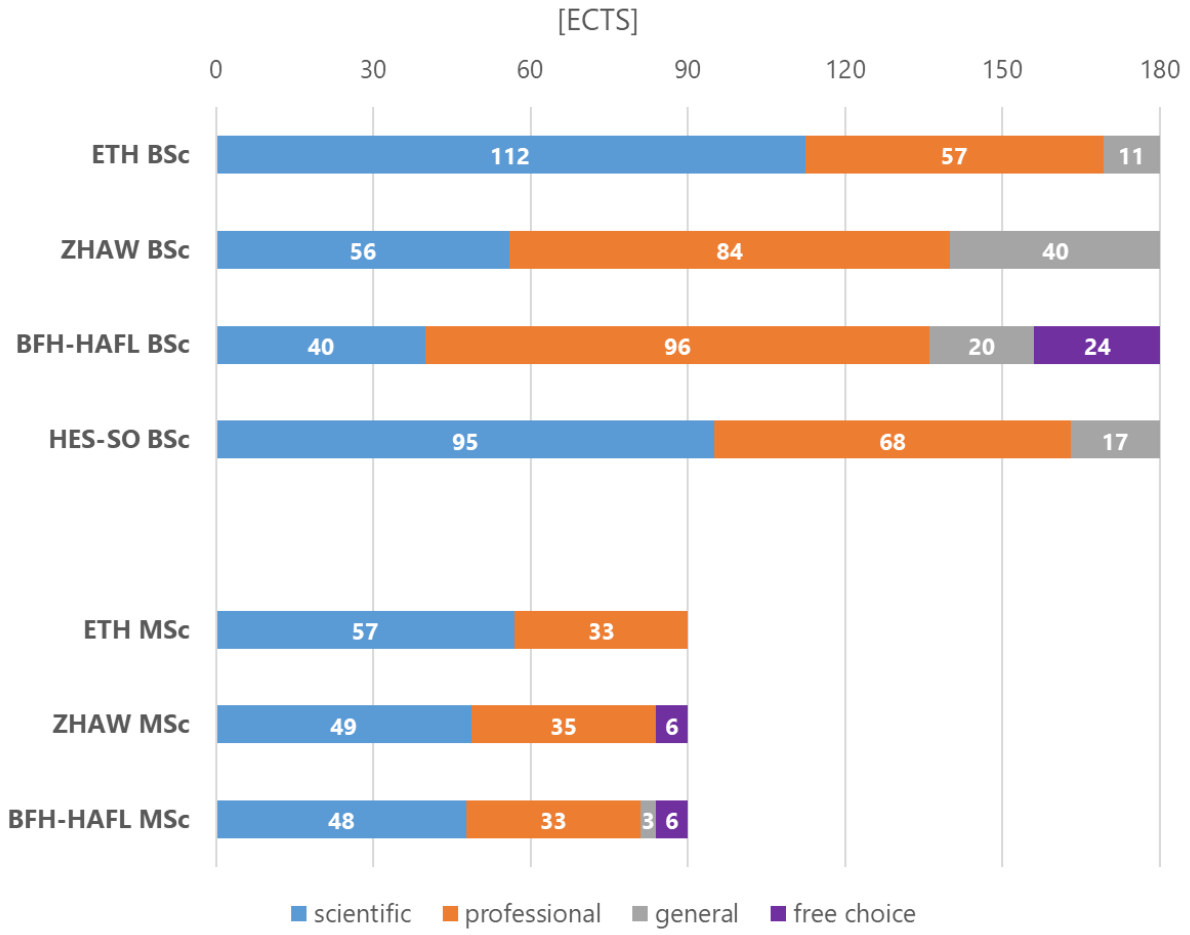

Figure 25: Course orientation. The classification of the courses is based on their orientation towards a scientific, a professional application, or a general content. Subjects to be freely chosen by the students are grouped in 'free choice'.

3.2.3.5 Competencies

While the curricula at ZHAW and BFH-HAFL teach a balance of competencies, the curricula at ETH and HES-SO are clearly dominated by subject-specific competencies (**Figure 26**). In the BSc curriculum at ETH, the share of subject- and method-specific competencies is over 90% while social and personal competencies account for less than 10%. The pattern is similar, but less drastic, for the BSc curriculum at HES-SO. In the BSc curriculum at ZHAW and BFH-HAFL, the subject- and method-specific competencies together account for around 60%, while social and personal competencies account for around 40%.

In the MSc curriculum at ZHAW and BFH-HAFL, the share of personal competencies increases at the expense of subject-specific competencies (**Figure 26**). The shares of method-specific and social competencies are similar to the BSc curricula. In the MSc curriculum at ETH, the shares of social and personal competencies are only slightly higher than in the BSc curriculum. The shares have shifted slightly from subject- to method-specific competencies.

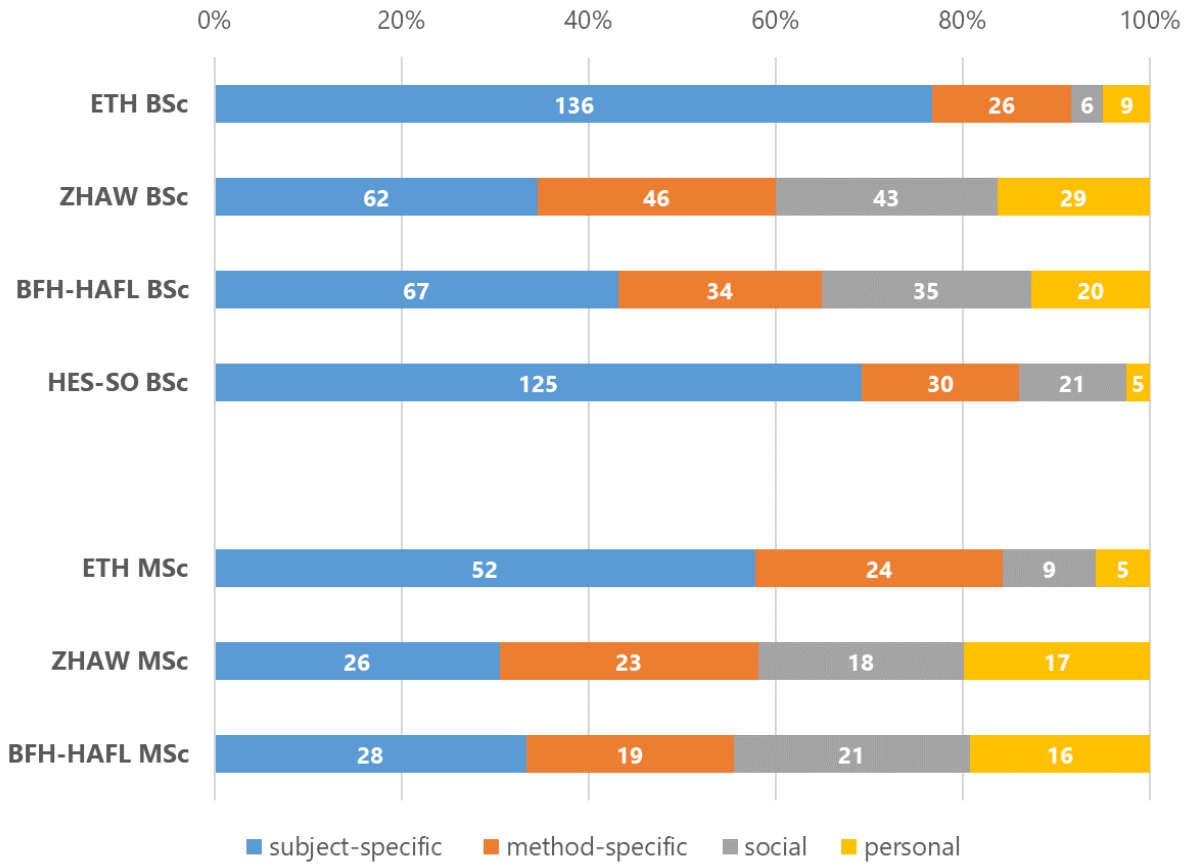

Figure 26: Competencies. The course descriptions were used to determine the competencies taught in a course. The competencies were assigned to one of the four competence domains (subject-specific, method-specific, social, or personal competencies). A course can train competencies from multiple domains. The graph shows the shares of the four competence domains in the total ECTS.

3.2.3.6 Type of performance assessment

In the BSc curriculum at ETH, more than half of the student performance, as measured in ECTS, is assessed by written exams (**Figure 27**). Students take some exams on the computer (online). The share of semester performances without grading is around 13%. In the Master's programme, there is an increase in graded semester work instead of written exams (share increases from about 7% in the BSc to 25% in the MSc). At the UAS, students mainly carry out performance assessments, graded or ungraded, during the semester. Lecturers frequently use a combination of different types of performance assessment to check the students' learning success. For example, students work on a project in a group during the semester and take an examination at the end. In the Master's programme, there are hardly any subjects without grading. The Master's thesis (written work) plays a major role in the Master's programmes. In all programmes, oral exams are rarely conducted. Due to missing information in the course catalogue, the types of performance assessment at HES-SO were not evaluated.

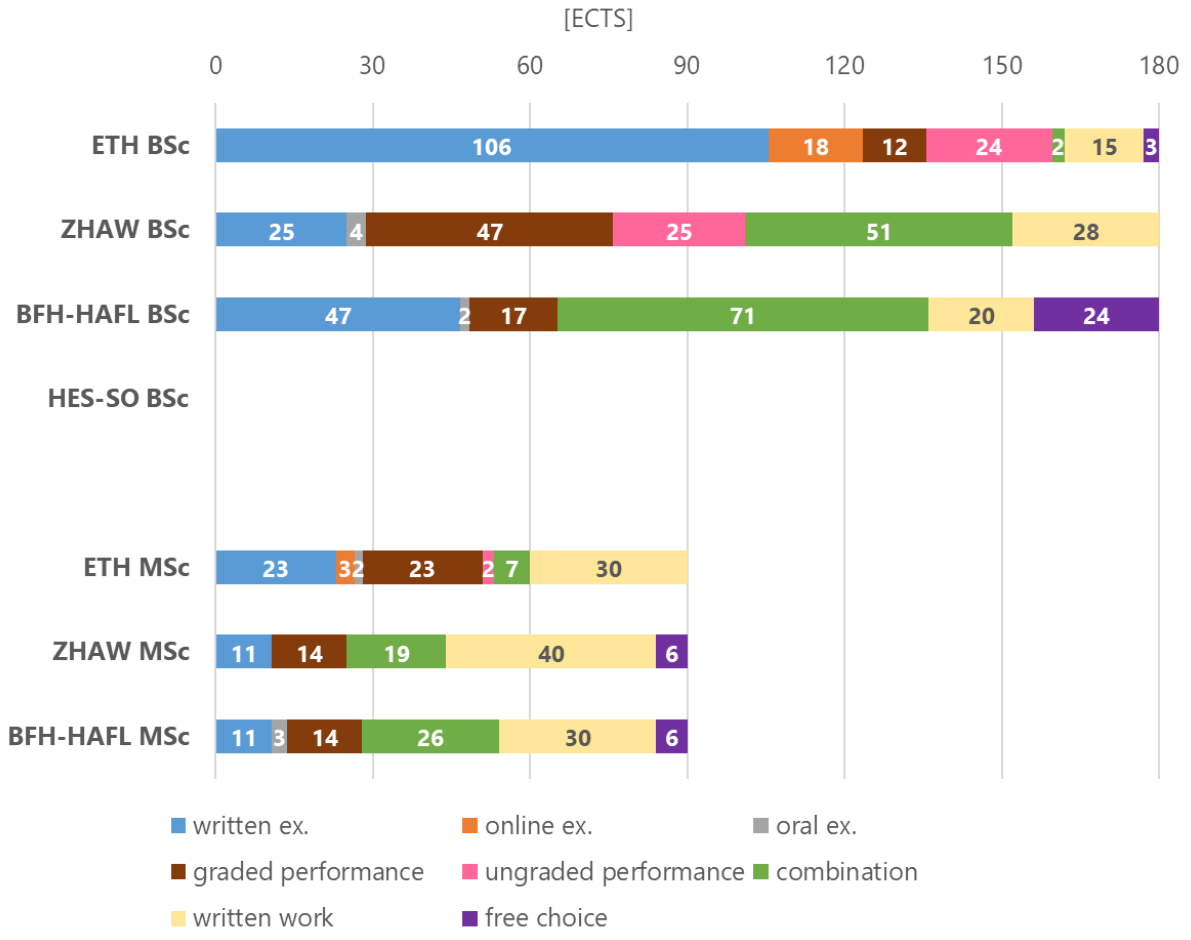

Figure 27: Type of performance assessment. Based on the course description, the performance assessments were categorised. The performance assessments are weighted according to ECTS.

3.3 Survey among graduates and professionals

3.3.1 Results of the survey among graduates

In this section, I only present the results from the survey among the ETH graduates that are relevant to solve the research question of this thesis (see section 1.1.2).

► *Which courses during your study do you find most useful for your job?*

Based on the survey results (**Figure 28**), the courses can be divided into three groups: 1) courses with high approval (> 50%), 2) courses with medium approval (30-50%), and 3) courses with low approval (< 30%). Group 1 (high approval) contains courses typical for food science. In addition, and this should be particularly noted, it also contains the practical courses. Group 2 (medium approval) includes further food science courses as well as the excursions and the general courses, which are not further specified. Group 3 (low approval) consist of a few food science courses, the course in economics, the colloquium and seminars, and the option for other courses. The reasons why the courses were considered as useful by the graduates were not asked. It is possible that positive or negative memories of a course influenced the selection. Further, it is unknown if the graduates have attended all the courses listed.

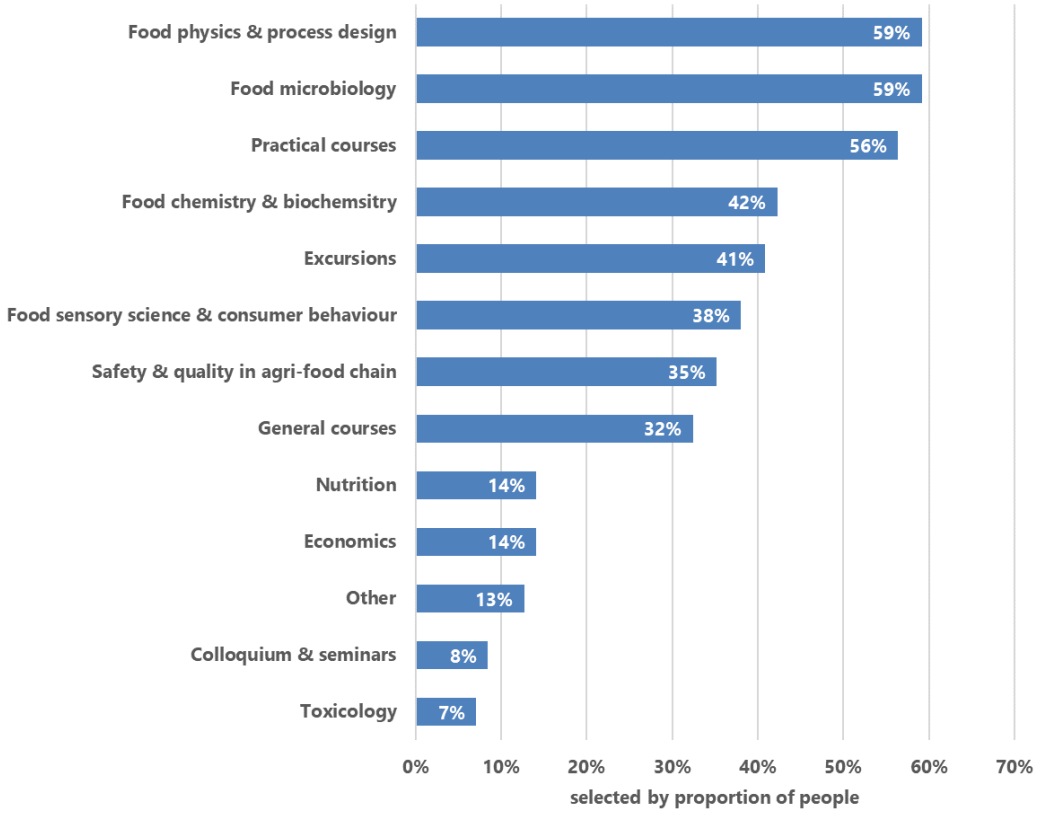

Figure 28: Which courses during your study do you find most useful for your job? Each respondent could choose multiple answers out of a predefined selection of courses. The question was answered by 71 graduates (N=71).

► *What scientific competencies were missing at the beginning of your professional career?*

Project management is the dominant answer to the question about the missing competencies (**Figure 29**). Three out of four graduates have lacked this competence when they started their professional career. Lack of competence in communication ranks second being select by every third graduate. Here, however, the survey lacks to specify further which competence in relation to communication are meant exactly. On the one hand, the respondents could have referred to communication in terms of the ability to express oneself in several languages or to the ability to converse correctly about scientific and/or technical issues. Only a few graduates have missed competencies in presenting, reporting, and writing when they started their professional career.

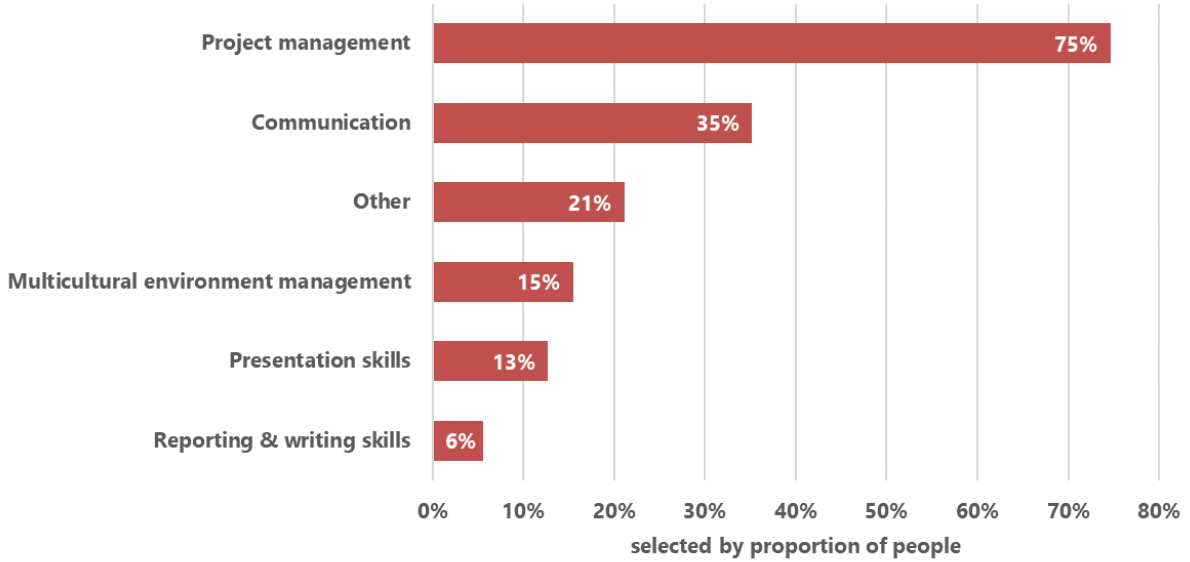

Figure 29: What scientific competencies were missing at the beginning of your professional career? Each respondent could choose a maximum of two options from a given set of options. The question was answered by 71 graduates (N=71).

► *Since your Master's degree, did you follow further educational programme?*

Almost half of the respondents, all of whom graduated no more than five years ago, have already completed or are in the process of completing continuing education (**Figure 30**). According to the results, most of the respondents are pursuing further education in the field of management (14% of all respondents) or have opted for a Certificate (CAS), a Diploma (DAS), or a Master of Advanced Studies (MAS) (11% of all respondents). A slightly smaller proportion opted for a doctorate/PhD (8% of all respondents). Around 6% of all respondents do a didactic certificate. Only few people continue their education in the field of food science (2% of all

respondents) or in the field of information and communication technology (ICT) (1% of all respondents).

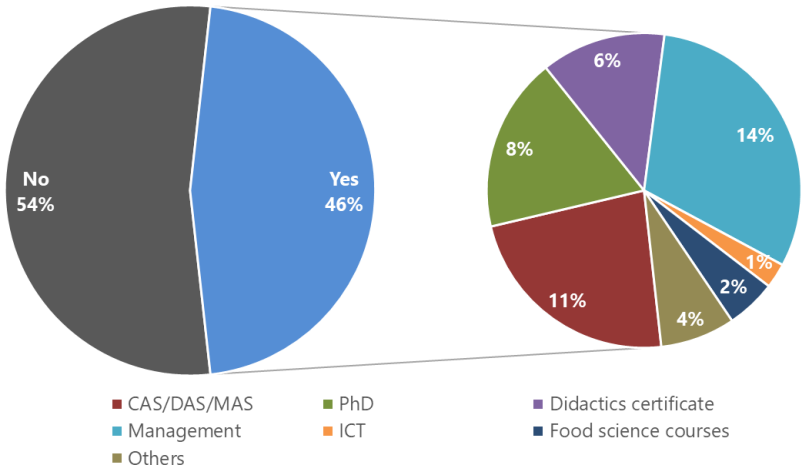

Figure 30: Since your Master's degree, did you follow further educational programme? If the question was answered in the affirmative, people should indicate the type of educational programme. The question was answered by 71 graduates (N=71).

3.3.2 Results of the survey among professionals

In this section, I only present those results from the survey among the professionals that are relevant to answer the research question of this thesis (see section 1.1.2).

► *What are the most typical reasons for you to choose a food scientist from ETH Zurich?*

There are two main reasons why professionals hire ETH graduates in the field of food science (**Figure 31**): first, their technical knowledge and second, their high level of education. Both reasons were selected by over 60% of all people surveyed. Technical knowledge is assigned to the subject-specific competencies. In principle, the level of education is neutral and encompass without further declaration competencies of all domains. However, people often refer to the subject- and method-specific knowledge of ETH graduates, which is also shown by the results of this survey.

As an additional strong reason to hire an ETH graduate, half of all professionals surveyed named the ability to work independently. Many professional (40%) hire ETH graduates because they are well prepared for a job and fit well to the open position. The good reputation of ETH Zurich is still a strong argument for hiring a person with an ETH degree, at least for 38% of the people surveyed. ETH graduates are less convincing because of their self-confidence and

proactivity. Hardly any reasons for employment are leadership skills and entrepreneurial thinking, which were mentioned by only 10% and 8% of respondents, respectively.

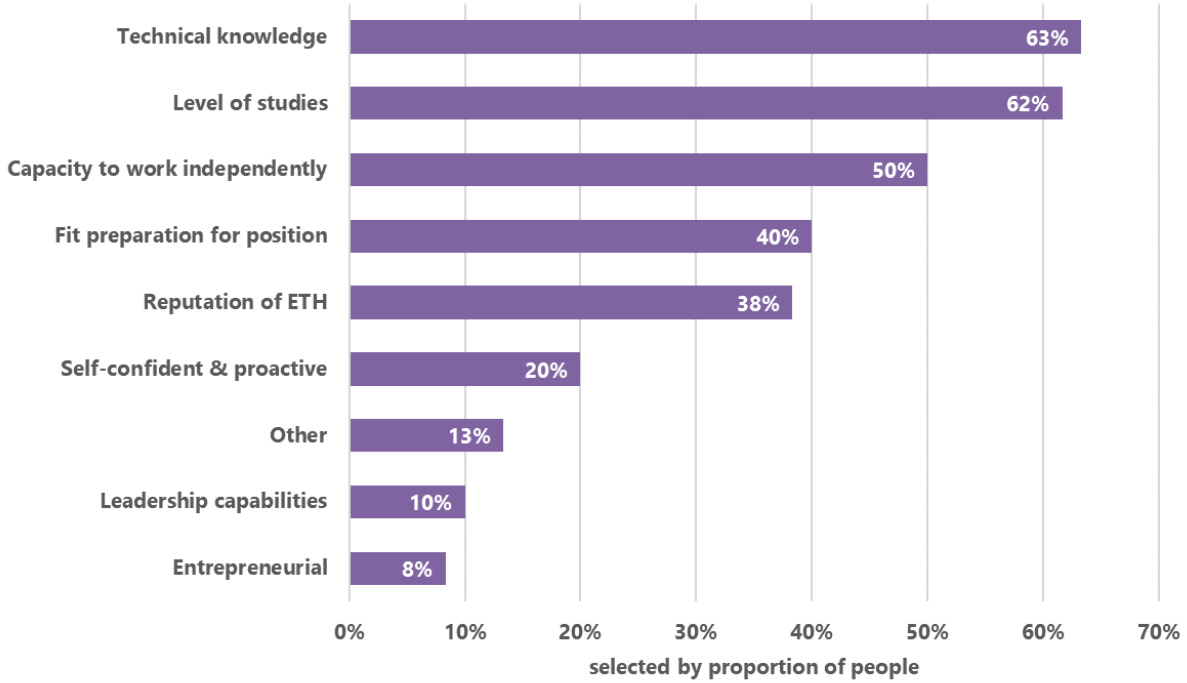

Figure 31: What are the most typical reasons for you to choose a food scientist from ETH Zurich? Each respondent could choose multiple answers out of a predefined selection of reasons. The question was answered by 60 professionals (N=60).

▶ *What competencies do you expect from a food scientist in general?*

When asked about the competencies expected from a food scientist in general, the following picture of the possible answers emerges (**Figure 32**). Beside the knowledge in food science and nutrition, a proactive behaviour received the highest affirmation. Both competencies were selected by 82% of the people surveyed. Likewise, team player abilities (76% of all respondents) and communication skills (65%) achieved high affirmation. Technical capabilities ranked only on fifth place with an approval rate of 47%. This is followed by the ability to work under pressure (41%), accuracy (35%), self-confidence (29%) and general scientific knowledge (29%) with similar approval ratings. Leadership skills were mentioned the least, just by 12% of people surveyed. However, I must note here that only 17 people answered this question. This is a too small sample size to make general statements with confidence. At most, tendencies can be read, and assumptions made. I am not aware of the reason why the number of responses to this question is so low.

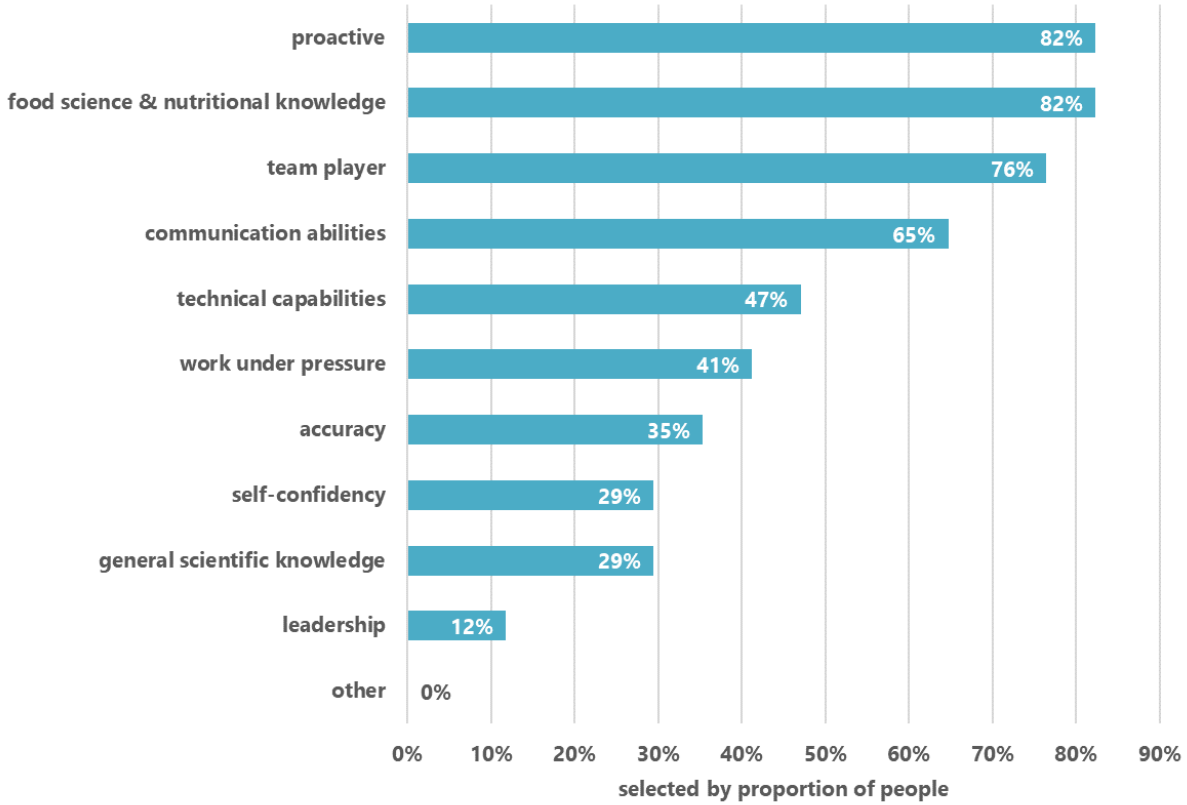

Figure 32: What competencies do you expect from a food scientist in general? Each respondent could choose multiple answers out of a predefined selection of competencies. The question was answered by 17 professionals (N=17).

► *What do the candidates from ETH Zurich fulfill well?*

In the view of most of the professionals, ETH graduates in food science are characterised by excellence in subject-specific and general scientific knowledge (**Figure 33**). A high degree of technical and practical abilities as well as of accuracy is also attributed to ETH graduates. Both competencies received over 40% affirmation of the people surveyed. Project management and a proactive behaviour achieved 29% and 24% affirmation, respectively. The abilities to work in a team and under pressure were significantly less selected, namely only by 18% and 12% of the people surveyed, respectively. The professionals do not see the abilities in communication and in leadership as strong characteristics of ETH graduates in food science and thus they ranked these competencies at the bottom of the list. As above, only 17 persons answered this question.

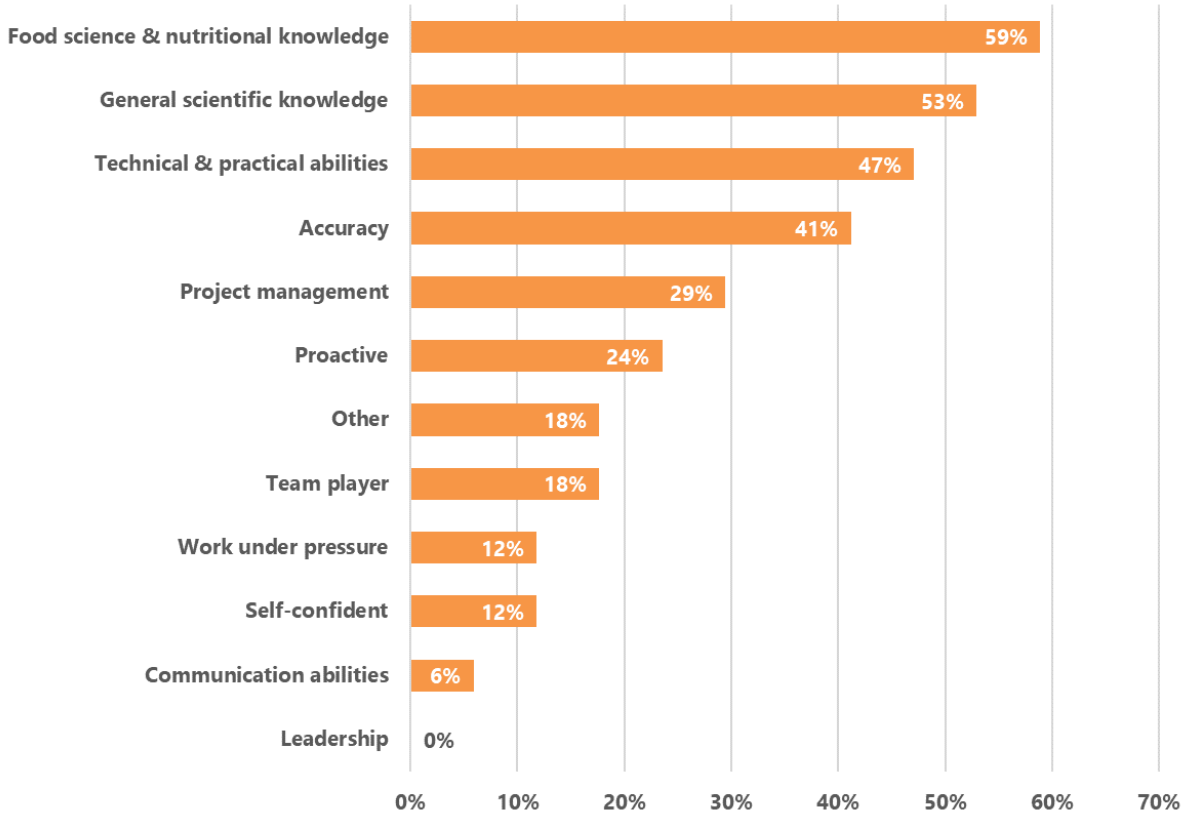

Figure 33: What do the candidates from ETH Zurich fulfill well? Each respondent could choose multiple answers out of a predefined selection of competencies. The question was answered by 17 professionals (N=17).

► *What do the candidates from ETH Zurich lack?*

Contradictory to the results of the question above, 41% of the respondents state that ETH graduates in food science lack technical and practical skills. Less surprising is the second most frequent answer - leadership, which was chosen by 35% of respondents. This is followed in third place (31%) by the answer "other", which the respondents were able to specify further. Among others, the following competencies and skills were listed as lacking: personality, IT and programming skills, practical experience, auditing, writing skills, business and economic skills, and critical thinking. The exact reasons for naming those were not asked. Abilities in project management (29%) and in communication (23%) were chosen with similar frequency as the "other" option. In the lower rank follow, with descending frequencies of being selected, working under pressure (16%), proactivity (13%), team player (12%), subject-specific knowledge (5%) and self-confidence (5%). Accuracy ranked on the last place (1%), which is, in contrast to the first place, consistent with the above question.

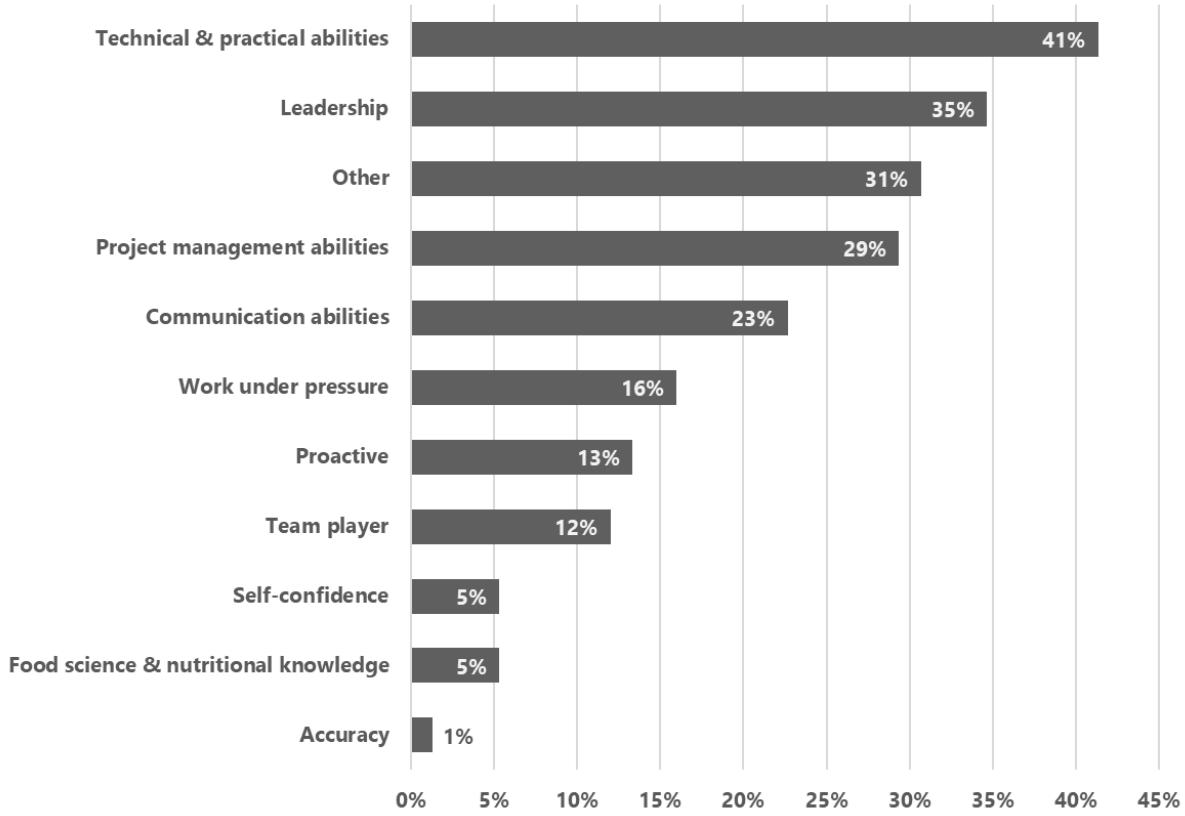

Figure 34: What do the candidates from ETH Zurich lack? Each respondent could choose multiple answers out of a predefined selection of competencies. The question was answered by 75 professionals (N=75).

4 Discussion

4.1 Curriculum design phase

Since the turn of the millennium, two major reform processes of the Swiss higher education sector directly and profoundly affect the design of curricula at the federal institutes of technology and the universities of applied sciences (Ehrenzeller, 2007): 1) the Bologna Process launched in 1999, and 2) the Higher Education Act entered into force in 2015.

The Bologna Process has forced higher education institutions to enter the curriculum design phase and to renew fundamentally their curricula. In particular, the structure of the degree programmes and their curricula respectively had to be adapted to the Bologna model. The old degree programmes, which were mostly built up from one level, had to be converted into a two-level system with Bachelor's and Master's degree programmes. Although this process seems to be completed at first glance, the optimisation is still in progress even in some of the study programmes examined here. In the curricula after the Bologna reform, students are often freer to choose from a wide range of courses. However, there is a danger of losing the common thread in the curriculum due to the wide range of choices. The educational institutions have structurally countered this danger by introducing specialisations or major and minor directions in the degree programmes. Depending on the perspective, these specialisations can be seen as a restriction or as a support for the students. However, they certainly sharpen the students' degree profile. They also serve as a criterion of independence for higher education institutions in the competition for students. Such specialisations can also be found in the food science programmes examined here (**Table 10**). One exception is the Bachelor's programme at ETH Zurich, which not only has no specialisation, but also generally offers students fewer options to choose subjects. The purpose of the Bachelor's programme at ETH Zurich is to provide students with the technical basics and to prepare them for the subsequent Master's programme (RSETHZ 323.1.0700.23). The BSc ETH in Food Science does not qualify for a profession and is strongly linked to Master's programme, which must be considered in this analysis. In contrast, the BSc programmes examined at the universities of applied sciences BFH-HAFL, HES-SO and ZHAW qualify for a profession and are geared towards specific professional activities.

Universities of applied sciences have only been allowed to offer Master's degree programmes since 2008. They were also obliged by SERI to offer them in collaboration with each other. The Master's programme in Life Sciences, which is offered jointly by four universities of applied

sciences (BFH, ZHAW, HES-SO and FHNW) and has multiple specialisations, has emerged from this legal obligation. The specialisation in food and beverage innovation offered by ZHAW and the specialisation in food, nutrition and health offered by BFH-HAFL are part of this collaborative Master's programme. Therefore, the structures of their curricula are very similar and about half of the modules (core competence and cluster-specific modules) are jointly offered. With the entry into force of the HEdA in 2015, this collaboration obligation was lifted. In addition, the degree programmes no longer have to be accredited individually by the Swiss Accreditation Council. This gives the educational institutions more possibilities and flexibility in the design of their degree programmes and their curricula, respectively.

4.2 Curriculum application phase

This study shows clear differences in all aspects examined (**Table 5**) between the curricula of the BSc programmes. Interestingly, the curricula of the MSc programmes differ less. As discussed above, these differences are set in the curriculum design phase and are mainly based on institutional factors as well as on the origin and development process of the degree programmes. If we take a closer look at the curricula of the BSc programmes, it is noticeable that they vary especially in the shares of the basic subjects (38 – 100 ECTS) and the additional subjects (14 – 62 ECTS) (**Figure 23**). In contrast, the share of the food science subjects is similar in the curricula of all BSc programmes (66 – 80 ECTS).

In the BSc programme at ETH Zurich, the share of basic subjects in the first and second year is extremely high (**Figure 9** and **Figure 23**). This applies in general to BSc curricula at ETH Zurich. In addition to teaching a profound knowledge in basic science, rigorous examinations in these subjects also serve to select students after the first and the second year. If the share of basic subjects is perhaps reduced in a curriculum reform, a different selection option might be needed. Most subjects are predefined, and the students can only choose courses to the extent of three ECTS freely. As I will discuss in detail later, this dominance of the basic subjects severely restricts the promotion of social and personal competencies (**Figure 26**).

Like the ETH, students at the HES-SO also have hardly any elective options in their BSc programme. The entire curriculum is predefined, except for the language (German or French) in which the programme is completed. This makes the competence profile of all graduates uniform, which can be an advantage or a disadvantage depending on the perspective.

In contrast, this analysis shows that the curricula of the BSc programmes at ZHAW and BFH-HAFL are balanced in terms of the subject shares. A direct comparison of the curricula of these degree programmes shows that share of the basic science subjects is smaller, and the share of the additional subject is higher in the curriculum at BFH-HAFL, although the differences are rather small. In the newest reform of the BSc curriculum at BFH-HAFL, particular attention has been paid to intertwine the basic and the food science subjects (Bürki & Stähli, 2021). As a result, students acquire competencies in theories, concepts, techniques, and methods of the basic sciences based on problems from the field of food science. In some courses, the teachers from both subjects teach as a team.

In the curricula at ETH Zurich, the transfer of knowledge from the professors to the students is often separated from the practical training and application. This is shown in the analysis of the course focus (**Figure 24**). The share of courses designed to impart exclusively theoretical knowledge and concepts is significantly higher in the Bachelor's and Master's programmes at ETH in comparison to the universities of applied sciences. At ETH Zurich, the courses are mainly classified as lectures, exercises, and practical courses. Thereby, the learning of theories and concepts is separated "by definition" from the practical training. There are probably two reasons for this separation of theory and practice: 1) a traditional understanding of teaching and 2) an organizational necessity. Basic subjects such as chemistry and biology are often offered for students from several degree programmes, which places great demands on staff and space.

In contrast, the universities of applied sciences operate with modules in which theoretical knowledge and practical application are taught in combination (**Figure 24**). There are only few modules in which theoretical knowledge and concepts are taught, without these being trained in practical applications at the same time. This is true for all universities of applied sciences examined here as well as for the Bachelor's and the Master's programmes.

An analogous picture emerges from the analysis of the types of performance assessments (**Figure 27**). Here, the curricula at ETH Zurich, especially in the BSc programme, rely mostly on written examinations. In a few courses and for some years now, students conduct examinations on computers (online). Thereby, the efforts of correction are significantly reduced, which is crucial for courses with a large number of students. Based on the additional experience in online exams gained during the Corona pandemic (Diel, Eymann, Kollenda, Sommer, & Storz, 2021), I expect that the implementation of online exams will continue to increase. At the

universities of applied sciences, performance assessments are often a combination of several elements and different types. Semester performances, whether graded or ungraded, allow lecturers to test the competencies taught in an application-oriented manner.

The differences in the focus and the orientation of the courses as well as in performance assessments reflect the different conceptions of the higher education institutions, which are sourced in the institutional factors (**Table 9**). The curricula at ETH Zurich, including the degree programmes in food science (**Figure 25**), are largely research-oriented and teaching often focuses on imparting knowledge. The curricula at the universities of applied sciences are application-oriented and the focus of teaching is on preparing students for clearly defined professional activities. The extent to which these differences affect the learning success and the employability of their graduates must be shown by further studies, which would be carried out within the curriculum feedback phase of the CVC and thus contribute to the further development of the curricula.

The Bachelor's programme in Food Science at BFH-HAFL has just undergone a curriculum reform (Bürki & Stähli, 2021). In the process, the degree programme was consistently oriented towards competencies. BFH-HAFL uses its own competency model with target values for the individual competency areas. In the degree programmes at BFH-HAFL, subject and methodological competences should make up around 70% of the curriculum, social competences around 20% and personal competences around 10%. Although I used a different competence model for my analysis (Salvisberg, 2010), it shows that the target values are well achieved in the BSc programme at BFH-HAFL. Based on my calculation, subject- and method-specific competencies account for around 65% of the curriculum, social competencies for around 22% and personal competencies for around 13%. In the curriculum of the Master's programme at BFH-HAFL, the distribution is slightly shifted towards social and personal competencies. The subject- and method-specific competencies make up around 56% of the curriculum, the social competencies around 25% and the personal competencies around 19%. The curricula of the degree programmes at the ZHAW show similar values in terms of the distribution of competencies compared to the curricula of the BFH-HAFL. The descriptions of the courses for the degree programmes at BFH-HAFL and ZHAW, on which these evaluations are based, mostly explicitly indicate the competencies to be learned, and not only the subject- and method-specific competencies. It is striking that most modules explicitly mention the social and personal competencies to be learned. It gives the impression that the competencies

that are promoted in the individual modules are coordinated. Overall, this shows that a consistent competence orientation in the curriculum design phase is reflected in the curriculum application phase. To which extent the students are effectively fostered in these competencies is examined in the curriculum feedback phase.

In the curricula at ETH Zurich, the emphasis of competence development is highly on the side of technical and methodological competencies. In the Bachelor's programme in Food Science, the subject- and method-specific competencies together make up around 92% of the curriculum. In the Master's degree programme, too, the subject and method-specific competencies together still make up around 84% of the curriculum. The fact that these values for subject- and method-specific competencies have turned out so high is typical for the degree programmes at ETH Zurich. However, it is also related to the fact that the course descriptions, although mostly explicitly formulated, are strongly oriented towards the subject- and method-specific contents. This issue applies even more to the curriculum of the degree programme at HES-SO. Based on the analysis of the course descriptions, subject- and method-specific competencies together make up around 86% of the curriculum. However, since most of the courses (approx. 79%) are described implicitly, I assume that this value is too high and that the social and personal competencies have a higher share in the curriculum at HES-SO. However, the effect of having minimal course descriptions that exclude social and personal competencies cannot be neglected. As a result, students often lack the awareness that they have trained and acquired these competences. This can lead to a false self-assessment in the application process. To counteract this, ETH Zurich, for example, has launched the ETH Talent Project[1]. It aims to empower students to actively shape and monitor the development of their competencies. In additions, it guides lecturers in promoting versatile competencies among students.

Usually, an overarching qualification profile exists for a degree programme, in which the main competencies are listed that are acquired by the students in the course of their studies. At ETH, the qualification profile is appended to the study regulations and to the diploma and therefore it is a public document. In addition, it plays an important role in the curriculum design phase (Tomforde, Volk, Barth, & Vaterlaus, 2020). It is drawn up very early in the curriculum development and then serves as a guide for the design of the curriculum. At the universities of

[1] Webpage of the ETH Talent Project: https://ethz.ch/en/the-eth-zurich/organisation/executive-board/rector/eth-talent-projekt.html (last visited: 10/07/2021)

applied sciences, according to the interviews with the persons responsible for the degree programmes, qualification profiles exist, too. However, these are not published for the degree programmes analysed. In summary, the channels through which students at the ETH and at the universities of applied sciences are shown the fostered competencies are different. The extent to which this influences the students' perception is partially analysed in the curriculum feedback phase.

4.3 Curriculum feedback phase

In the curriculum feedback phase, findings on the curriculum and its outcome, in particular the integration of graduates into the labour market, are collected and fed into the curriculum design phase as inputs for the curriculum development (Renold, et al., 2015). Here, I evaluated two surveys that were conducted by the D-HEST/Food Science. My analysis of the data showed that we have to interpret the surveys with caution due to the following reasons. First, both surveys were explicitly designed for the degree programmes in food science at ETH Zurich. Second, the professionals were selected and do not represent a well randomised sample. Third, the number of responses (sample size) are relatively small for both surveys. Despite these limitations, the surveys provide some insights into the degree programmes at ETH Zurich and to identify major trends that may even be of significance for the other curricula. Thereby, the comparison between the competencies taught in the curriculum and the competencies demanded by the labour market is of particular interest. A strong mismatch between them would be a sign that the education and employment systems are not well linked (Rageth & Renold, 2020).

In many of the job profiles that graduates occupy after entering the labour market, project management is a main activity. However, three quarters of the interviewed graduates stated that they lack project management skills at the beginning of their working life. Indeed, there is no explicit subject on this in the BSc and MSc curriculum at ETH Zurich. Projects are carried out individually and in teams, and students must independently write a Bachelor's and a Master's thesis. However, these projects as well as the BSc and MSc thesis mainly train students to work scientifically and not as they would in the private sector (**Figure 25**). Therefore, the universities of applied sciences are increasingly implementing job-oriented working methods and procedures in their modules (Bürki & Stähli, 2021). In the new BSc curriculum at BFH-HAFL, students have a ‘food science project’ module in each of the fourth, fifth and sixth semesters

in which they implement a project as close to practice as possible. Thereby, the students learn the important steps of project management (**Figure 12**). Overall, the share of additional subjects in which management skills are taught is significantly higher in the BSc curriculum at ZHAW and BFH-HAFL as at ETH Zurich and HES-SO (**Figure 23**). In the Master's programmes at ZHAW and BFL-HAFL, project management is a core competence module (**Figure 18** and **Figure 20**). These findings underscore what the analysis of the institutional factors has already shown: the food science curricula of the universities of applied sciences are more specifically designed for job profiles of the labour market as the curricula at ETH (**Table 9**). However, the curriculum analysis as well as the surveys show that the difference in application orientation is not based on the subject-specific competencies in food science, but rather on method-specific and social competencies, which are trained in particular in the additional subjects. This can be underlined with the evaluation of the question about the existing skills at ETH graduates (**Figure 33**). A large proportion of the professional surveyed are of the opinion that ETH graduates have excellent knowledge in food science as well as the necessary technical and practical skills. On the contrary, project management (method-specific competence), self-confidence (personal competence) and communication (social competence), to name a few examples, achieved much lower approval. However, the results of the question about the lack of competencies among ETH graduates, puts this initially sharply drawn picture into perspective again (**Figure 34**). In this question, 41% of the professionals surveyed stated that ETH graduates lack the necessary technical and practical skills. Therefore, the experts are not unanimous in this regard.

There is clear agreement among the professionals that ETH graduates have low leadership skills (**Figure 33** and **Figure 34**). However, the survey also shows that this leadership competence is not expected of ETH graduates (**Figure 32**), which may also apply to the UAS graduates. Leadership is a social competence. Social and personal competencies are difficult to integrate into the curriculum in a purposeful way due to several reasons (Chan, Fong, Luk, & Ho, 2017). The pedagogical methods to foster these competencies are complex. In particular, the assessment of social and personal competencies is difficult, because teachers and students usually perceive them differently. In contrast to the subject- and method-specific competencies, there is usually not only one right answer. To foster social and personal competencies effectively, they must be well embedded in the curriculum and the embedding must be strongly supported by the institution.

Social and personal competencies are acquired in particular through experience - "learning by doing" - or in the later course of a professional career through further training - "lifelong learning". It may therefore come as little surprise that of the graduates surveyed who graduated no more than five years ago, almost half had already started or completed continuing education (**Figure 30**). The largest share of the programmes is in the area of management.

These observations raise the crucial question of the curriculum design phase whether the competencies fostered in the curriculum still sufficiently satisfy the diverse demands of the various stakeholders. Every educational institution must ask this question in a self-critical manner at regular intervals. The HedA (HFKG Abs. 27-28) provides the legal framework for accreditation and quality management of the degree programmes. However, it would be wrong to infer from this that a degree programme must meet all the requirements of the various stakeholders. It is up to the federal institute of technology and the universities of applied sciences to gear the curriculum to a specific qualification profile. UAS have it slightly easier in this respect, since the institutional factors and the legal framework clearly set the direction. The UAS should primarily educate professionals with a clear qualification profile for the labour market. In this respect, ETH Zurich is always in a clinch between raising the next generation of academics and training professionals for the labour market. The academy and the labour market are stakeholders with different requirements in competencies.

5 Conclusions

In this thesis, I use the concept of the curriculum value chain (Kelly, 2009; Renold, et al., 2015) to analyse the degree programmes in the field of food science and technology offered at ETH Zurich and the universities of applied sciences ZHAW, BFH-HAFL and HES-SO. The combination of the methods used and the different perspectives taken provide insights into the different phases of the CVC. I have developed a procedure for the curriculum analysis that converts the qualitative information of the course descriptions into a quantitative evaluation of the whole curriculum. This approach provides a good overview of the curricula and allows curricula to be compared with each other. The procedure elaborated here can be applied to other curricula and serve as a starting point for curriculum reforms.

My analysis confirms that institutional factors significantly influence structure and content of the curricula, especially in the curriculum design phase. The mandate of the governing body and the legal framework set the goal and the guidelines for the curricula. However, institutional factors change over time. In particular, international agreements and national legal reforms can lead to sudden and profound changes in institutional factors. In recent years, the Bologna process with the introduction of the Bachelor's and Master's degrees and the ECTS throughout Europe, as well as the entry into force of the HEdA, have led to major adjustments to the curricula. Although the HEdA has created more freedom in curriculum design, the guidelines for the universities of applied sciences are slightly tighter in comparison to the federal institutes of technology. However, this is not a disadvantage regarding the curriculum design. In curriculum development, ETH Zurich is always in a clinch to find a good balance between a research-oriented and an application-oriented curriculum. In contrary, the challenge for the universities of applied sciences is to react appropriate to the changing needs of the labour market.

From the curriculum analysis, I draw the following conclusions:

- The analysed degree programmes differ only slightly in the share of food science subjects, but strongly in the shares of basic science and additional subjects. This difference is more pronounced in the Bachelor's programmes than in the Master's programmes.

- The organisation of the curriculum in modules, as it is the case at the universities of applied sciences, makes it possible to organise teaching in such a way that theoretical knowledge can be better combined with practical applications. At ETH Zurich, teaching of technical knowledge and practical application is often separated into lectures, exercise, and lab courses.

- In the degree programmes, the subject-specific, method-specific, social, and personal competencies are promoted to varying degrees. A broad and balanced teaching of competencies is successful when a consistent orientation towards competencies is aimed for in the curriculum design phase. This influences how much and which competencies are fostered.

- From a pedagogical point of view, fostering social and personal competencies in the curricula is more complex and work-intensive compared to subject- and method-specific competencies. Special teaching formats are required, which often include practical work or simulations in groups. My analysis shows that these teaching formats are incorporated more frequently in the additional subjects and in the modular structure found in the curriculum of the universities of applied sciences.

- A competence-oriented degree programme includes the types of performance assessment. To assess competencies from the different domains, the performance assessments must be diverse and goal-oriented. The universities of applied sciences, especially ZHAW and BFH-HAFL, have already considered this in their new curricula by using different types of performance assessment. At ETH Zurich, written examinations dominate, which is hardly possible otherwise for administrative reasons due to the high number of students in the Bachelor's degree programmes.

In the curriculum feedback phase, surveys are a central instrument to elicit the outcome of the curriculum application phase and to check whether the degree programme meets the needs of the stakeholders. They provide an indication of how well the education and employment systems are linked (Rageth & Renold, 2020). The results from the surveys on the food science

programmes at ETH Zurich, which I partially include in this thesis, should be viewed with caution for the reasons mentioned above. Nevertheless, the results indicate that the outcome of the curriculum in terms of employability and professional career can be improved at ETH Zurich. Both the graduates and the professionals recognise a lack of competencies, especially in social and personal competencies.

My analysis showed that every year around 240 to 260 new students start a BSc programme and 70-90 new students start an MSc programme in food science at the universities of applied sciences or at ETH Zurich. The trend in student numbers is stable to slightly increasing. Based on the number of students, it makes sense to look at the education and employment system holistically and not just at a single course in isolation. The Food Science Initiative offers the various instruments for this. The overarching research question of whether the degree programmes satisfy the needs of the labour market can only be conclusively clarified with the findings from the additional modules of the Food Science Initiative.

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7 Appendix

7.1 Semi-structured interviews

The semi-structured interviews with the persons responsible for the study programmes were organised into the four sections (A-D) below. Each section contained a few questions for guidance and consistency among the interviews.

Section A: Curriculum of the degree programme

1 How would you describe the structure of the degree programme?
2 How would you describe the content of the degree programme?
3 How do you create the alignment of the course content and learning objectives throughout the curriculum?

Section B: Competencies

1 Does a competence profile exist for the degree programme?
2 Is the competence profile visible to the students?
3 How are the courses aligned with the competence profile and *vice versa*?
4 How is the learning of the competencies assessed?

Section C: Institutional factors on the level of the study programme

Students

1 How many students enter the degree programme each year?
2 How many students graduate each year?
3 Can you provide an overview about the student numbers over the past five years?
4 How is the student body composed?
5 What is the proportion of international students?
6 Is there an estimate for the cost of the study? Cost per student?

Faculty

1 How many academic staff belong to the faculty?
2 How many professors belong to the faculty?

Section D: Degree programme

1 When was the degree programme established?
2 When was the degree programme last overhauled?
3 When is the next reform of the degree programme planned?
4 What would the procedure be for a reform of the degree programme?

7.2 Survey among the ETH graduates

Complete questionnaire of the survey that D-HEST/Food Science conducted among ETH graduates in 2020 (**Table 11**).

Table 11: Complete questionnaire of the survey among the ETH graduates.

	Question	Answer selection	Considered in thesis
1	Do you work in the food sector?	a) Yes b) No	no
2	Please indicate the field in which you work.	*open comment box*	no
3	Why did you change fields?	a) I wanted a job in the food industry, but could not find one that fit my preferences. b) I did not want a job in the food industry. c) Other (please specify)	no
4	You do not have a job because:	*multiple answers possible* a) Your job search was not successful or is ongoing. b) You do a temporary career break (i.e. family, medical, or other reasons). c) You do not want a job. d) Other (please specify)	no
5	In which food sector do you work?	*multiple answers possible* a) Food Production b) Food Quality c) Food Safety d) Research and Development e) Marketing f) Nutrition g) Wholesale and distribution h) Regulation i) Education j) Financial services k) Retail l) Other (please specify)	no
6	What is your current position?	*open comment box*	no
7	For how long have you had this position?	*open comment box*	no
8	In which city and country do you work?	*open comment box*	no
9	What is the size of your company?	a) Micro (<10 persons) b) Small (10 - 49 persons) c) Medium (50 - 249 persons) d) Large (>250 persons) e) I do not know.	no
10	How did you find your Job?	*multiple answers possible* a) By responding to an ad b) By spontaneous application c) Was recruited d) After an internship e) Other (please specify)	no
11	Is it a fix term contract or unlimited contract?	a) unlimited contract b) fixed term contract	no
12	What is your salary (100% annual including taxes)?	*open comment box*	no
13	Do you work 100% or part-time?	a) 100% b) Part-time (please specify)	no

14	Which courses during your study do you find most useful for your job?	*multiple answers possible* a) General courses (biology, mathematics, physics...) b) Economics c) Food chemistry/biochemistry d) Food microbiology e) Food physics and food process design f) Food sensory science and consumer behaviour g) Toxicology h) Nutrition i) Safety and quality in agri-food chain j) Colloquium and seminars k) Excursions l) Practical courses m) Other (please specify)	**yes**
15	What scientific competencies were missing at the beginning of your professional career?	*two responses maximum* a) Presentation skills b) Reporting / writing skills c) Project management d) Communication e) Multicultural environment management f) Other (please specify)	**yes**
16	How satisfied were you with your decision to study food science at the ETH Zurich?	a) Very satisfied b) Satisfied c) Somewhat satisfied d) Not Satisfied If not satisfied, may you indicate why	no
17	How can the education programme in food science be improved?	*open comment box*	no
18	Since your Master, did you follow further educational programme?	a) No b) Yes c) Please indicate what type of course(s) you followed	**yes**
19	What is your gender?	a) Woman b) Man c) I do not wish to answer	no
20	What is your age?	*open comment box*	no
21	In what year did you complete your Bachelor's degree?	*open comment box*	no
22	From which university did you obtain your Bachelor's degree?	*open comment box*	no
23	In what year did you complete your Master's degree at the ETH Zurich?	*open comment box*	no
24	How long was your job search after the completion of your studies?	a) I already had a position before finishing my Master. b) Less than 3 months c) Less than 6 months d) Less than 1 year e) More than 1 year f) I do not have a job	no

7.3 Survey among professionals in food and nutrition

Complete questionnaire of the survey that D-HEST/Food Science conducted among professionals in food and nutrition (**Table 12**).

Table 12: Complete questionnaire of the survey among the professionals in food and nutrition.

	Question	**Answer selection**	**Considered in thesis**
1	You work in …	a) the public sector b) the private sector c) other (please specify)	no
2	What is the size of your company?	a) Micro (<10 persons) b) Small (10 to 49 persons) c) Medium (50 to 249 persons) d) Large (>250 persons)	no
3	What is your position in your company?	*open comment box*	no
4	Do you/Does your company hire food scientists?	a) Yes b) No	no
5	In which type of public organisation do you work?	a) Government office (i.e. BAFU…) b) Research institute (i.e. Agroscope…) c) Education (i.e. University…) d) Other (please specify)	no
6	What is your position in your institution?	*open comment box*	no
7	Do you/does your institution hire food scientists in general?	a) Yes b) No	no
8	What type of professionals do you hire?	*open comment box*	no
9	For which type of position do you hire food scientists?	*multiple answers possible* a) Project Management b) Production c) Quality and safety d) Nutrition e) Marketing f) Research and Development g) Sale h) Regulation i) Engineering j) Other (please specify)	no
10	Do/did you hire food scientists from ETH Zurich?	a) Yes b) No	no
11	Roughly, which percentage of the food scientists you have hired are from ETH Zurich?	*Selection between 0 and 100%*	no
12	What are the most typical reasons you choose a food scientist from ETH Zurich?	*multiple answers possible* a) Level of studies b) Technical knowledge c) Reputation of the ETH Zurich d) Fit preparation for position e) Leadership capabilities f) Self-confident and proactive in their work g) Entrepreneurial h) Capacity to work independently i) Other (please specify)	**yes**
13	Are there specific criteria/competencies from graduates in food science of ETH Zurich that influenced your decision?	a) No b) Yes If yes, which ones? (please specify)	no

14	What competencies do you expect from a food scientist in general?	a) Excellent technical capabilities b) Excellent general scientific knowledge c) Excellent food science and nutritional knowledge d) Self-confidence e) Proactive f) Can work under pressure g) Communication abilities h) Leadership i) Accuracy j) Team player k) Other (please specify)	**yes**
15	What do ETH Zurich candidates fulfil well?	a) Food science and nutritional knowledge b) General scientific knowledge c) Technical and practical abilities d) Project management abilities e) Self-confidence f) Proactive g) Can work under pressure h) Communication abilities i) Leadership j) Accuracy k) Team player l) Other (please specify)	**yes**
16	What do ETH Zurich candidates lack?	a) Food science and nutritional knowledge b) Technical/practical abilities c) Project management abilities d) Self-confidence e) Proactive f) Ability to work under pressure g) Communication abilities h) Leadership i) Accuracy j) Team Player k) Other (please specify)	**yes**
17	Do you have any further comments?	*open comment box*	no

7.4 ETH Competence Framework

The ETH competence framework comprises twenty competencies allocated to four superior domains (**Figure 35**).

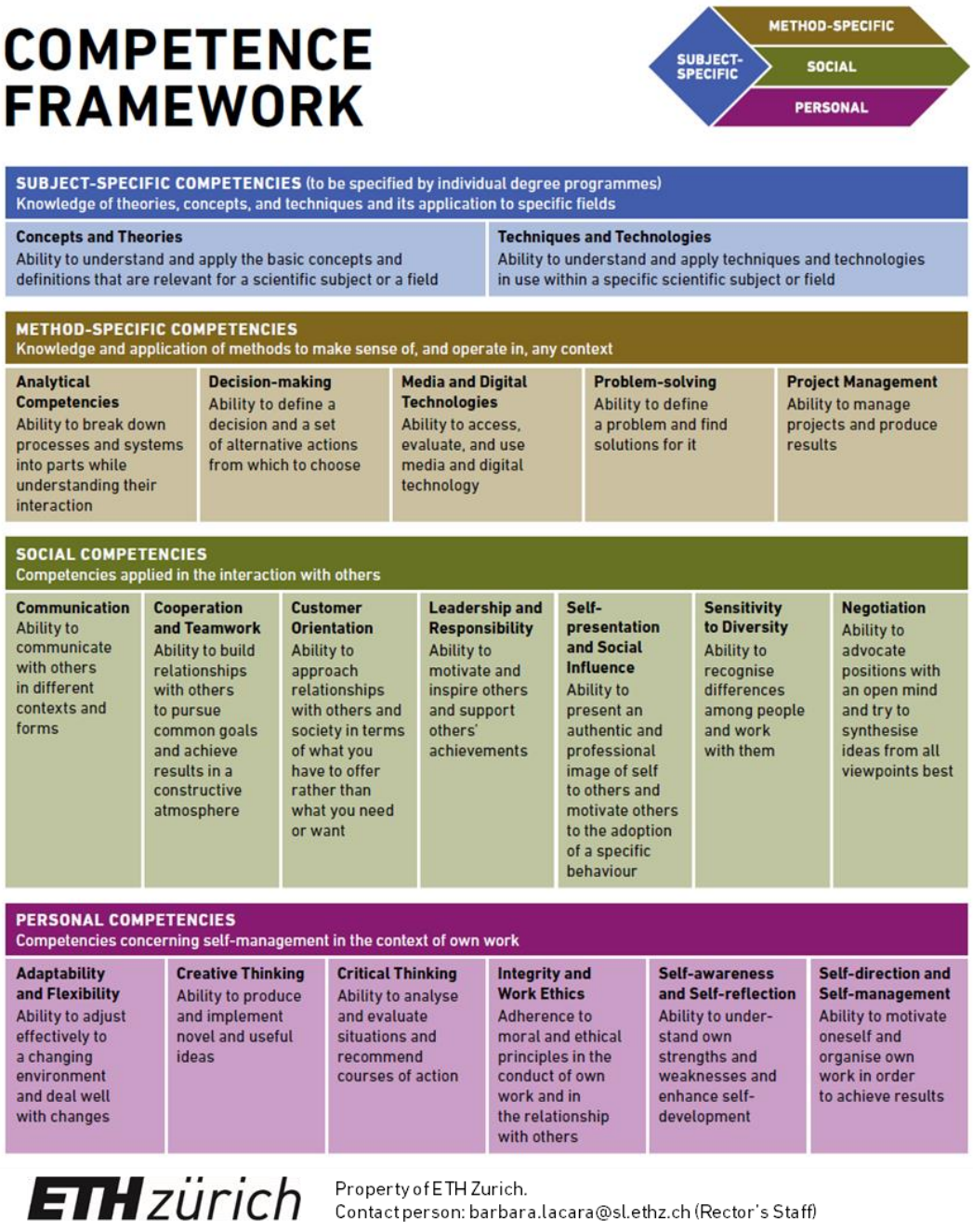

Figure 35: Competence Framework of the ETH Talent Project. The ETH Competence Framework is a compilation of competencies that ETH Zurich aims to foster. Source: https://ethz.ch/en/the-eth-zurich/organisation/executive-board/rector/eth-talent-projekt.html (last visited: 12/06/2021)

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