

Researching the Development of Team Competencies in Computer Science Courses

Kathrin Figl, Renate Motschnig
University of Vienna

kathrin.figl@univie.ac.at, renate.motschnig@univie.ac.at

Abstract

The capability to effectively work in teams has been a key competence for computer scientists for a long time. Gradually, more attention is paid to developing this generic competence as part of academic curricula. At the University of Vienna, we have conducted and researched a number of different courses that were aimed at developing students' team competencies along with subject specific and/or other generic competencies. The major scientific goal of the accompanying studies was to investigate the influence of person-centered technology-enhanced courses on the development of team knowledge, skills and attitudes. In these courses, emphasis was put on team projects with authentic tasks selected by students, and on providing a cooperative atmosphere.

Students' perceptions were collected in online questionnaires and analyzed using qualitative and quantitative methods. Results indicate that courses had significant effects on the development of team competencies, whereby effects on knowledge and skills were stronger than on attitudes. Courses including reflection were perceived as having stronger impact on team competencies in general than other courses. As expected, sub-skills that were promoted by specific interventions in a course were also perceived as those being most significantly improved as a result of that course.

Index Terms – Computer Science Education, Person-centered Education, Soft Skills Training, Team Competencies

INTRODUCTION

Teamwork in information systems development was important from the early start on; already in 1971 Gerald Weinberg wrote in the classic “The Psychology of Computer Programming” about programming teams and addressed programming as a team effort [1].

A recent study confirmed that for Computer Science graduates [2], team competence is one of the most essential generic competencies. Subject specific student employability profiles state that a graduate in Computing should have the

ability to “work as a development team member, recognising the different roles within a team and different ways of organising teams” [3]. According to the Study “Higher Education and Graduate Employment in Europe”, graduates perceive working in a team as one of the Top 6 competencies required in their current employment [4].

In the context of research on promoting team competencies in engineering education [5-7], this study specifically focuses on the possible contribution of a number of different technology-enhanced courses based on person-centered principles.

THEORETICAL BACKGROUND ON TEAM COMPETENCIES

Team competencies on the individual level are the characteristics a team member has to have to engage successfully in teamwork [8]. They are team-generic, held by individuals and can be transported to other teams. As depicted in Figure 1 team competencies cannot only be characterized in relation to teams, but also in relation to tasks. Task-generic team competencies are transportable to other tasks, e.g. interpersonal or communication skills. For the Computer Science curriculum task-contingent team competencies are especially relevant, since graduates apply in different firms and have to work in new teams in their job. Examples for important task-contingent team competencies, are IT project management skills or knowing specific role responsibilities in a development or user interface design team. Furthermore the development of transportable team competencies, which would be useful in all IT-related jobs, is important for the Computer Science curriculum.

		Relation to task	
		Specific	Generic
Relation to team	Specific	Context-driven	Team-contingent
	Generic	Task-contingent	Transportable

FIGURE 1: TYPES OF TEAM COMPETENCIES [9]

According to Cannon-Bower et al. there are three important types of team core competencies [9]: Knowledge Competencies, Attitude Competencies and Skill Competencies. Knowledge Competencies include e.g. to know about proper behaviour in teamwork, roles in a team or the team's goals. Regarding Attitude Competencies positive attitudes towards teamwork are important for

effective teamwork. Skill Competencies are the learned capacity to interact with other team members and include group decision-making skills, adaptability/flexibility skills, interpersonal relations skills and communication skills [9].

INVESTIGATED COURSES

All courses that were researched into were conducted at the University of Vienna, faculty of Computer Science, as part of the curriculum on Computer Science and business informatics. The only course that was compulsory and part of the bachelor studies was *Web Engineering*. All other courses could be chosen as a part of the students' master curriculum. Thereby the courses on project management, soft skills, and organizational development belonged to the same specialization field and thus were taken by some students within one year, whereby *Project Management* and *Soft Skills* took place during the same term.

Description of courses

Generally, all courses have groups of about 20 participants and their workload is about 5 credits point according to ECTS (European Credit Transfer System). They are conducted in the form of blended learning courses. In order to enhance the scope of learning, courses are accompanied by a virtual space in which written reflections and contact are continued between the face-to-face phases. Except for *Web Engineering* and *Project Management*, the courses employ self-evaluation and peer evaluation of students' projects as a part of grading. In the following paragraphs the investigated courses will be briefly described.

- **Web Engineering (WE):** The course goal of *Web Engineering* is to learn about methods and processes to plan, model and develop web information systems. In the beginning of the term students assigned themselves to teams of three or four. During the term they had to develop a small web application with XML-web services, the specific topic could be chosen according to personal interest. Various analysis and design techniques like UML, XML, PHP or Java should be chosen according to their suitability to support the development process of the particular application. Due to the work in teams cooperative learning should be experienced. The module *Web Engineering* followed a blended learning design mixing face to face and online activities. The students were assigned to create documents or model program parts of their web project and deliver them online on the course platform in each phase. Then they presented the results of the milestone in the laboratory course units. Partner team evaluation was used for quality assurance of the student teams' projects.
- **Soft Skills (SS):** The primary goal of this course is to improve students' competencies in project work situations, in particular in team communication, ad hoc presentations and moderation techniques. The course is based on active, experiential learning and accompanied by an e-learning space for knowledge intensive inputs and

materials. The initial three workshops are moderated by the instructor/facilitator, then students take over. More precisely, student teams (about 3-4 persons) are free to decide on a particular soft skills topic, based on their interest, which they prepare and thereupon they moderate their own workshop. Feedback is given during the workshops as well as in online reaction sheets. Further details on the course can be found in [10] [11].

- **Person Centered Communication (PCC):** The core goal of the course on *Person Centered Communication* is to allow students to experience a person centered atmosphere based on constructive openness, acceptance and empathic understanding and to provide space for unfolding and experiencing their (inter)personal capacities and communication styles in a non-directive, unstructured setting. While the major part of the course takes the form of unstructured encounter groups (self experience groups [12]), three initial workshops are used to sensitize students to issues of active listening, the Person Centered Approach, sharing of ideas in small teams, and the idea of encounter groups.
- **Organizational Development (OD):** The course on organizational development and business processes is aimed at allowing students to experience selected, authentic issues of organizational development and to model business processes on the basis of distinctly expressed strategic goals. The course involves group decision making procedures, team exercises, and small team projects around topics that students select from their perceived need of areas amenable to organizational development. The topics and projects are introduced in three workshops, their presentation, detailed discussion and process reflection take place in four consecutive days co-facilitated by the instructor and an international facilitator [13].
- **Project Management (PM):** In *Project Management* students learn about methods and techniques of planning and controlling IT projects. The theoretical topics include network plans, cost and time estimation of projects, project metrics, quality assurance and program management. Students create and plan projects in small teams, they have to develop project documents and use MS Project for project plans. In the course units practical exercises are done and team work is reflected.

Person-centered didactic baseline

All investigated courses built upon humanistic educational principles as realized in the Person-Centered Approach by Carl Rogers [14]. The Person-Centered teaching and learning style lived in the courses was expressed through activities such as selecting and solving authentic problems in teams, giving constructive oral and written feedback, and incorporating some facet of self-evaluation of students' projects. Essentially, a facilitative, open atmosphere based on person-centered attitudes like congruence, empathic understanding and regard invited sharing, listening and discussion in class as well as online.

A minimum degree of person-centeredness of the instructor, better facilitator, is a necessary precondition for learning to be called person-centered [15] [16]. As shown in Figure 2, students perceived instructors as far beyond the threshold level of 3 on person-centered attitudes in all courses.

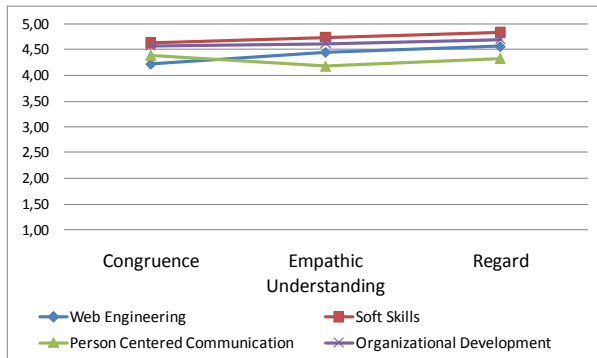


FIGURE 2: RATINGS OF PERSON-CENTERED ATTITUDES OF INSTRUCTORS (N_{TOTAL}=206-453, N_{PER COURSE}=40-211, SCALE WENT FROM 1=“STRONGLY DISAGREE” TO 5=“STRONGLY AGREE”)

Overview of Activities, which promote Team Competencies in Courses

The ways of “teaching” team work competencies ranged from cooperative teamwork in all courses to more explicit emphasis on communication competence in Soft Skills, Person Centered Communication and Organizational Development. Reflections on communication, interaction, atmosphere, feelings and interpersonal relationships and discussion about teamwork issues was a major part of the courses Soft Skills, Organizational Development and Person Centered Communication, whereas in Project Management and Web Engineering it was only a side issue. There the focus lay on subject matter like programming web based systems and practising project management in a small project. Team based projects and team “supervision” by instructors was part of all courses. Students worked on projects or seminar papers in small teams. In Soft Skills specific collaborative exercises were done in-class and online to promote students’ team related skills. In Person Centered Communication encounter groups took place, strongly challenging students’ communicative competencies.

RESEARCH QUESTIONS

This paper deals primarily with the question, which influence academic courses that include didactic teamwork elements can have on various facets of team competencies. Our studies addressed the following research questions:

- Which influence do the courses Soft Skills, Person Centered Communication, Project Management and Web Engineering have on Team Knowledge, Skill and Attitude Competencies? Which Team Skills were explicitly promoted in courses?
- How did the students experience the influence of other courses of the Curriculum on team competencies?

Method and Sample

In the winter term 2006 we asked Master students to assess the influence of the courses Project Management, Soft Skills, Web Engineering and Person Centered Communication on Team Knowledge, Skill and Attitude Competencies in an online questionnaire. Items like for example “Did your knowledge about proper behavior in teamwork change during the above named courses?” could be answered on a 5-point scale (from “declined” to “enhanced”). A total number of 25 students took time to answer the questionnaire, from these 12 took part in all courses.

For a detailed assessment of the courses’ influence on team skills, online course evaluation questionnaires were used in the winter and summer term 2006. A self-constructed questionnaire based on the ALL Model for Understanding Teamwork (D.P. Baker et al., 2005) was constructed for measuring Skill Competencies. Students could directly rate the course’s influence on skill competencies. According to the ALL model, 4 scales with 6-9 items were formulated. Students had to assess on a 5-point scale (from “not at all” to extremely”) whether taking part in a course did have an influence on these competencies. Examples of items were e.g. “Communicate with others effectively” for Communication Competencies, “Work cooperatively with others” for Interpersonal Relations Competencies or “Reallocate tasks” for Flexibility Competencies. Altogether 98 students filled out this questionnaire, with about 14-28 students per course.

Results: Overall Influence of Courses on Team Knowledge, Skill and Attitude competencies

For finding out whether students think if different courses have more or less influence on these competencies, Chi-Square Tests were calculated for all items. Students assessed the changes of team knowledge, skill and attitude competencies to be different for the aforesaid courses (detailed results in Table 1).

TABLE 1: INFLUENCE OF SELECTED COURSES ON TEAM KNOWLEDGE, SKILL AND ATTITUDE COMPETENCIES

	Mean Rank				Chi-Square	df	Asymp. Sig.
	PM	SS	WE	PCC			
Knowledge change	2.04	3.24	1.67	3.04	21.13	3	0.000***
Skill change	2.17	3.25	1.33	3.25	27.37	3	0.000***
Attitude change	2.38	2.92	1.96	2.75	11.49	3	0.009**

As it can be seen in Figure 3 students appraised the effect of Soft Skills and Person Centered communication on these competencies to be higher than the effect of Project Management and Web Engineering (about which students believed the competencies stayed nearly the same). This could be probably due to the fact that Soft Skills and Person Centered Communication both included communicative exercises and addresses these competencies more directly than the other courses. Web Engineering did not offer

explicit training of competencies, students could only learn through their own team experiences.

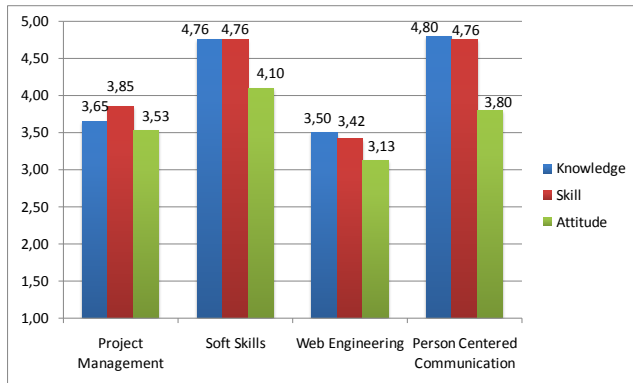


FIGURE 3: INFLUENCE OF SELECTED COURSES ON TEAM KNOWLEDGE, SKILL AND ATTITUDE COMPETENCIES (N=19-25; SCALE WENT FROM 1=“DECLINED” TO 3=“STAYED THE SAME” TO 5=“ENHANCED”)

In further Chi-Square analyses, the differences of the changes in competencies for single courses were examined. Generally, the average opinions about the courses’ influence on attitude competencies are lower than those on knowledge and skill competencies. In Soft Skills and Person Centered Communication students judged the change of attitudes towards teamwork significantly lower than the change of knowledge about appropriate behavior in teamwork ($X^2_{df=2}=16, p=0.000$) and the skills to interact with other team members ($X^2_{df=2}=23, p=0.000$). It seems harder to influence students’ team attitude competencies than to effect knowledge or skill competencies. This may be due to the fact that attitudes in general, are more stable throughout life than knowledge and skills that can be acquired more rapidly through training and receptive learning.

The overall assessment of courses and their influence of team competencies was accompanied by qualitative data. For the three types of team competencies students could also fill in a text field to indicate how they perceived the influence of other courses in their studies on these competencies. The following paragraphs summarize the qualitative results.

Team Knowledge Competencies (23 answers, 878 words):

Nine students wrote that they did not learn anything about proper behaviour in teamwork in other courses in their studies (e.g. „Although in most courses work was done in teams, no behavior useful to teamwork was taught. It stayed the same everywhere”, “In other courses no knowledge was imparted in this respect. Most teamwork at university is only demanding a certain output; the way to it is not looked more closely at. This is the team’s job...”, Further seven students explained that they learned by experience, by teamworking in other courses (e.g. “Basically I would say that every new work in a team has as a result that one learns something more about teamwork.”) Nevertheless, there were three students who wrote that they could learn about proper behavior in teamwork in other courses and gave examples.

Team Skill Competencies (22 answers, 626 words):

Six students wrote that team skill competencies were not clearly referred to in other courses by instructors. Nevertheless, they could learn from experience (Six nominations, e.g.: “I also think that with each additional teamwork these skills improve. Learning effects – one learns from mistakes- in other words, learning by doing”). Four students reported that the courses Soft Skills and Person Centered Communication were exceptional and that those courses dealt with the interaction skills with other team members (“Of course one learns with each course, in which one has to display in a team new skills concerning this matter, however Person Centered Communication has surely contributed proportionally more”, “About Soft Skills I have above all - as the name already says – learned in the course Soft Skills as well as in Person Centered Communication, in other courses this was not so much the case.”) Five students spoke from their experience about how their skills changed during their study (“By increasing professional competence and perhaps also by development of personality over the years, the interacting skill improved” or “In addition, it helps a lot to get experience in different teams, one learns to express oneself more accurately and also to understand the others, to listen more actively and act accordingly.”)

Team Attitude Competencies (17 answers, 412 words):

Five students stated that their attitude stayed the same and three students wrote that they always had a positive attitude and it did not change (e.g.: “My attitude towards teamwork was always positive and there were no experiences that could change my attitude”). Further four students wrote that their opinion improved during the studies by the experience of teamwork (e.g. “My opinion changed in so far that I appreciate teamwork more than previously and I appreciate the advantages of teamwork as well as of single work”). Other students wrote about their positive experiences that also supported their positive opinion. (Four nominations, e.g.: “I never thought about my attitude towards teamwork in other courses, perhaps because I only had positive experiences”).

Table 2 summarizes students’ statements on other courses in their studies.

TABLE 2: PROMOTION OF TEAM KNOWLEDGE, SKILL AND ATTITUDE COMPETENCIES COURSES OF THE COMPUTER SCIENCE CURRICULUM

	Knowledge	Skills	Attitudes	Total
Positive learning effect				
by experience of teamwork in general	7	6	4	17
by Soft Skills and Person Centered Communication	2	4	2	8
by studies in general	0	5	1	6
by specific other courses	3	1	0	4
No learning effect				
no (direct) promotion of competencies in other courses	9	6	2	17
competencies stayed the same	2	2	5	9
attitude was always positive and stayed the same	0	0	3	3

Generally, students reported positive learning effects through working in teams. However, many students had the impression that the development of team competencies was not explicitly addressed in courses and competencies stayed the same. Therefore students especially valued the learning effect of Person Centered Communication and Soft Skills.

Results: Specific Influence of Courses on Team Skill competencies

Students assessed the effects on teamwork skills differently in courses according to a multivariate analysis of variance (Pillai's Trace = 0.27, $F_{16,372} = 1.67$, $p = 0.051$, Partial Eta Squared = 0.067). The enhancement of teamwork skills was generally assessed higher in Project Management and Organizational Development and lower in Web Engineering and Person Centered Communication. It is interesting that when asked about detailed skill competencies students judge courses slightly differently than in the overall assessment presented first. Especially the influence of Project Management was judged higher and the influence of Person Centered Communication lower in comparison with other courses. This may be due to the fact that in Person Centered Communication competencies were promoted at quite implicit, experiential level. Skills were not explicitly trained but acquired from authentic interactions. Consequently, when asked for an overall estimation for the skill change, students responded positively. However, when asked for specific skills like gathering and sharing information or reallocating tasks, students realized that these skills were more explicitly addressed in Project Management.

Highest improvements of Communication Competencies and Interpersonal Relations Competencies in teamwork could be found in Soft Skills, Organizational Development and Project Management. Pairwise comparisons show that in Organizational Development and Project Management Group Decision Making Competencies were supported more strongly than in Web Engineering and in Soft Skills. In addition, Flexibility Competencies were promoted better in Organizational Development and Project Management than in the other courses.

For finding out why the courses' effect on teamwork skills was assessed differently, analysis was expanded to item level. Due to the high amount of items, only selected items showing interesting differences between courses are discussed in detail. A more detailed discussion on individual dimensions and items of team skill competencies can be found in a complementary study, presented in [17].

"Communicating with others effectively" was promoted most strongly in Project Management, Organizational Development and Soft Skills. As expected the increase was lower in Web Engineering in which communicative exercises are not included. Furthermore students judged the effect of the course on "Listen effectively" especially high in Soft Skills, Person Centered Communication and Organizational Development. These courses explicitly

included an in-class exercise on effective listening and reflection on it in oral and written form. Soft Skills and Project Management had the strongest effect on "Attending to non-verbal behavior" as depicted in Figure 4 since course explicitly addressed this competency in practical exercises.

Communication Competency - Item 9: "Attend to non-verbal behaviors"

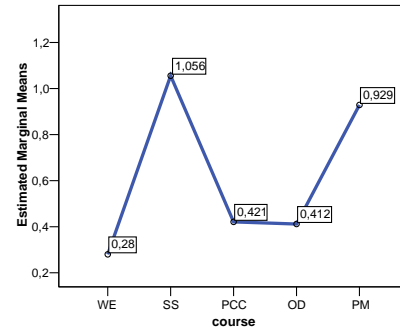


FIGURE 4: INFLUENCE OF COURSES ON "ATTENDING TO NON-VERBAL BEHAVIOR"

Concerning interpersonal relations competencies, "Seeking mutually agreeable solutions" was judged especially high in Soft Skills, Organizational Development and Project Management. In Soft Skills group dialogue and decision making are promoted and practiced along an authentic topics, such as the choice of more specific 'themes' in the very broad realm of communication and soft skills.

"Reallocating tasks" was promoted mostly in PM as depicted in Figure 5, probably because this course included the planning of tasks in a project management software and students had to find possibilities for reallocating tasks in case of occurring problems. In Organizational Development which ranked similarly high on reallocating tasks, the flexible, ad hoc schedule of team presentations required students to flexibly adjust to constraints by time and seminar room equipment.

Flexibility Competency - Item 4: "Reallocate tasks"

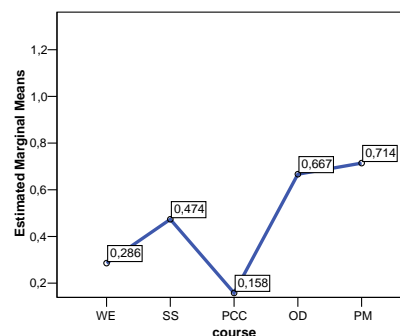


FIGURE 5: INFLUENCE OF COURSES ON "REALLOCATING TASKS"

"Providing and accepting feedback" was influenced less strongly in Web Engineering than in other courses. This could be due to the fact that in the other courses reflection

on teamwork in class and online were included, while this was not the case in Web Engineering.

CONCLUSION

The major scientific goal of this study was to investigate the influence of person-centered interventions in technology-enhanced environments on the development of team competencies of Computer Science students. Through qualitative and quantitative analysis valuable insight could be gained.

As expected, the gain in team skill and knowledge competencies is perceived by students more distinctly than a shift in attitude competencies. Generally, students reported positive learning effects through working in teams during their studies. However, many students had the impression that the development of team competencies was not explicitly addressed in courses. Therefore students especially valued the learning effect of courses like Person Centered Communication and Soft Skills and rated their overall influence on team competencies highest. However when asked for specific team skill competencies like gathering and sharing information or reallocating tasks, students assessed the influence of the course Project Management highest, which explicitly addressed these skills. Finally the study shows that courses like Web Engineering, which solely employ team projects without further elaboration of teamwork experience are distinctly less potent in promoting team competencies.

As a consequence we recommend that any engineering curriculum aimed at promoting team competencies should include courses that provide space for addressing teamwork and team competencies. Furthermore courses including teamwork should also provide space for reflecting on team experiences.

REFERENCES

- [1] Weinberg, G.M., "The psychology of computer programming (silver anniversary ed.)", Dorset House Publishing Co., Inc., 1998.
- [2] Figl, K., "Developing Team Competence of Computer Science Students in Person-Centered Technology-Enhanced Courses (PhD, in work)", in Faculty of Computer Science. Vienna: University of Vienna, 2008.
- [3] Rees, C., Forbes, P., and Kubler, B., "Student employability profiles", The Higher Education Academy, York, 2006.
- [4] Brennan, J., Johnston, B., Little, B., Shah, T., and Woodley, A., "The employment of UK graduates: Comparisons with Europe and Japan. A report to the HEFCE by the Centre for Higher Education Research and Information, Open University", Open University, London, 2001.
- [5] Ruiz, U.B.C. and Adams, S., "A conceptual framework for designing team training in engineering classrooms", Proc. American Society for

Engineering Education Annual Conference & Exposition, Salt Lake City, UT, 2005

- [6] Fellers, J.W., "Teaching teamwork: exploring the use of cooperative learning teams in information systems education", The DATA BASE for Advances in Information Systems, Vol 27, No 2, 1996, pp. 44-60.
- [7] Nance, W.D., "Improving information systems students' teamwork and project management capabilities: Experiences from an innovative classroom", Information Technology and Management, Vol 1, No 4, 2000.
- [8] Baker, D., Gustafson, S., Beaubien, J., Salas, E., and Barach, P., "Medical Teamwork and Patient Safety: The Evidence-based Relation.Literature Review." Vol 05-0053, Agency for Healthcare Research and Quality, Rockville, MD, 2005.
- [9] Cannon-Bowers, J.A., Tannenbaum, S.I., Salas, E., and Volpe, C.E., "Defining competencies and establishing team training requirements", in Team effectiveness and decision making in organizations, R. Guzzo and E. Salas, Eds. San Francisco: Jossey Bas, 1995, pp. 333-380.
- [10] Motschnig-Pitrik, R., "Participatory Action Research in a Blended Learning Course on Project Management Soft Skills", Proc. 36th ASEE/IEEE Frontiers in Education Conference, San Diego, California, 2006
- [11] Motschnig-Pitrik, R. and Figl, K., "Developing Team Competence as Part of a Person Centered Learning Course on Communication and Soft Skills in Project Management", in Frontiers in Education Conference (FIE). Milwaukee: IEEE, 2007.
- [12] Rogers, C.R., "Encounter Groups", Pelican Books, London, 1973.
- [13] Motschnig-Pitrik, R., Kabicher, S., Figl, K., and Santos, A.M., "Person Centered, Technology Enhanced Learning in Action: Action Research in a Course on Organizational Development", Proc. 37th ASEE/IEEE Frontiers in Education Conference, Milwaukee, WI, 2007
- [14] Rogers, C.R. and Freiberg, H.J., "Freedom to Learn", (3rd ed.), Charles E. Merrill Publishing Co., Columbus, Ohio, 1994.
- [15] Aspy, D.N. and Roebuck, F., "A Lever Long Enough", National Consortium for Humanizing Education, Washington, DC, 1976.
- [16] Rogers, C.R., "Freedom to Learn for the 80's", Charles E. Merrill Publishing Company, Columbus, Ohio, 1983.
- [17] Figl, K. and Motschnig-Pitrik, R., "Developing Team Competence in Technology Enhanced Courses", in World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED-MEDIA). Vancouver: AACE, 2007.

AUTHOR INFORMATION

Kathrin Figl, Research Lab for Educational Technologies, University of Vienna, Rathausstrasse 19/9, 1010 Vienna, Austria, kathrin.figl@univie.ac.at

Renate Motschnig, Research Lab for Educational Technologies, University of Vienna, Rathausstrasse 19/9, 1010 Vienna, Austria, renae.motschnig@univie.ac.at