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Social skills as predictors of communication, performance and quality of collaboration in project-based learning

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Abstract The assumption that social skills are necessary ingredients of collaborative learning is well established but rarely empirically tested. In addition, most theories on collaborative learning focus on social skills only at the personal level, while the social skill configurations within a learning group might be of equal importance. Using the integrative framework, this study investigates which social skills at the personal level and at the group level are predictive of task-related e-mail communication, satisfaction with performance and perceived quality of collaboration. Data collection took place in a technology-enhanced long-term project-based learning setting for pre-service teachers.

For data collection, two questionnaires were used, one at the beginning and one at the end of the learning cycle which lasted 3 months. During the project phase, the e-mail communication between group members was captured as well. The investigation of 60 project groups (N = 155 for the questionnaires; group size: two or three students) and 33 groups for the e-mail communication (N = 83) revealed that personal social skills played only a minor role compared to group level configurations of social skills in predicting satisfaction with performance, perceived quality of collaboration and communication behaviour. Members from groups that showed a high and/or homogeneous configuration of specific social skills (e.g., cooperation/compromising, leadership) usually were more satisfied and saw their group as more efficient than members from groups with a low and/or heterogeneous configuration of skills.

Keywords computer mediated communication, group collaboration, project-based learning, social skills.

Introduction

Collaborative learning is an educational approach to teaching and learning that involves groups of learners working together to solve a problem, complete a task or create a product (Dillenbourg, 1999). A typical variant of collaborative inquiry-based learning is project-based learning (PBL) (Loyens, Kirschner, & Paas 2011). Goals of PBL are for students to develop a product for a particular target audience, to work through a given problem, and to evaluate the project and the development process (Blumenfeld *et al*., 1991). PBL meets many requirements for personal skill development in the 21st century. According to Chu *et al*. (2012), more traditional skills like reading, writing and arithmetic are complemented by additional skills such as critical thinking and problem solving, communication, information and media literacy, collaboration, teamwork and leadership,

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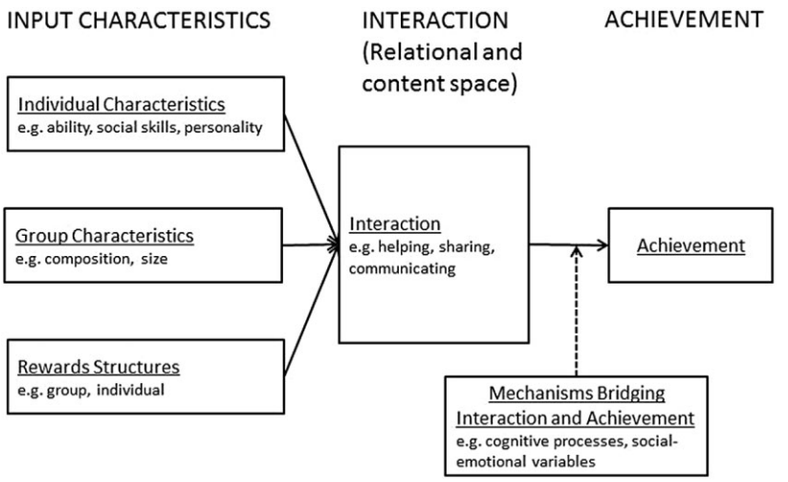

Figure 1 Input-Interaction-Achievement System in Collaborative Learning Groups (Modified from Webb, 1982)

creativity and innovation, career and learning self-reliance, cross-cultural understanding, and computer and information and communication technologies literacy. According to a report from the University of Indianapolis (2009), PBL has been shown to benefit a variety of students in developing collaborative skills. For example, through PBL, elementary students learned to understand multiple perspectives (ChanLin, 2008) and conflict resolution skills (ChanLin, 2008), special education students developed social skills such as patience and empathy (Belland, Ertmer, & Simons, 2006), and low-ability students demonstrated initiative, management, teamwork and conscientiousness as they worked in groups (Horan, Lavaroni, & Beldon, 1996). However, positive effects were found to depend largely on the quality of the group process (Achilles & Hoover, 1996; Weng-yi Cheng, Shui-fong, & Chung-yan Chan, 2008).

In this paper, the term 'skill' refers to the ability to perform a certain class of behaviour (e.g., the behaviour 'being able to organize things' as an expression of leadership skill). Following Rubin, Booth, Rose-Krasnor, and Mills (1995) and Rose-Krasnor (1997), a person has a high level of social skills when he/she acts effectively in social interactions. That means one is able to satisfy one's own goals and personal needs while maintaining positive relationships with others in specific contexts. As such, this definition does not tell us which social skills lead to an effective coordination of needs in a particular social setting, for example, in collaborative PBL.

Peterson (1997), for example, names five interpersonal skills particularly relevant for collaborative learning: consensus capacity, discussion skills, skills concerning evaluation and feedback formulation, conflict resolution skills and leadership ability. Heuermann and Krützkamp (2003) mention the importance of empathy, team building and sustaining skills, the capacity to formulate feedback, to mediate conflicts and to argue about common group goals and norms. At the moment, the suggestions of Peterson (1997) and Heuermann and Krützkamp (2003) remain prescriptive and empirically untested.

The quality of the group process is potentially mediated and moderated by a host of intrapersonal, interpersonal and environmental variables (see Cohen & Bailey, 1997; Wilkinson & Fung, 2002). Webb (1982; see Figure 1), for example, proposed an integrative framework that differentiates between various influences on the group process, among them are individual characteristics such as ability, social skills or personality factors, group characteristics such as the compositional criteria used for group formation and reward structures (e.g., individual grading or grading the group as a whole). Group interaction, finally, translates into achievement by way of the quality of cognitive processes (e.g., whether the group is able to cognitively restructure the learning material or to resolve conflicts of opinion productively) and the presence of certain social-emotional variables (specifically high motivation, low anxiety and high satisfaction).

Purpose of the study

The study uses a multi-level approach to investigate the role of social skills as individual and group

characteristics in PBL (see Webb, 1982). As an individual characteristic, social skills are conceptualized as abilities that differ between students. As a group characteristic, social skills are viewed as group composition variables, that is, groups differ according to whether group members on average possess a high or a low level of certain social skills and whether group members are among themselves similar or dissimilar in their manifestation of certain social skills. With similar manifestations in a social skill a group is called homogeneous, whereas with dissimilar manifestations it is called heterogeneous. The average level of a social skill is conceptually independent of the within-group variability of the same social skill, thus yielding two measures to capture the social skill dynamics or configurations within a group. Social skills as individual and group characteristics have been used in this study to predict interaction (i.e., communication behaviour) and achievement (i.e., satisfaction with performance and self-rated quality of collaboration).

Definition of social skills

We understand the term 'skill' to refer to the ability to perform a certain class of behaviour (e.g., the behaviour 'being able to organize things' as an expression of leadership skill). Following Rubin *et al.* (1995) and Rose-Krasnor (1997), a person possesses a high level of a social skill when he/she acts effectively in a specific type of social situation. Effectivity is defined as the ability to satisfy one's own goals and personal needs while maintaining positive relationships with others in specific contexts (Rose-Krasnor, 1997). As such, this definition alone does not tell us what social skills lead to an effective coordination of needs in a particular social setting, for example, in collaborative PBL. But the definition at least delineates two types of behaviours that might be relevant: (a) behaviours that help satisfy one's goals (e.g., leadership, assertiveness, initiative, etc.) and (b) behaviours that serve to build and maintain good relationships with others (e.g., being prosocial, being able to compromise and solve interpersonal conflicts, etc.).

Social skills in collaborative learning

On a prescriptive level, Peterson (1997) names five interpersonal or social skills particularly relevant for collaborative learning: consensual decision-making skills, dialogue and discussion skills, maintenance skills (this includes giving evaluative feedback about group members' commitment and contribution to the project, the affective climate within the group, team's efficacy or group's ability to handle conflict), conflict resolution skills and team leadership skills. Similarly, Heuermann and Krützkamp (2003) mention the importance of empathy, team building and team sustenance skills, that is, the capacity to formulate feedback, to mediate conflicts, and to argue about common group goals and norms. Both researchers argue that these skills must be learned prior to the implementation of PBL or other forms of collaborative learning (Peterson, 1997). However, hardly any studies investigated the social skills most predictive of group performance and achievement empirically and systematically (see van den Bossche, Segers, & Kirschner, 2006, for an overview). Furthermore, those few studies have focused almost exclusively on the skill levels of individuals, neglecting that group success and collaboration are as much dependent on personal skills as on the skill configuration within the whole group. To illustrate this: Without doubt it is helpful to have members with good leadership skills in a group, who are then capable of structuring and organizing things. But what picture emerges when all group members are equally skilled and motivated to lead? Will there ensue power struggles that diminish group effectiveness (see Peterson, 1997)? And what happens when most group members are dependent and passive? Will they be readily led through the group process, unable to detect management and agenda setting errors committed by a leader? Consequently, the picture does change when we reframe social skills within the group context.

Successful collaborative learning

A large variability in the effectiveness of collaborative learning groups exists even when the assigned task and the prior knowledge of group members are held constant (Barron, 2003). Up to date, there have been two strands of research aiming at uncovering the factors that contribute to successful collaboration: (a) group composition studies and (b) group process studies.

A tentative picture emerging from group composition studies is that homogeneous group compositions pose an advantage over heterogeneous group composi-

tions provided that the variable in question is positively associated with the learning or collaborative processes, for example, high cohesiveness or high sociability (Cohen & Bailey, 1997; Gully, Devine, & Whitney, 1995; Holen, 2000; Hsu, Chou, Hwang, & Chou, 2008). Results emerging from group process studies show that beneficial interaction processes are: (a) giving and receiving adequate help (Webb, 1982; Webb, Nemer, & Zuniga, 2002) and (b) psychological safety, openness and flexibility (Barron, 2003; Holen, 2000; van Gennip, Segers, & Tillema, 2009; Webb *et al*. 2002).

Hypotheses and research question

So far, we have argued that individual and group characteristics should not be seen in isolation. In the case of social skills, grouping individuals with high, low or mixed skill levels may lead to different dynamics on the group level. Input characteristics influence the type of interaction that takes place within a group. If, for example, group members do not possess skills for social initiative or prosocial behaviour, supportive and positive communicative behaviour might not take place. Input characteristics as distal factors and interaction as proximal factor influence group achievement. However, as shown, only limited empirical research exists proving the usefulness of certain social skills in collaborative learning and virtually no research that has considered social skills as characteristics of collaborative learning groups. Our research was thus guided by the following two research questions:

- Which personal social skills are predictive of communication behaviour, satisfaction with performance and self-rated quality of collaboration in a collaborative PBL setting?
- Which group configurations of social skills (average level and within-group variability) are predictive of communication behaviour, satisfaction with performance and self-rated quality of collaboration in a collaborative learning setting?

Method and sample

The present study was conducted with 155 participants in two cohorts (2009 and 2010) at the Pädagogische Hochschule Bern (University of Teacher Education). The students participated in a mandatory media education course and as a course requirement had to work on a media project during 3 months. They were free to select their group mates (group size was two or three students). The project they had to fulfil was the creation of media-enhanced lessons for students in lower secondary education. There was no mandatory communication channel for the project, but all e-mail communications between group members from selected groups were captured and recorded automatically.

At the start of the PBL curriculum, students (92 female, 63 male, average age: 24.3 years; $SD = 3.48$) completed a questionnaire (t1) self-assessing various social skills. Consistent with our definition of social competence, targeted skills covered the spectrum of agentic, goal-achieving behaviours to communal, relationship-maintaining behaviours (see Rose-Krasnor, 1997). At the end of the project, students were given a second questionnaire (t2) tapping their satisfaction with their group's performance and their judgements about the quality of collaboration. No significant differences concerning the responses of the two cohorts (2009 and 2010) could be detected: *t*-test range of values between*:* $t(133) = -1.3$, $p = 0.19$ (variable: satisfaction with performance) and $t(144) = 1.0$, $p = 0.99$ (variable: assertiveness). Therefore, the two cohorts were pooled for further analysis.

Self-assessment of social skills (t1)

The questionnaire addresses social skills as individual input characteristics according to Webb (1982) and was inspired by several standardized instruments from the field of child and adolescent psychology (Gresham & Elliott, 1990; Ladd & Profilet, 1996; Tremblay, Vitaro, Gagnon, Piche and Royer, 1992; Walker & McConnell, 1988). The questionnaire contained 16 self-referential statements which students rated on a 4-point scale [*do not agree at all* (1) – *totally agree* (4)]. In order to reduce complexity for the analysis, the 16 items of the questionnaire (t1) were reduced to five factors using principal component analysis (equamax rotation). The five extracted factors explained 66.9% of the variance. Items were assigned to a factor when their factor loadings were above 0.40. All factor scales had medium to satisfactory internal consistencies (Cronbach's α).

- Cooperation/compromising: for example, getting along with other people, being able to collaborate, being able to compromise, being able to mediate in conflict situations (Cronbach's $\alpha = 0.69$).

Table 1. Conceptual Overlap between the Social Skills Factors Proposed by Peterson (1997) and Heuermann and Krützkamp (2003) and the Social Skills Factors Used in the Present Study

		Social skills (predictors)				
		Cooperation/ compromising	Prosocial behaviour/ openness	Social initiative	Leadership	Assertiveness
Peterson (1997)	Consensual decision-making skills	X				
	Dialogue and discussion skills	X				
	Maintenance skills	X				
	Conflict resolution skills	X	X			
	Team leadership skills			X	X	
Heuermann and Krützkamp (2003)	Empathy		X			
	Team building			X	X	X
	Team sustenance skills	X			X	

- Prosocial behaviour/openness: for example, openness to other people's opinions, being able to take someone else's perspective, being ready to help someone (Cronbach's $\alpha = 0.60$).
- Social initiative: for example, initiating conversations, being able to make contact with other people easily (Cronbach's $\alpha = 0.71$).
- Leadership: for example, being able to organize things, being good at taking on the leadership role (Cronbach's $\alpha = 0.63$).
- Assertiveness: for example, setting clear limits to inappropriate demands, standing up for one's rights, feeling self-confident (Cronbach's $\alpha = 0.65$).

Our empirically derived factors of social skills showed a certain conceptual overlap with the social skills proposed by Peterson (1997) and Heuermann and Krützkamp (2003) to be beneficial for collaborative learning. The highest overlap can be found with the factor cooperation/compromising (see Table 1).

Satisfaction with performance and self-rated quality of collaboration (t2)

At the end of the project, students completed a second short questionnaire tapping satisfaction with performance (i.e., 'I was satisfied with group performance') and the perceived quality of collaboration (i.e., group efficiency, degree of division of responsibilities, centrality of leadership, mutuality of support, group harmony and permissibility to bring in one's ideas) on a 4-point scale [*do not agree at all* (1) – *totally agree* (4)]. These items were formulated specifically for this research. Perceived quality of collaboration and satisfaction with performance were considered achievement variables (according to Webb, 1982) because they represent intended goals of collaborative learning.

Caption and processing of the interchanged e-mail communication

In order to detect groups' communication patterns, for 33 out of the 60 project groups ($N = 83$) the e-mail communication was recorded (16 groups of the first cohort and 17 of the second cohort). In groups for which e-mail communication was captured, the participants implemented a rule on their e-mail server which copied the incoming e-mail from the project partners, then forwarded and collected it on another server. A total of 970 e-mails were captured this way (mean = 29.4 e-mails per group). Participants indicated that for them e-mail was an important communication channel for project work. Groups had to agree in advance to the recording and use of their e-mail communication for scientific purposes. Other than communicating via e-mail, groups also met face-to-face and used other communication channels such as phone, SMS or voice over IP to interact. No data concerning these communication channels have been recorded.

Once the student projects were finished, all collected e-mails were analysed using qualitative content analysis (Mayring, 2007) and the software MAXQDA™ (Sozialforschung GmbH, Berlin). A coding scheme proposed by Weinberger and Fischer (2006) was applied to the material. Four coders were trained until an intercoder reliability of Cohen's kappa (k) = 0.71 was

reached. In their coding scheme, Weinberger and Fischer allow for the analysis of multiple dimensions of argumentative knowledge construction in computer-supported collaborative learning. Effective collaborative learning may be measured as the amount of communication containing elements related to the co-construction of knowledge. Codings distinguish between three process dimensions of co-construction of knowledge: (a) the epistemic dimension encompasses arguments that are steps towards solving the learning task; (b) the argument dimension includes the way in which arguments are formally presented (e.g., simple arguments without explanation or arguments with an attached explanation or example); and (c) the dimension of social modes of co-construction which represents how learners interact with each other and how they relate their own arguments to arguments of their partners (e.g., one learner brings in a lot of new project-related arguments while other group members react to the new arguments or build their arguments on previously mentioned statements) (see Weinberger & Fischer, 2006). All codings relating to the three dimensions of knowledge co-construction were aggregated. In our 35 analysed groups, a total amount of 1063 codings in all e-mail communications concerned knowledge co-construction. For our research, we enhanced Weinberger's scheme with codings relating to project management like 'giving time guidelines', 'arranging face to face meetings', 'requests to perform tasks' and 'information related to work distribution'. On the basis of 970 e-mails, a total of 1263 codings were found referring to project management.

Analyses

In our research design, individuals are nested within learning groups. As we were interested in the predictive power of individual (level 1) and group (level 2) level variables on satisfaction with performance, perceived quality of collaboration and e-mail communication behaviour, a multi-level approach was pursued using the hierarchical linear modeling software HLM 6.02 (Raudenbush, Bryk, & Congdon, 2004). This was done for all interaction, performance and achievement variables for which the intraclass correlation coefficient (ICC) demonstrated significant variance at level 2. Significant variance between groups was found for satisfaction with performance [ICC = 0.47, $\chi^2(58) = 180.27$, $p < 0.001$], group efficiency [ICC = 0.29, $\chi^2(58) = 113.39$, $p < 0.001$], degree of division of responsibilities [ICC = 0.25, $\chi^2(58) = 103.58$, $p < 0.001$], centrality of leadership [ICC = 0.35, $\chi^2(58) = 131.60$, $p < 0.001$], mutuality of support [ICC = 0.27, $\chi^2(58) = 107.15$, $p < 0.001$], co-construction [ICC = 0.71, $\chi^2(31) = 242.92$, $p < 0.001$] and project management [ICC = 0.62, $\chi^2(31) = 164.74$, $p < 0.001$]. Two outcome variables had non-significant ICCs, that is, group harmony [ICC = 0.10, $\chi^2(58) = 69.00$, ns] and permissibility to bring in one's ideas [ICC = 0.00, $\chi^2(58) = 45.79$, ns]. These two outcome variables were analysed with multiple linear regression models. The basic multi-level regression equations were as follows:

$$\text{level 1: outcome} = \beta 0 + \beta 1\,(\mathbf{social\ skill}) + r0$$

$$\begin{aligned}\text{level 2: } \beta 0 = {} & \gamma 00 + \gamma 01\,(\boldsymbol{social\ skill\ level}) \\ & + \gamma 02\,(\boldsymbol{social\ skill\ variability}) \\ & + \gamma 03\,(\text{interaction level} \times \text{variability}) \\ & + u0\end{aligned}$$

$$\beta 1 = \gamma 10 + u1$$

Variables in bold are group mean centred and variables in bold and italics grand mean centred.

The configuration of the investigated social skills within learning groups was modeled on level 2 using group members averaged skills as indicators of social skill level, the standard deviation of social skills within the group as indicator of social skill variability, and the interaction between level and variability.

Results

Descriptive statistics

Table 2 shows the means, standard deviations and correlations for all variables at level 1. Variables relating to the same construct, that is, social skills, group process (achievement and performance) and e-mail communication behaviour, show low to moderate significant correlations, while significant correlations between variables from different constructs are rare. This could be evidence for method artefacts which have to be taken into consideration when interpreting the results.

Table 2. Means, Standard Deviations and Correlations for All Variables at Level 1

Variables	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Exchange orientation	3.38	0.35	–													
2. Prosocial behaviour/empathy	3.52	0.56	0.50***	–												
3. Social initiative	3.21	0.36	0.24**	0.15	–											
4. Leadership skills	3.08	0.59	0.28***	0.11	0.27***	–										
5. Assertiveness	3.28	0.43	0.21**	0.19*	0.40***	0.16*	–									
6. Satisfaction with performance	3.48	0.71	0.14	0.02	–0.07	0.06	0.01	–								
7. Efficiency of collaboration	3.59	0.65	0.03	–0.16	0.06	0.08	–0.04	0.48***	–							
8. Division of responsibility	3.43	0.66	0.12	–0.05	0.07	0.07	0.06	0.31***	0.53***	–						
9. Centrality of leadership	2.43	0.85	–0.02	0.00	–0.00	0.08	–0.08	0.06	–0.01	–0.03	–					
10. Mutual support	3.59	0.59	0.11	–0.07	0.04	–0.03	–0.01	0.33***	0.66***	0.46***	–0.03	–				
11. Group harmony	3.83	0.44	–0.06	–0.13	–0.06	–0.07	–0.05	0.29***	0.63***	0.41***	0.02	0.61***	–			
12. Bringing in one's ideas	3.59	0.51	–0.07	–0.09	–0.08	0.09	–0.15	0.26**	0.42***	0.35***	0.18*	0.34***	0.27***	–		
13. Project management	15.20	13.01	–0.01	–0.05	0.12	0.22*	0.10	–0.21	–0.18	–0.04	0.11	–0.06	0.01	–0.01	–	
14. Co-construction	12.60	13.62	0.02	–0.06	0.08	0.14	0.05	–0.10	–0.02	0.02	0.06	0.06	0.07	0.04	0.81***	–

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Multi-level and multiple regression statistics

Tables 3 and 4 summarize all significant and marginally significant effects between social skills and satisfaction with performance, perceived quality of collaboration and e-mail communication behaviour. The following sections give a more detailed overview of the various effects.

Of the five social skills (cooperation/compromising, prosocial behaviour/openness, social initiative, leadership and assertiveness), three were on the individual level predictive of the outcome of specific achievements, that is, students with higher scores in leadership regarded their group interactions as less mutually supportive and students with higher scores in assertiveness thought there had been less permissibility of bringing their ideas into the work process. Leadership and prosocial behaviour/openness had furthermore a positive relationship with e-mail communication behaviour: students with higher scores in leadership sent more project-management-related information to other group members and made more contributions concerning the co-construction of knowledge. Furthermore, students who were more prosocial and open communicated more often in the co-constructive mode.

On the group level, every social skill configuration was associated with at least one performance, achievement or interaction variable, and there were several interaction effects between the skill level in a group and the within-group skill variability.

Cooperation/compromising

When the level of cooperation/compromising within a group was high and at the same time homogeneously distributed, group members reported more efficient collaboration and a clearer division of responsibilities than groups with other configurations (see Figures 2 and 3), but a lower permissibility of bringing in one's ideas (the last result holds also for groups with a heterogeneous skill configuration). Congruent with the above findings, students in groups with a high but heterogeneous distribution of cooperation/compromising reported less group harmony. No effects could be found with respect to satisfaction with performance, centralized leadership and mutual support.

Table 3. HLM Results for Satisfaction with Performance, Quality of Collaboration and e-mail Communication Behaviour

		Satisfaction with performance		Efficiency of collaboration		Division of responsibility		Centrality of leadership		Mutual support		Project management		Co-construction	
		Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*	Coefficient	*t*
Exchange orientation															
Level 1	Individual	0.03	0.13	0.08	−0.37	0.11	0.43	0.14	0.64	−0.08	−0.39	1.45	0.36	3.84	1.08
Level 2	Mean	0.52	1.40	0.06	0.18	0.33	0.99	−0.58	−1.24	0.21	0.65	0.04	0.00	−9.89	−1.12
	Variability	−0.24	−0.55	−0.32	−0.92	−0.17	−0.50	−0.28	−0.57	−0.21	−0.60	16.51	1.18	9.57	0.68
	Mean × Variability	−0.18	0.12	−2.77*	−2.02	−2.32*	−1.91	−0.33	−0.01	−1.38	−1.28	−3.27	−0.09	−69.05	−1.41
Prosocial behaviour/empathy															
Level 1	Individual	−0.03	−0.19	−0.11	−0.56	0.05	0.24	0.08	0.49	−0.14	−0.76	3.19	0.93	5.99**	2.48
Level 2	Mean	0.11	0.41	−0.51	−1.37	−0.06	−0.18	−0.15	−0.30	−0.26	−0.90	−4.35	−0.56	−11.34	−1.45
	Variability	−0.43	−1.17	−0.46	−1.54	−0.11	−0.33	−1.03†	−1.86	0.01	0.03	20.73*	2.29	10.35	0.99
	Mean × Variability	−2.04†	−1.68	−2.02*	−2.18	−2.86*	−2.22	2.91	1.17	−1.42	−1.26	20.40	0.63	33.76	0.98
Social initiative															
Level 1	Individual	−0.07	−0.84	0.10	1.36	0.12	1.18	0.14	1.02	0.01	0.16	2.84	1.18	2.01	1.00
Level 2	Mean	−0.17	−0.83	0.07	0.39	0.08	0.43	−0.50†	−1.73	0.07	0.43	−0.38	−0.06	−0.90	−0.13
	Variability	−0.13	−0.42	0.26	1.44	0.27†	1.68	−0.81***	−3.49	0.26	1.65	−1.14	−0.20	3.53	0.49
	Mean × Variability	0.33	0.30	−0.11	0.63	0.77	1.49	−0.50	−0.58	−0.36	−0.70	−50.44†	−1.88	−50.91	1.68
Leadership skills															
Level 1	Individual	−0.06	−0.60	−0.14	−1.24	−0.06	−0.62	0.12	0.91	−0.18†	−1.85	5.21**	2.92	2.98*	2.34
Level 2	Mean	0.35	1.58	0.55**	2.76	0.35†	1.72	0.28	0.93	0.25	1.35	6.53	1.14	7.50	1.19
	Variability	0.19	0.61	−0.18	−0.86	0.02	0.11	0.85**	2.84	−0.18	−1.02	−5.07	−0.82	−5.77	−0.81
	Mean × Variability	0.47	0.63	0.28	0.54	0.39	0.58	0.40	0.48	−0.60	−1.50	21.46	0.73	11.65	0.30
Assertiveness															
Level 1	Individual	0.08	0.49	−0.20	−1.16	−0.09	−0.49	−0.21	−0.96	0.01	0.10	1.89	0.70	0.71	0.28
Level 2	Mean	−0.06	0.29	0.10	0.50	0.24	1.11	−0.08	−0.30	−0.02	−0.10	1.43	0.17	−1.53	−0.21
	Variability	0.28	0.57	0.16	0.54	−0.17	−0.62	−0.83†	−1.88	0.08	0.33	−2.08	−0.22	3.66	0.47
	Mean × Variability	1.08	0.64	0.80	0.70	−0.17	−0.14	2.64	1.42	0.10	0.09	−44.46	−0.91	−72.44†	−1.76

†$p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 4. Multiple Regression Results for Group Harmony and Bringing in One's Ideas

		Group harmony				Bringing in one's ideas			
		B	SEB	β	R^2	B	SEB	β	R^2
Exchange orientation					0.053*				0.012
	Individual	–0.037	0.140	–0.030		0.012	0.170	0.009	
	Mean	–0.450	0.255	–0.229†		–0.562	0.304	–0.249†	
	Variability	–0.288	0.231	–0.144		–0.320	0.277	–0.110	
	Mean × Variability	–2.866	0.956	–0.303**		–1.554	1.122	–0.143	
Prosocial behaviour/empathy					–0.004				–0.012
	Individual	–0.183	0.140	–0.146		–0.041	0.162	–0.029	
	Mean	–0.029	0.230	–0.014		–0.264	0.264	–0.114	
	Variability	–0.062	0.232	–0.024		0.095	0.265	0.033	
	Mean × Variability	–0.945	–0.980	–0.087		–0.496	1.120	–0.040	
Social initiative					–0.006				0.001
	Individual	0.001	0.092	0.001		–0.073	0.105	–0.080	
	Mean	–0.055	0.158	–0.041		–0.054	0.178	–0.036	
	Variability	0.193	0.124	0.147		–0.133	0.140	–0.090	
	Mean × Variability	0.200	0.435	0.045		0.479	0.490	0.095	
Leadership skills					–0.008				–0.016
	Individual	–0.122	0.081	–0.158		0.071	0.097	0.080	
	Mean	0.237	0.159	0.157		0.058	0.191	0.033	
	Variability	–0.024	0.132	–0.016		0.122	0.153	0.073	
	Mean × Variability	–0.080	0.423	–0.017		–0.335	0.486	–0.063	
Assertiveness					–0.004				0.056*
	Individual	–0.191	0.124	–0.186		–0.366	0.139	–0.314**	
	Mean	0.307	0.187	0.204		0.387	0.209	0.226†	
	Variability	0.043	0.202	0.019		–0.504	0.224	–0.201*	
	Mean × Variability	0.697	0.841	0.077		–0.515	0.932	–0.050	

†$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

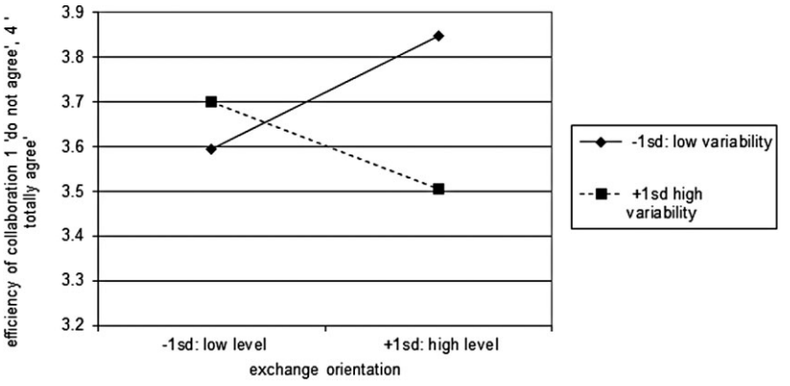

Figure 2 Interaction Effect Between Average Exchange Orientation (Mean) and Variability of Exchange Orientation Within Groups on Perceived Efficiency of Collaboration

Prosocial behaviour/openness

Students' satisfaction with performance and the perceived efficiency of collaboration was lower when the average level of prosocial behaviour/openness in the group was high and heterogeneously distributed. In addition, these groups displayed a clearer division of responsibilities (see Figure 4). Members from groups with a homogeneous distribution of prosocial behaviour/openness, independent from the average skill level, agreed more often to have had a centralized leadership established, that is, someone who was in charge. No effects could be found with respect to mutual support, group harmony and permissibility of bringing in one's ideas. Groups that were heterogeneous with respect to prosocial behaviour/openness wrote more messages related to project management than more homogeneous groups.

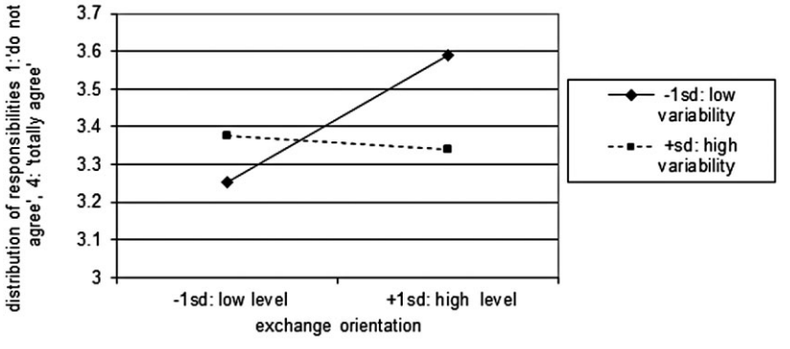

Figure 3 Interaction Effect Between Average Exchange Orientation (Mean) and Variability of Exchange Orientation Within Groups on Division of Responsibilities

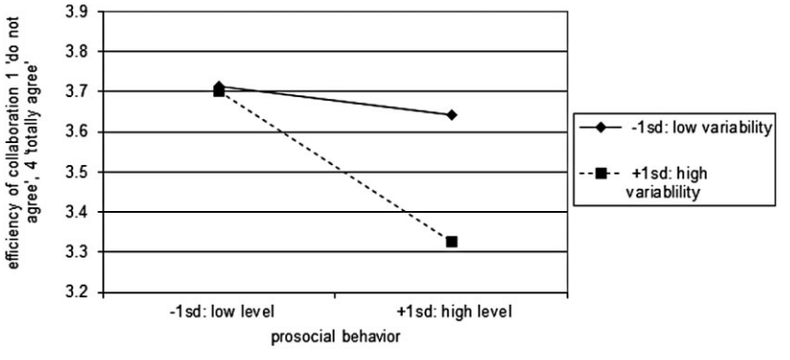

Figure 4 Interaction Effect Between Average Prosocial Behavior (Mean) and Variability of Prosocial Behavior Within Groups on Efficiency of Collaboration

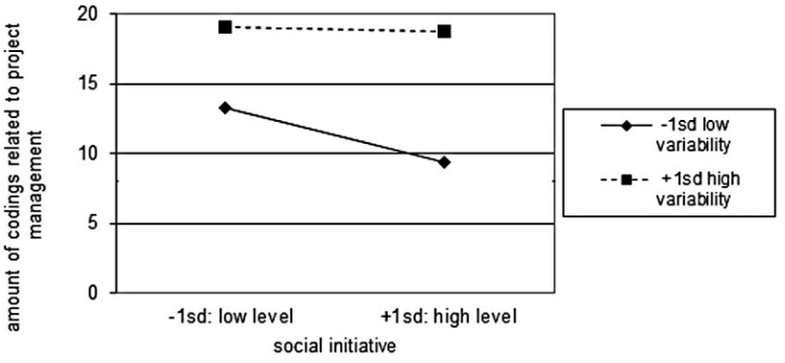

Figure 5 Interaction Effect Between Average Social Initiative (Mean) and Variability of Social Initiative Within Groups on The Amount of Codings Related to Project Management

Social initiative

When group members differed in their levels of social initiative and when the average skill level in the group was high, more project-management-related information was exchanged (see Figure 5). Greater interindividual differences in social initiative were furthermore associated with more division of responsibilities and less centrality of leadership, the latter being also less frequent with higher average levels of social initiative. No effects could be found with respect to satisfaction with performance, efficiency of collaboration, mutual support and co-construction.

Leadership

Students from groups that were on average high in leadership reported more efficient collaboration and a clearer division of responsibilities. Furthermore, groups with a heterogeneous configuration of leadership more often had a centralized leadership established than groups with other configurations. No effects could be found with respect to mutual support, group harmony and permissibility of bringing in one's ideas.

Assertiveness

The permissibility of bringing one's ideas into the work process was perceived to be higher when the average assertiveness in the group was high or when heterogeneity of assertiveness within the group was low. Groups that showed a homogeneous configuration with respect to assertiveness more often had a centralized leadership in place. No effects could be found with respect to satisfaction with performance, efficiency of collaboration, division of responsibilities, mutual support and group harmony. However, a trend for an interaction effect was detected: When the average level of assertiveness was high, homogeneous groups interchanged more co-constructive messages than heterogeneous ones, but when the average level was low the difference was the other way around, that is, heterogeneous groups exchanged more co-constructive messages than homogeneous ones (see Figure 6).

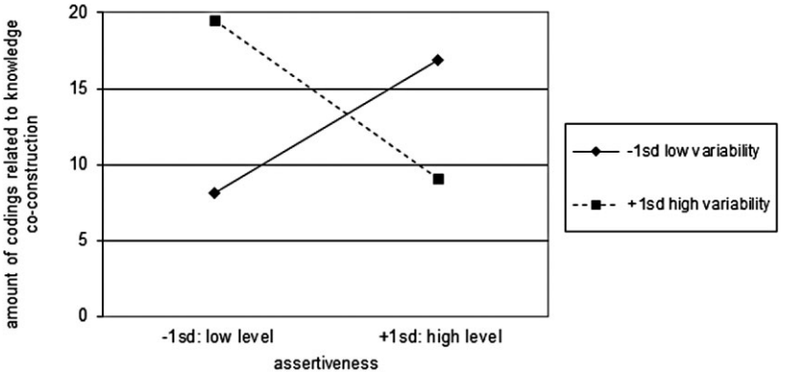

Figure 6 Interaction Effect Between Average Assertiveness (Mean) and Variability of Assertiveness Within Groups on Amount of Codings Related to Knowledge Co-Construction

Discussion

In our study, we analysed whether social skills and/or group configurations based on these social skills were associated with various interaction, performance and achievement variables. To our knowledge, such an approach has not been followed to date in the research literature on collaborative learning. Instead, social skills are traditionally postulated as prerequisites or treated as by-products of group learning. However, on an empirical basis, it is unclear which social skills are the most important ones for collaboration and how they are connected to group performance and achievement. Furthermore, research exists investigating the ability of homogeneous and heterogeneous groups or school classes (see Johnson & Johnson, 1999; Lou, Abrami, & Spence, 2000; Wang & Lin, 2006; Webb, Nemer, Chizhik, & Sugrue, 1998) demonstrating convincingly the importance of group composition for the collaborative process and the interpersonal interaction. Therefore, it seems plausible that groups composed of students with either similar or dissimilar levels of specific social skills show differential achievement and performance. What these differential associations might be remains in the dark.

In our research, achievement and performance variables displayed significant intercorrelations. Satisfaction with performance and perceived efficiency of collaboration were rated higher when there was more division of responsibilities, more mutual support, more group harmony and when there was a higher permissibility of bringing in one's ideas. No associations existed with centralized leadership. While the associations with mutual support, group harmony and permissibility to bring in one's ideas are quite expected (see, e.g., the work on helping by Webb, 1982 and Webb *et al*., 2002 and on psychological safety, openness and flexibility by Barron, 2003; Edmondson, 1999; Holen, 2000 and Webb *et al*., 2002), the positive correlation between satisfaction with performance and perceived efficiency of collaboration on one hand and the division of responsibilities on the other hand conflicts with the perception of collaborative learning as an interdependent task (Dillenbourg & Jermann, 2007; van Gennip *et al*., 2009). However, it may be that interdependence is just a special case of achieving successful group learning. In cases where it is possible to segment tasks, when there are clear and delineated roles in the work process or when contextual parameters such as time pressure or concurrent workload force upon the students a careful management of resources, divisions of responsibilities may lead to more efficiency and even to a greater empowerment of individual group members by giving them a visible share in their group's achievement.

No significant correlations were found between e-mail communication behaviour and performance and achievement variables. This is quite unexpected, as communicative behaviour should be closely linked to social dynamics within the group and consequently also with performance and achievement.

In relation to Webb's (1982, see Figure 1) integrative framework in our research, we found few interdependencies between individual characteristics (social skills) and outcome quality but more interdependencies between group characteristics and perceived outcome quality. We also did not find significant interdependency between interaction (mail communication) and satisfaction with the performed work. A possible explanation for that divergence may be explained by our focus on social skills, while Webb (1991) also relates his framework to other characteristics like ability, group size and reward structures.

Discussion of effects on the individual level

On the individual level, three social skill variables served as predictors for interaction and achievement variables. First, students high in leadership skills tended to be unhappy with the mutual support given within the group. Arguably, as leaders, they are responsible for many important decisions and possibly in charge of some of the more difficult tasks. This may contribute to a feeling of isolation and lack of support, the proverbial 'loneliness at the top'. Second, students high in assertiveness found it harder to bring their ideas into the project. However, when all group members are assertive (i.e., the skill level in the group is high and homogeneous) contributing ideas becomes easier. Behaviours that we used to operationalize assertiveness, that is, self-confidence and standing up for one's rights, might be construed by less assertive group members as egoistical tendencies which in turn could lead these group members to selectively ignore contributions made by assertive students. Third, students high in prosocial behaviour/openness sent more

co-constructive messages in e-mail communication which agrees well with their social skill disposition. However, taken together, personal social skills had only a marginal influence on communication, performance and achievement.

Discussion of effects on the group level

More meaningful effects emerged at the group level. Groups that were high and homogeneous with respect to cooperation and compromising were perceived as collaborating more efficiently and dividing responsibilities clearer among group members. As mentioned, following Dillenbourg and Jermann (2007), splitting tasks is seen as detrimental to group learning for which building a shared understanding is considered essential. On the face of it, therefore, it could be concluded that groups with a high and homogeneous configuration with respect to cooperation and compromising learn less than groups with other configurations in this variable. We think, however, that such a conclusion would be premature. A division of responsibilities is conducive to the emergence of specific roles (not only leadership) which according to Strijbos, Martnes, Jochens, and Broers (2007) lead to a higher degree of self-reported group efficiency. Moreover, according to Tolmie *et al*. (2010), the social benefits of collaborative learning are a separate outcome of group work rather than being either a precondition for or a direct consequence of successful activity.

But there were other downsides for cooperation and compromising to be useful social skills in collaborative learning. Groups with a high, yet heterogeneous configuration of cooperation and compromising were seen as less harmonious, possibly due to conflict between sociable and less sociable members (see Zurita, Nussbaum, & Salinas, 2005). In addition, a high average level of compromising and cooperation diminished groups' permissibility for members to bring in their ideas, maybe to safeguard the group from potentially conflicting views.

With respect to prosocial behaviour/openness we assume heterogeneity to be the main responsible factor for the above-mentioned group dissatisfaction with performance, the perceived lack of efficiency of collaboration and the division of responsibilities. For prosocial behaviour to be maintained, reciprocity or equity is very important (Walster, Walster, & Berscheid, 1978). With increasing heterogeneity, reciprocity diminishes, and as a consequence prosocial group members may have decided to divide tasks more often instead of putting up with the perceived lack of support or even social loafing from others (Karau & Williams, 1993). Besides diminishing reciprocity, prosocial heterogeneity had the further effect of increasing the amount of project-related e-mail communication. It could be argued that more time had to be spent on making organizational agreements when group members differed in their level of prosocial behaviour/openness. The same observation can be made for groups with a heterogeneous distribution of social initiative (at least, when the average level of social initiative within the group was high).

Strikingly, groups that were homogeneous with regard to prosociality/openness or assertiveness more often had a centralized leadership in place who took charge of organizing the group process, while the reverse was true for groups that were heterogeneous with respect to social initiative or leadership. More information is needed to decide whether a centralized leadership can be considered a negative or positive dynamic for group learning. The results were clearer for leadership as a skill: When the average leadership level in the group was high, members reported more efficient collaboration.

Finally, group members perceived it to be easier to bring in their ideas into the work process when the average level of assertiveness within the group was high or homogeneous. Thus, in a group where members are equally assertive there seems to exist no hidden censorship that may make assertive groups especially creative and thus better able to benefit from the goals of a collaborative learning setting. This is supported partially by the result that groups with a high average level of and a low variability in assertiveness exchanged more messages in the co-constructive mode.

Conclusions

To sum up, more than on the personal social skill level, effective collaborative learning depends on the social skill configuration within the learning group. Here, homogeneous and/or high-level social skill configurations tend to be more favourable than heterogeneous and/or low-level social skill configurations, especially for social skills that focus on communal goals (as

cooperation/compromising and prosocial behaviour/openness). Therefore, if one wishes to teach students relevant social skills before engaging them in collaborative group learning, strengthening their ability to cooperate and compromise as well as their prosocial behaviours and their leadership skills would be good starting points. Of equal importance are computational tools that help teachers in the formation of groups according to specific criteria. In recent years, such compositional algorithms have been proposed, for example, by Lin, Huang, and Cheng (2010) or Meyer (2009). However, before these algorithms can be used by practitioners, more research on a broader spectrum of social skills and social skill configurations as well as on a broader spectrum of collaborative tasks is necessary.

In our study, we have dealt with some questions that have to date found no coverage in the literature on collaborative learning. We were able to demonstrate empirically the relevance of social skills as a group-level construct in explaining certain interpersonal dynamics and achievements of collaborative learning. As such, this research marks only the beginning and has therefore to cope with some important limitations.

First, because of constraints in sample sizes, we were not able to evaluate more than one social skill at once, even though interaction effects between different social skills are highly likely at the group level. Second, the social skills chosen for this study are only a subsample of all possible skills. Not included were, for example, skills concerning empathy, discussion or giving and receiving feedback. Further studies have to show if there are social skills even more important to group learning than the ones investigated by us. Third, group sizes were relatively small in our study (two or three students). Hence, different dynamics are probably at work in larger groups. And finally, all judgements concerning group performance and efficiency of collaboration were collected as retrospective self-ratings. With exception of the tracked e-mail communication, no information is available, telling us what really went on during the collaborative learning phase. Or in the words of Wilkinson and Fung (2002), '[Research to date] still provides only a "black box" as far as understanding what happens in the groups and the role of peer influences' (p. 437). The fact that we did not find significant associations between e-mail communication behaviour and performance and achievement variables suggests further that different aspects were captured here, though at the moment it is not possible to decide which measure has more validity in judging the effectiveness of collaborative learning.

Further research will focus on two domains. First, we will evaluate the validity of our results by forming groups *a priori* according to supposedly beneficial social skills configurations and then comparing them to randomly formed groups. Second, we will expand on our current results (a) by analysing additional social skills for their relevance in collaborative learning and/or re-analysing the social skills in the present study using alternative measures, and (b) by testing the predictive value of social skills (both on the individual and the group level) in other group-based collaborative learning settings such as problem-based learning in order to make generalizations or differentiations.

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