What Competences do Employers, Staff and Students expect of a Computer Science Graduate?

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Abstract **- The higher education sector is faced with several strategic decisions in order to maximize quality, impact, and competitiveness. In the context of "engineering" of competences and learning outcomes one core challenge is the inclusion of curriculum stakeholders in prioritizing subject-specific and generic competences in study programs. In this paper we present an empirical study in which methods like a qualitative content analysis of job offers and questionnaires are applied to find out what competences are considered essential by employers and instructors. Results show how instructors and employers value competences and in how far stakeholders' views differ. Furthermore, strategies for the transfer of the findings into the Computer Science (CS) curriculum are discussed, e.g. the development and use of a generic-competence matrix, scenarios for competence facilitation, and workshops with teaching and administration staff.**

Index Terms – CS curricula, curriculum stakeholders' inclusion, competences

INTRODUCTION

European higher education is undergoing change in the direction of more transparency, competitiveness and encouragement of mobility on the basis of compatible curriculum structures and transferable credits [1]. In this context, objectives like "employability", "learner-oriented learning outcomes", and "subject-specific and generic competences" [2] gain importance. For example, the European Qualification Framework (EQF) [3] is developed in order to serve as a qualification description framework to make different national educational systems comparable across Europe. An important component of such far-reaching change is organizational learning that we incorporate within the "active curriculum of computer science" project (ActiveCC). ActiveCC is a faculty-wide initiative at the Faculty of Computer Science, University of Vienna. It aims to support the implementation and steady evolution of the new bologna-conform bachelor curriculum by the features/qualities such as transparency, sharing and coordination. The core idea of ActiveCC in the area of stakeholder-inclusion for prioritizing aspired graduate's competences is to fully involve particular stakeholders, e.g. students, instructors, and employers at curriculum level, and students in learning and assessment at course level [4].

The primary goal of this paper is to illustrate the strategy of inclusion by a concrete way of including various stakeholders in the process of co-determining those competences of CS graduates that are considered most important for an appropriate qualification of graduates for their future jobs and lives. A further goal is to present the outcomes of our studies in order to inspire thought and dialogue in our own as well as other universities responsible for CS education. With our work we want to contribute to make the curriculum highly relevant to all stakeholders - students, instructors, and employers - by genuinely including them into the process of curriculum design as well as implementation.

The paper is structured as follows: the first section refers to the empirical study investigating the stakeholders' perspectives concerning the importance of particular competences. The second section concentrates on the comparison and interpretation of the findings. The third section deals with three scenarios that illustrate the transfer of the findings into the CS curriculum. The final section concludes the paper with a summary and an outlook.

LITERATURE REVIEW

In discussions on curricular design the terms "transferable skills" (or generic competences) and "employability" are gaining importance. Transferable skills are "generic capabilities which allow people to succeed in a wide range of different tasks and jobs" [5, p. 5]. Employability is defined as: "a set of achievements - skills, understandings and personal attributes - that make graduates more likely to gain employment and be successful in their chosen occupations which benefits themselves, the workforce, the community and the economy" [6, p. 8]. Earlier studies have reported that although companies strongly demand soft skills beside technical skills, job advertisements rather focus on hard skills. For soft skills, communication and interpersonal skills are most often mentioned [7]. Up to now, numerous studies have addressed competence requirements for universities' graduates as perceived by graduates themselves and their employers [8, p. 23]. The British Dearing-Report, for example, recommends higher education to focus on the key skills communication, numeracy, use of information technology and learning how to learn, which are considered to be the keys to success of graduates [9]. According to Yorke [6, p. 5] undergraduate programs should foster abstraction, system thinking, experimentation and

collaboration. Research on how to align curricular design [10] with learning outcomes show how competence requirements can be put into practice. However, research on how to include all stakeholders in the selection of competences and the comprehensive transfer process into the curriculum as addressed in this paper is rare up to now.

COMPETENCE REQUIREMENTS – AN EMPIRICAL STUDY

In order to evaluate the stakeholders' requirements of particular competences, the following research instruments were applied: a qualitative content analysis of job offers, and questionnaires for employers and faculty instructors.

I. Qualitative Content Analysis of Job Offers

The qualitative content analysis was applied to evaluate job offers for CS graduates. The main questions of interest underlying the qualitative content analysis of job offers were: *Which subject-specific competences of CS graduates are expected by the employers? Which generic competences of CS graduates are particular important by employers?*

Data was collected from popular Austrian online career networks (www.jobpilot.at and www.monster.at). A total of 128 job offers (cases) announced by 58 employers in Vienna and surrounding area could be found during the time period 18th July until 21st August 2008. Altogether, the material for analysis comprised 32,337 words. Categories were elaborated inductively. The category system included two main categories "subject-specific competences" and "generic competences", and a total of 18 subcategories. The two main categories and their subcategories are illustrated in Table 1. Results are specified according to the amount of statements in general (count), the amount of cases (one job offer represents one case) and the amount of companies.

TABLE 1
CATEGORY SYSTEM

Subcategory	Count	Cases	Employers
SUBJECT-SPECIFIC COMPETENCES			
Work experience	130	88 (~69%)	40 (~69%)
Software and tool experience	71	59 (~46%)	30 (~52%)
Software development	50	41 (~32%)	25 (~43%)
Information Technology	53	35 (~27%)	24 (~41%)
Economic knowledge	54	47 (~37%)	19 (~33%)
Database technologies	29	26 (~20%)	19 (~33%)
Process management	22	20 (~16%)	10 (~17%)
Certifications	6	6 (~12%)	4 (~7%)
GENERIC COMPETENCES			
Language skills	99	97 (~76%)	48 (~83%)
Team competence	115	90 (~70%)	41 (~71%)
Communication competence	71	56 (~44%)	38 (~66%)
Way of working	91	59 (46%)	33 (~57%)
Thinking skills	97	71 (~55%)	28 (~48%)
Flexibility	78	64 (50%)	23 (~40%)
Learning	96	50 (~39%)	19 (~33%)
Project management	21	17 (~13%)	11 (~19%)
Social competence	45	45 (~35%)	10 (~17%)
Creativity	31	31 (~24%)	5 (~9%)

Subject-Specific Competences

Most of the statements (130) and at the same time most of the companies (69%) asked for *work experience*. In 59 job offers (46% of the cases), *software and tool experience* were expected for CS graduates, including SAP, MS Office in general, Excel in particular, project management tools, business intelligence tools, product modeling tools, and reporting tools. 43% of the companies expected *software development competence*, particularly programming skills like Java, C/C++, Perl, and XML. Several statements (53) addressed *Information Technology (IT) knowledge*, referring to standards and reference models like ISO, ITIL, COBIT, CMMI, as well as ERP systems. Furthermore, the comprehension and affinity of IT in general, network and web-technologies skills were mentioned. In 37% of the job offers, *economic knowledge* was expected by the employers. Statements addressed a variety of subject areas that ranged from accounting to risk management, marketing, production and logistic issues. Some employers (33%) asked for *database technology skills*, in particular handling skills of databases running on Oracle, MS, and SQL server.

Generic Competences

Most of the employers (~83%) expected excellent *English and German* skills. A few of the employers mentioned further language skills as nice to have, e.g. other European or Asian languages. Most of the statements (115) refer to *team competence*. Employers searched for future employees with team competence including team-oriented thinking and acting, the ability to work in a team as a communicative, motivated, performance-oriented team player, or team leader. Furthermore, many employers (~66%) asked for *communication competence*, including the ability to handle conflicts, criticism and to find consensus, as well as the ability to use moderation- and presentation techniques. Future employees shall act in a self-confident, professional, poised manner. About 57% of the employers formulated statements in their announcements that are summarized as "*way of working*". These statements referred to self-directed, careful, responsible, cost-conscious, solution-oriented, customer-oriented, and a structured way of working as well as the ability to work under pressure, and to coordinate and organize. 48% of the employers asked for analytical, structural, innovative, holistic, entrepreneurial, and abstract thinking (summarized as *thinking skills*). 40% of the employers asked for *flexibility*, e.g. the ability to handle change, to work with/in intercultural, multi-lingual, geographically dispersed teams, the willingness to travel (mobility), or to work abroad. About 33% of the employers mentioned a need for *learning skills* and openness for personal development.

II. Questionnaire on Generic Competences for Employers and Faculty Members

Additionally to the analysis of the job offers, a study on the perception of importance of generic competences was conducted. The questionnaire was adopted from the competences questionnaire used in the EU Project Tuning Educational Structures which included instrumental, interpersonal and systemic competences. Particular items were adapted, for example, the item "knowledge of a second language" was transformed into a item "oral and written communication in English"; "elementary computing skills"

was changed into "ability to deal with new technology", "capacity to adapt to new situations" was transformed into "capacity to adapt to new situations/flexibility", "appreciation of diversity and multiculturality", "ability to work in an international context", and "understanding of cultures and customs of other countries" were merged to the item "intercultural competence". Furthermore, we shortened the questionnaire by editing out the items "grounding in basic knowledge of the profession in practice" and "will to succeed". The adapted questionnaire consisted of 25 items and the possibility to add particular items which were not mentioned. Representatives were asked to rate the importance of each of the 25 competences as well as the graduates' level of achievement of these competences by using a scale from 4 to 1 (4 = substantial, 3 = high, 2 = low, 1 = no importance/achievement). Faculty members were asked to judge the importance of the competences.

Data from future employers was collected at an Austrian job fair for graduates on the 15th November 2007. Representatives of IT-related companies (often employees of the human resources department who knew staff requirements of the company) or representatives of companies employing CS (including business informatics) graduates were asked to answer the questionnaire. Additionally we asked teaching staff of the Faculty of Computer Science to rate the importance of particular competences in the questionnaire. A total number of 35 questionnaires were filled out by employers and 17 questionnaires were filled out by faculty members.

Figure 1 shows the results of the employers' questionnaire. Universities should especially concentrate on competences with high importance and low level of achievement [3]. For competences with high importance and high level and achievement efforts should be maintained. Results show, that employers attach high *importance* to the competences "capacity to learn" (3.68), "team competence" (3.50), "ability to work autonomously" (3.43), "interpersonal skills" (3.41), "problem solving" (3.37), "concern of quality" (3.37), "ability to work with new technology" (3.35), "oral and written communication in German" (3.31), "capacity for applying knowledge in practice" (3.29), "ability to work in an interdisciplinary team" (3.26), "capacity for generating new ideas (creativity)" (3.26), "capacity for analysis and synthesis" (3.21), "oral and written communication in English" (3.21), "adaptability/flexibility (3.21), "information management skills (ability to retrieve and analyze information from different sources)" (3.20), "critical and self-critical abilities" (3.15), "planning and time management" (3.14), and "project design and management" (3.06). All other items were rated below 3.00. Employers rated the graduates' *level of achievement* of these competences as follows: "capacity to learn" (3.21), "oral and written communication in German" (3.08), "information management (…)" (3.08), "ability to work with new technology" (3.04), "basic general knowledge in the field of study" (3.00). All other competences are rated below 3.00.

The survey ended with the question, how much time of university education for CS should be dedicated to generic competences compared to subject-specific training. Employers recommended to invest about one third of time (32%) to facilitate generic competences (or soft skills) and 68% for subject-specific training. When asked why generic competences should be promoted, employers responded in the following way: "soft skills are important for working with customers", "our engineers are consultants and commonly work closely with our customers", "subject-specific knowledge is usually learned on the job" and "specialist know-how is easier to lean on the job". Employers were additionally asked whether they were interested to cooperate more with universities in order to fine tune competence facilitation at universities in such a way that graduates' qualifications meet better their expectations. Results on this question were varying, 14 out of the 32 participants (44%) answered affirmative, 8 (25%) were not interested and 10 (31%) said that they could not answer this question.

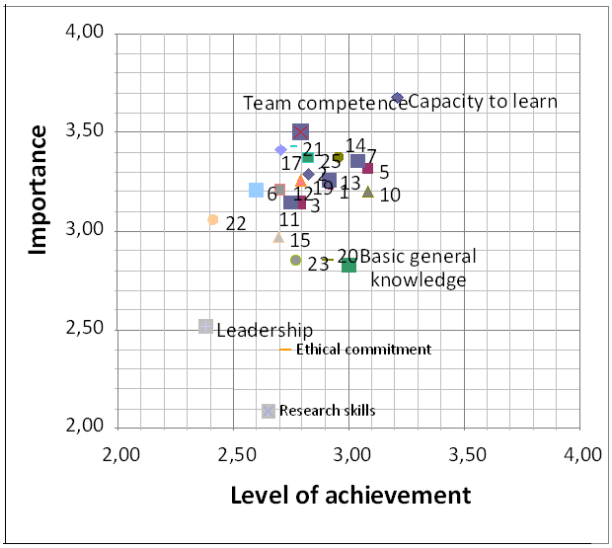

FIGURE 1
IMPORTANCE AND LEVEL OF ACHIEVEMENT OF COMPETENCES RATED BY EMPLOYERS (N=35); NO RATINGS BELOW 2,00 (NO. 1-25 ARE EXPLAINED IN TABLE 2)

Figure 2 shows a comparison of the competence importance rating by the instructors and by employers. Results of a t-test show that particularly the competences "1. capacity for analysis and synthesis" (T=-2.94, p=0.005), "4. basic general knowledge" (T=-2.66, p=0.010), and "8. research skills" (T=-4.59, p=0.000) were rated significantly higher by faculty's teaching staff than by employers. Other competences were significantly rated as more important by employers: "9. capacity to learn" (T=2.95, p=0.0005), "17. interpersonal skills" (T=2.51, p=0.015) and "20. intercultural competence" (T=2.21, p=0.032). The results are in line with results of a similar survey of the Ilmenau University of Technology [11].

INTERPRETATION OF FINDINGS

The Importance-Performance Analysis [2, 12] is used as tool for interpreting findings of the questionnaires. According to the ratings competences are subdivided into competences with high importance and a high level of achievement (ratings ≥ 3, +/+), competences of high importance but little achievement (+/-), and competences of low importance. Table 2 compares results of the three applied research instruments. Both, employers and teaching staff rated the following competences as highly important for CS graduates: 1, 2, 6, 9, 10, 11, 16, 19, 21, 22, and 25.

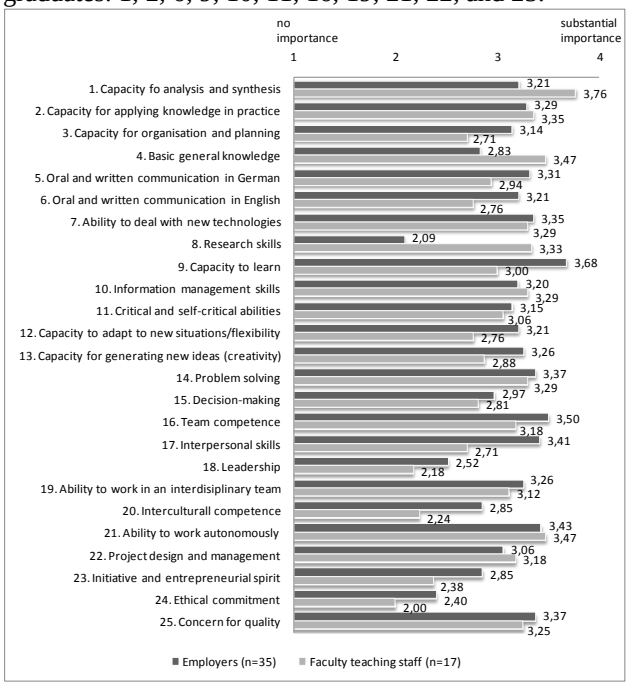

FIGURE 2
IMPORTANCE OF COMPETENCES RATED BY FACULTY TEACHING STAFF COMPARED WITH RATINGS OF EMPLOYERS

However, some discrepancies can be found between the perspectives of the employers and teaching staff: in comparison to employers, instructors rated basic general knowledge and research skills with higher importance. Vice versa, employers rated the capacity for organization and planning, oral written communication in German, the ability to deal with new technology, flexibility, creativity, problem solving, and interpersonal skills as more important. According to the viewpoint of the employers the competences 1, 2, 3, 6, 11, 12, 13, 14, 16, 17, 19, 21, 22, and 25 should be concentrated on (high importance but little achievement) and the competences 5, 7, 9, and 10 should be maintained (high importance and high level of achievement. Competences that should be given low priority (low importance) are according to the employers' ratings the following: 4, 8, 15, 18, 20, 23, and 24. An interpretation of low ratings of some of the competences could be that, for example, research skills (like knowing and applying various research methods) are commonly seen as skills particularly required for working in science. As one would expect for young graduates, team competence appears to have more weight than leadership. Nevertheless, leadership of teams was mentioned in job offers. The comparison of employers' questionnaire results with results of the qualitative content analysis of job offers shows consistency in findings. For example, competences which were rated with high importance by the employers were as well often mentioned in job offers.

TABLE 2
COMPARISON OF FINDINGS

No.	Competences	Job offers	Employers' questionnaire	Teachers' questionnaire	Matrix
1.	Capacity for analysis and synthesis	Thinking skills	+/-	+	✓
2.	Capacity for applying knowledge in practice		+/-	+	✓
3.	Capacity for organisation and planning		+/-		✓
4.	Basic general knowledge			+	
5.	Oral and written communication in German	Communication competence	+/+		✓
6.	Oral and written communication in English	Language skills	+/-	+	✓
7.	Ability to deal with new technologies		+/+		✓
8.	Research skills			+	✓
9.	Capacity to learn	Learning	+/+	+	✓
10.	Information management skills		+/+	+	✓
11.	Critical and self-critical abilities		+/-	+	✓
12.	Capacity to adapt to new situations/flexibility	Flexibility	+/-		
13.	Capacity for generating new ideas (creativity)	Creativity	+/-		
14.	Problem solving		+/-		✓
15.	Decision-making				
16.	Team competence	Team competence	+/-	+	✓
17.	Interpersonal skills	Social competence	+/-		
18.	Leadership				
19.	Ability to work in an interdisciplinary team		+/-	+	✓
20.	Intercultural competence				
21.	Ability to work autonomously	Way of working	+/-	+	✓
22.	Project design and management	Project management	+/-	+	subject-specific
23.	Initiative and entrepreneurial spirit				
24.	Ethical commitment				✓
25.	Concern for quality		+/-	+	✓

Nevertheless, the questionnaire did not highlight that employers search for communicative, highly skilled individuals with presentation and moderation skills, the ability to handle conflicts, criticism, as well as to find consensus, and to act in a poised manner. In this respect, the QCA truly complemented the questionnaire by illuminating those particular competences that were not explicit items in the questionnaire. In a similar vein, the QCA helped us to find out, what thinking skills were required especially from CS graduates, e.g. abstract, analytical, structural, solution-oriented, innovative thinking, and seeing the big picture. In addition to the analysis of generic competences, we used the QCA of job offers to find out, which subject-specific competences are required especially for CS graduates on the labor market. Results show, that work experience of graduates, particularly collected in internships, project work and jobs, as well as software and tool experience are highly required. Software development skills refer mainly to programming skills like Java, C/C++, etc. Economic skills are particularly required from "business informatics" graduates, including knowledge in finance, controlling, logistic, etc.

THE STUDENTS' VOICE ON LEARNING AND COMPETENCES

In a course on business processes and organizational development (2006), we facilitated a group dialogue in which we invited students to elaborate a learning strategy that would optimally meet their goals. In final statements, students, for example, disagree that the instructor is the only

one who knows what students need to learn. Students appreciate the freedom to have influence on their courses and to assume co-responsibility for their courses. Offering freedom to students is risky but can be rewarding for both sides, as giving freedom allows students to focus on their particular strengths and weaknesses during a course. In such a setting the instructor would act as a coach or facilitator of learning. Furthermore, learning to discuss, to present, and to give feedback is favored to be part of the studies. Students seek such learning since they assume that it is essential for their future job and life. Curriculum and learning strategy are interdependent. In the students' point of view, curricula should not be overloaded with content. Many instructors think that their content must be known by students. From the students' point of view there should be core topics and sufficient freedom and a basic coverage of "soft skills" based on the Person-Centered Approach, which focuses on behavior and feelings of the students and can enhance the ability of students to listen, give feedback, to contribute to discussions, and to present their work.

Students' predominantly positive reactions to courses on communication and on soft skills that were facilitated in a person-centered way tend to confirm that students appreciate the generic competences they gain from these courses. Furthermore, most students like to improve their skills in communicating in English. Sample reactions are: "I will remember this course well, since I learned many things that I will not only need in my work but in everyday life. It is really important to understand others well and to be able to listen well", "I enjoyed having experienced something that I can use and make myself aware of each day", "Most important for me was my own personal experience in such a group of nice people, how everybody can thrive by/from sharing with others", "I also improved my English and my ability to work in a group". For a detailed study on the development of team competencies see [13]. An encompassing study of the students' and graduates' view on the curriculum is being prepared.

STRATEGIES FOR INCLUDING STAKEHOLDERS

In this section we discuss three scenarios for transferring findings into the CS curriculum.

I. Workshop with teaching and administration staff

In February 2008 the Research Lab for Educational Technologies organized a workshop on the formulation of student-centered learning goals for the faculty's teaching staff, where 31 persons (~30%) (faculty's teaching staff, dean and employees of the teaching and learning center) attended. During the workshop, curriculum-related issues were the focus of short presentations, sharing in small groups, collaborative elaboration of learning outcomes specifications for selected courses, discussions on staff development and incentives, etc. Some exemplary questions were, for example: Why do we need learning outcomes? Which generic and subject-specific competences do we as the Faculty of Computer Science want to facilitate in CS programs and what challenges arise when formulating and using learning outcomes for curriculum-, module-, and course-goals (e.g. student-centeredness, coordination among learning outcomes, student workload, course concept, and mode of assessment, how to formulate learning outcomes, qualification of teaching staff, etc.). Workshop results served as a basis for further considerations:

- **Professional training must not be neglected:** There is concern that a too heavy focus on generic competences may lead to a decrease of subject-specific competence facilitation. It is more reasonable to find opportunities where generic competences can be consciously facilitated within a subject-specific context in an integrated way.
- **Sensitization of students during the starting phase of study:** Students have to be sensitized for teaching- and learning methods which facilitate generic competences. Currently, many students, particularly students in the starting phase of study, are not used to actively participate in courses. Often, students prefer to get frontal lectures. Thus, already during the beginning phase of study, students should experience what is expected from them.
- **Individuality has to be retained:** By training particular norms for behavior, individuality of our students could get lost. Therefore it is important to consider talents of the individuals, and to know one's strengths and weaknesses. Particularly important are personal attitudes (like willingness and respect), as well as reflection, which need to be stimulated rather than taught.
- **Facilitation of generic competences:** The facilitation of generic competences requires the decision of the faculty's teaching staff community, the willingness and openness of the instructors and students, qualification of the instructors, offer of space, integration throughout the curriculum implementation, and some courses particularly designed for facilitation of particular generic competences.

II. Development and use of a generic-competence matrix in interviews with teaching staff

In a procedure taking into account the described qualifications of CS graduates in the formal curriculum document, the findings of the empirical study discussed above, the five disciplines of a learning organization, the Tuning project, material supplied by the teaching and learning center of the University of Vienna, as well as the Person-Centered Approach, a generic-competence matrix was elaborated. The first version of the matrix included generic competences like critical-/analytical-/systems thinking skills (ability to analyze, ability to abstract, ability to critically question), communication competence (oral and written communication competence as well as ability to communicate with new media), team competence, learning to learn (ability to learn and work in a self-directed way, ability to take responsibility for own learning, deadlines, etc., ability to deal with stress, ability to plan one's own

professional development), and practice transfer (ability to transfer theory/knowledge into practice).

In personal interviews with the faculty's teaching staff subject-specific and generic learning goals (among other issues) were discussed and formulated in which the generic-competence matrix was used to support instructors during reflecting their courses. Instructors marked the appropriate generic competences of their courses in the matrix and explained in which way they are facilitated. Furthermore, instructors extended the matrix with competences which were not yet mentioned, e.g. ethics, internationality, media competence (ability to use the internet and to download, install, and use computer software), problem solving (ability to solve a problem according to a structured way), ability to work academically, etc. Thus, the generic-competence matrix gives an overview of the facilitated competences across the courses of the CS bachelor curriculum. Table 2 (column "Matrix") highlights the competences of the questionnaires which are listed in the matrix.

III. Scenarios of competence facilitation

Basically, there exist various options regarding the development or training of generic competences in academic courses. These competences can be promoted (a) just accidentally without explicit notion or focus; (b) explicitly, but subordinate or on the side of to some other core subject matter, such as team skills in software development; (c) explicitly as main theme of a course such as communication or self-experience, or soft skills in project management. In accordance to other researchers (e.g. [6]) we consider each of the options as valuable contributions and favor a thoughtful mix throughout a curriculum, with focus on option two. A knowledge base of reusable patterns, based on the person-centered approach to technology enhanced learning [14] has been elaborated and is being complemented with new scenarios based on our current teaching/facilitation practice and research [13]. During the workshop on "formulating learning goals" we emphasized the importance of making generic learning goals explicit and transparent. This is because their explicit expression is a precondition to promoting them systematically and incrementally throughout the whole curriculum. For example, several courses include some form of teamwork, but hardly any instructor reflects students' team experience, although this appears to be highly promotive in building team competence [13]. Yet, too much reflection on the same issues could be perceived as redundant. Therefore we are convinced that the effective promotion of generic competences needs to empathically take into account the whole situation, including (at least) the instructor, the course's position in the curriculum, the course's core subject matter, and the particular cohort of learners.

CONCLUSION

The data collection and analysis helped us to get an overview of what employers require and what competences faculty's teaching staff (who often can be thought as employers from academia) sense as very important for CS students. Using these ways of data collection and evaluation in a regular way, results can help us to elaborate, confirm, or to fine-tune the competences which will be (or which are) implemented in our CS curricula. Results of the questionnaire for employers give us an overview of competences rated by the level of importance and achievement. The QCA of job offers helps to inductively find aspects which are not explicitly phrased in the questionnaire for employers. Although there are many similar competence expectations, the difference in ratings by future employers and faculty members raise questions that call for further dialogue to allow for a thoughtful balance of stakeholders' expectations. Thus, the questionnaires, their reflection in an upcoming workshop and the regular personal exchanges (e.g. in terms of workshops, individual meetings, etc.) serves as a "sensing-tool" of "institutional thinking" and "team learning". As further work, we want to integrate our graduates and students experiences into the evaluation mechanism, in order to include all relevant stakeholders into curriculum considerations.

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