Do interpersonal skills and interpersonal perceptions predict student learning in CSCL-environments?

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A B S T R A C T

Although Computer-Supported Collaborative Learning (CSCL) is regarded as an effective pedagogical approach, this heavily depends on whether its members function effectively as a group. This study examines whether students' interpersonal skills and students' perceptions of those skills predict individual achievement and group performance in CSCL-environments. In total, 87 secondary education students working in 29 triads collaborated on a collaborative problem-solving task. Students' interpersonal skills and the perception of students' interpersonal skills were conceptualized as *agency* (displaying dominant behavior, e.g., leadership) and *communion* (displaying empathic behavior, e.g., being helpful). Students' interpersonal skills were measured by coding the chat-utterances of the group discussions. Perceptions of interpersonal skills were measured by administering a questionnaire after the group task. Individual achievement was measured by a pre-test and a post-test. Group performance was measured by coding the quality of the problem-solution. Multi-level analysis revealed that, when corrected for pre-test scores, students' agency and communion skill positively predict their individual achievement. Multiple regression analysis revealed that the group level scores for collaborative behavior, interpersonal skill perception, and pre-test scores did not significantly predict group performance. The results suggest that students' interpersonal skills significantly predict the degree to which CSCL has an impact student individual achievement.

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1. Introduction

Environments that emphasize collaborative learning mediated by technology are referred to as computer-supported collaborative learning (CSCL) environments (Stahl, Koschmann, & Suthers, 2006). In CSCL-environments, two or more students work together to solve a problem which is assumed to evoke a dynamic process of eliciting one's knowledge, discussing this knowledge with group members, establishing a group understanding of the problem-domain, and applying knowledge to solve the problem (Hmelo-Silver, Duncan, & Chinn, 2007). By doing so, CSCL might stimulate critical thinking and deeper processing of the subject matter, and offer opportunities for developing communicative and social skills (Johnson & Johnson, 2009; Laughlin, Carey, & Kerr, 2008). Although research has shown that collaborative problem solving can be an effective pedagogical approach, this heavily depends on whether its members function effectively as a group (Barron, 2003; Dillenbourg & Traum, 2006; Meslec & Curşeu, 2015). Research on group effectiveness, therefore, has taken an interest in

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examining whether and why certain input variables, such as role division and group composition, predict group learning processes and outcomes (de Wever, van Keer, Schellens, & Valcke, 2007; Janssen, Kirschner, Erkens, Kirschner, & Paas, 2010).

The premise in this study is that groups will not be effective unless they overcome barriers such as free riding, social loafing, and a lack of psychological safety (Järvenoja & Järvelä, 2009; Phielix, Prins, & Kirschner, 2010; Raes, Kyndt, Decuyper, van den Bossche, & Dochy, 2015). Inadequately resolving these interpersonal conflicts negatively affects individual achievement and group performance (Behfar, Mannix, Peterson, & Trochim, 2010; DeDreu & Weingart, 2003). When group members focus on negative emotions towards one other, this makes them more resistant to others' ideas. This hinders students in establishing a proper and shared understanding of the domain, and applying this understanding to the problem at hand (Cheruvelil et al., 2014; Lee, Huh, & Reigeluth, 2015; Linnenbrink-Garcia, Rogat, & Koskey, 2011).

Maintaining positive interpersonal relationships with group members requires the appropriate use of interpersonal skills (Johnson & Johnson, 2009; Notari, Baumgartner, & Herzogt, 2013; Prichard, Stratford, & Bizo, 2006). In management literature, interpersonal skills are often conceptualized in terms of conflict resolution skills, consensual decision-making skills, leadership skills, dialogue and discussion skills, team building skills, and empathic skills (Belbin, 1981; Parker & Hackett, 2012; Peterson, 1997; Wooley, Chabris, Pentland, Hashmi, & Malone, 2010). Whereas this provides insight into the interpersonal skills required to resolve interpersonal conflicts, studies examining which interpersonal skills are most predictive for student learning in CSCL-environments remain scarce (Lee et al., 2015; van den Bossche, Gijselaers, Segers, & Kirschner, 2006).

The present study addresses the paucity of research into the relationship between interpersonal relationships and collaborative learning by further conceptualizing the interpersonal skills group members may utilize in CSCL-environments. To this end, we introduce interpersonal relationship theory into the field of CSCL. Interpersonal theory has a firm tradition of 25 years in the field of research on teaching and teacher education. Interpersonal theory describes the interpersonal relationship between teachers and students and its effect on student achievement (Wubbels, Brekelmans, den Brok, Levy, Mainhard, & van Tartwijk, 2012). The conceptualization of teachers' interpersonal skills will be used to develop a research methodology in the field of CSCL. That is, group members' interpersonal skills will not solely be measured in terms of perception (self perception or perception of other group members' skills) but also in terms of displayed interpersonal behavior. By doing so, this study aims to gain more insight into whether interpersonal skills and student interpersonal skill perceptions predict group performance and individual achievement in CSCL-environments.

2. Interpersonal theory applied to CSCL-environments

2.1. Interpersonal theory: interpersonal relationship in classrooms

In interpersonal theory (Bruckmuller & Abele, 2013; Gurtman, 2009; Horowitz & Strack, 2011; Wubbels et al., 2012), teachers' interpersonal skills are often conceptualized in terms of agency and communion. *Agency* suggests that a teacher displays dominant behavior (e.g., taking matters in his or her own hand, and having control of the classroom situation). *Communion* suggests that a teacher displays empathic behavior (e.g., affiliation, friendliness, and love). In line with Notari et al. (2013), Pennings et al. (2014) state that agency and communion skills can be distinguished by examining the
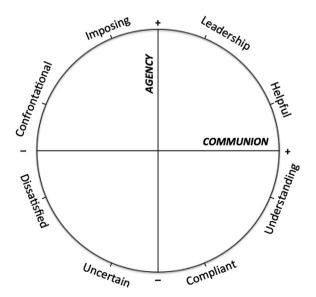

Fig. 1. Teachers' interpersonal skills (adapted from Pennings et al., 2014).

interpersonal behavior a teacher displays. As represented in Fig. 1, eight types of behavior are distinguished (leadership, helpful, understanding, compliant, uncertain, dissatisfied, confrontational, and imposing). Each type of behavior represents a specific combination of agency and communion skills.

Most research on interpersonal relationships focuses on teacher–student relationships and their effect on individual achievement (Farmer, Lines, & Hamm, 2011; McAlpine & Norton, 2006). The obtained results (e.g., Wubbels et al., 2012) often show that when a teacher utilizes both agency as well as communion skills, their students achieve higher individual learning results. In such a situation, a teacher displays both strong leadership (i.e., utilizing agency skill) and helping behavior (i.e., utilizing communion skill). However, according to den Brok, Brekelmans, and Wubbels (2004) the relation between teacher agency skill and student achievement is not always straightforward. Research shows that displaying dissatisfied and admonishing behavior (i.e., low communion) is for example related to lower individual student achievement, but also that helping and understanding behavior (arising from close communion) is not always related to higher student achievement (Rawnsley, 1997).

2.2. Interpersonal theory: interpersonal relationship in CSCL-environments

As teachers and students in classrooms, group members are also part of a 'peer-ecology' in which the interpersonal relation is affected by their own and others' interpersonal skills (Gest and Rodkin, 2011; Kenny, 1994). The interplay between a group member's displayed behavior and how others perceive this behavior determines the nature of the interpersonal relationship between group members (Fiske, Cuddy, & Glick, 2007; Sadler, Ethier, & Woody, 2011). The nature of students' interpersonal relation is often explained by the group's hierarchical organization and the group member's position within the organization (Ahn, Garandeau, & Rodkin, 2010; Gest, Davidson, Rulison, Moody, & Welsh, 2007). In line with interpersonal theory, the perception of a group member and, thus, his/her position in the organization is based on the kind of agency (i.e., group dominance) and communion (i.e., group empathy) related behavior he/she displays (Rubin, Bukowski, & Parker, 2006; Tseng & Seidman, 2007).

2.2.1. Agency
Hawley (1999) suggests that the position of a group member within the group hierarchy is based upon his/her ability to control material resources (e.g., lesson books) and social resources (e.g., the attention of other students, the choice of activity). Socially dominant members are positioned centrally in the structure of the group network and are extremely influential since they regularly display competitive and initiative-taking behavior (de Bruyn & van den Boom, 2005). In contrast, members with a less central position in the group hierarchy are often unmotivated or unable to control material and social resources. They are often neglected in the group. Groups with one dominant member often have one-sided conversations, due to the fact that conversations are not based on equal cognitive participation. Ideas coming from other members are often ignored and the discussion is often solely based on the view of the group leader (Arvaja & Häkkinnen, 2002). With respect to the impact of leadership during collaborative learning, mixed results have been found. Some researchers found positive effects of team leadership on group effectiveness (Sivasubramaniam, Murry, Avolio, & Jung, 2002; Strijbos, Martens, Jochems, & Broers, 2004), while others found negative effects (Cummings & Cross, 2003; Kayes, 2004).
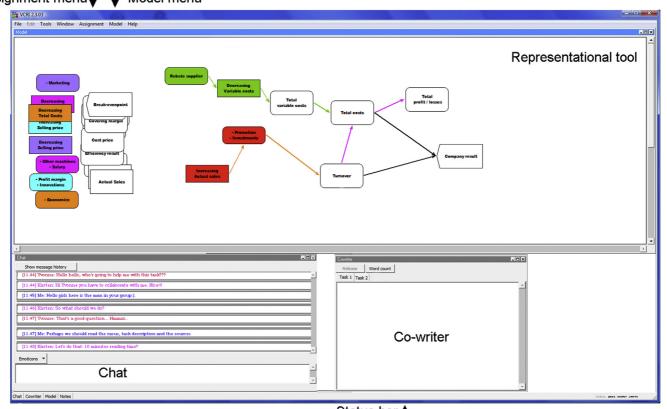
2.2.2. Communion
Group members with a higher position in the group hierarchy are often seen as empathic since they regularly display behavior to support (e.g., help, give feedback) or to agree with others in the group (Marks, Mathieu, & Zaccaro, 2001). This type of behavior requires an awareness of the roles of other group members and the willingness to offer support (Porter, Gogus, & Chien-Feng Yu, 2010). This means that members keep an eye on each other and recognize when one of them is experiencing difficulty. In addition, support from emphatic group members is accepted more often since other group members trust them. The greater the trust amongst the group members, the more effective their combined effort will be (Johnson & Johnson, 2009). Group members who do not trust each other will spend too much time protecting, checking and inspecting each other, and thereby leave themselves with less time for constructive collaboration (Peterson & Behfar, 2003).

3. Research question

We advocated that combining literature from different fields might provide more insight into the interpersonal skills required during collaborative problem solving. Utilizing such skills may be a mediating factor to positively resolve interpersonal conflicts and improve student learning in CSCL-environments. Since hardly any studies examined this topic, the present study addresses this scarcity of research by answering the following research questions:

1) To what extent do students' interpersonal skills (i.e., agency and communion) predict individual achievement?
2) To what extent does student perception of interpersonal skills (i.e., agency and communion) predict individual achievement?
3) To what extent do students' interpersonal skills (i.e., agency and communion) predict group performance?
4) To what extent does student perception of interpersonal skills (i.e., agency and communion) predict group performance?

Fig. 2. Screenshot of the VCRI-environment (based on Slof, Erkens, Kirschner, & Helms-Lorenz, 2013).

4. Method

4.1. Sample and participant selection

The participants were 99 (60 girls and 39 boys) secondary education (pre-university) students from four business-economics classes in the Netherlands. Classes were recruited by e-mailing/calling business-economics teachers from different parts of the country asking them if they were willing to participate in the study. The average age of the students was 15.26 years ($SD = 0.58$, Min $= 14$, Max $= 17$). The students were, within classes, randomly assigned to 33 triads that had to solve a business-economics problem in a CSCL-environment.

4.2. CSCL-environment and group task

4.2.1. Virtual Collaborative Research Institute (VCRI)

Students each worked on a separate computer with the VCRI-environment (Jaspers, Broeken, & Erkens, 2004; see Fig. 2). To facilitate collaborative problem solving, several shared tools were embedded within the VCRI. The *chat tool* made real-time communication possible and supported the students in discussing their knowledge and ideas. All the chat history was stored automatically, which gave the students the opportunity to re-read their communication history. The *co-writer* is a shared text-processer in which the groups had to write their solution for the problem. The *status bar* displayed which students were online and what tool they were using. The *representational tool* facilitated the constructing of domain-specific representations. The *notes tool* — an unshared tool — enabled students to store information and structure their own knowledge and ideas before making them explicit.

4.2.2. Group task

The groups were given the task of advising a fictitious company on changing its business strategy, with profit maximization as the main goal (see also Slof et al., 2013). In order to give a proper advice, the groups had to complete two problem phases, namely (1) determining how certain interventions (e.g., decreasing selling price), affect the company result, and (2) comparing the effect of these interventions and formulating the final advice based on the comparison. In total, groups had three 45-min lessons to solve the problem. Before commencing their work, all students received information about the group composition, the VCRI-environment, and the assigned problem. The teacher was on stand-by for subject matter related questions and the researcher was present for technical support.

4.3. Measuring instruments

4.3.1. Interpersonal skills perception

The original Dutch version of the Questionnaire on Teacher Interaction (QTI, see Wubbels, Créton, & Hooymayers, 1988) consists of 77 items that are answered on a five-point Likert scale. The QTI exists in several languages, amongst others Chinese, Dutch, English (UK and US), French, Hebrew, Italian, Slovenian, and Turkish. The QTI has been administered in different national (e.g., primary, secondary, and higher education) and international (i.e., different countries, and comparison between countries) contexts. The obtained results revealed that the QTI is a valid and reliable instrument for measuring student perception of their teachers' interpersonal skills (e.g., Wubbels, Brekelmans, den Brok, & van Tartwijk, 2006; Wubbels et al., 2012; Wubbels & Levy, 1991). Adapted 64-item versions of the QTI were developed, to gain more insight the perceived interpersonal relationships between a) PhD students and their supervisors (Questionnaire on Supervisor Doctoral Student Interaction; see Mainhard, van der Rijst, van Tartwijk, & Wubbels, 2009) and b) master students and their supervisors (Questionnaire Supervisor Interaction; see de Kleijn, Mainhard, Meijer, Pilot, & Brekelmans, 2012). In line with these developments, we used all 64 items from the Dutch version of the QSI (see de Kleijn et al., 2012) and slightly reformulated ("my group member" instead of "my supervisor") them. For all eight types of behavior, students had to answer eight questions on a five-point scale varying from (1) "almost never" to (5) "almost always". For example, questions related to a) agency were "my

Table 1
Coding scheme interpersonal skills.

Type of behavior	Description	Example	Score	
			Agency	Communion
Leadership	Brings good ideas	'Shall we read the description of the case?'	4	3
Helpful	Helps another member/gives explanation	'You can see what happens to this if you increase that.'	3	4
Understanding	Thinks along, if someone else makes a suggestion	'Yes, that looks good, but what machine will we use?'	2	4
Compliant	Goes along with ideas of other group members	'Ok, that's fine. Which shall I do then?'	1	3
Uncertain	Doesn't really know what he/she thinks	'Well, I don't understand it anyway.'	1	2
Dissatisfied	Doesn't believe what someone else says	'Where do you get that from?'	2	1
Confrontational	Irritable	'Do you think I'm stupid or something?'	3	1
Imposing	Wants the group members to do what he/she says	'No, you have to fill in what I just sent you!'	4	2

group member takes the lead" and 'my group member is undecided' and b) communion were "my group member is patient" and "my group member is understanding". This questionnaire was administered when students completed the group task. Since students worked in triads, each student had to fill in the questionnaire for both group members. Adding up all underlying item scores and dividing the total score by the number of items resulted in a weighed average score for the perception of each student's agency and communion skill. For example, items corresponding to helpful behavior (e.g., "my group member supports me") had more impact on the communion skill's average score than items corresponding to dissatisfied behavior (e.g., "my group member lets me know that I cannot do something"). In line with prior research on the QTI, QSI and QSDI, the internal consistency scores (i.e., Cronbach's alpha) for all eight types of interpersonal behavior were sufficient (leadership = 0.86, helpful = 0.88, understanding = 0.87, compliant = 0.81, uncertain = 0.80, dissatisfied = 0.88, confrontational = 0.78, and imposing = 0.80). The internal consistency score for the agency and the communion skill were respectively, 0.78 and 0.94.

4.3.2. Interpersonal skills

Chat-protocols – stored when groups worked on the problem – were selected and transferred from the VCRI log-files to the "Multiple Episode Protocol Analysis" (MEPA) program (Erkens, 2005). Using so called "concordance" software (e.g., MEPA, Erkens, 2005; !Kwictex, Mercer Littleton, & Wegerif, 2004) minimizes the work associated with coding chat-protocols and maximizes coding allowing the content of chat-protocols to be searched for the occurrence of important words or phrases within their linguistic context to show their specific function in the dialogue. MEPA uses a multidimensional data structure, allowing chat-protocols to be segmented into multiple levels for analysis, here the event level; coding and analysis took place at a fine grain size, namely the utterance (Chi, 1997; Mercer et al., 2004). A problem here is that even within in an utterance, multiple concepts, statements, or types of behavior may be expressed and, thus, may require multiple codes (Strijbos, Martens, Prins, & Jochems, 2006). With a MEPA-filter that makes use of 300 "if-then" decision rules, the utterances were automatically segmented into smaller, still meaningful, subunits. Punctuation marks (e.g., full stop, exclamation mark, question mark, comma) and connecting phrases (e.g., "and if", or "but if") were for example used to segment the utterances.

After segmentation, one of the authors and a graduate student independently coded the same nine chat-protocols according to the type of interpersonal behavior that was utilized (see Table 1). That is, they indicated in the MEPA-file (one per group) for each line whether the utterances reflected one of the eight types and, if so, which specific type of interpersonal behavior. Per researcher, all nine protocols were merged into one MEPA-file and the coding of both merged MEPA-files was compared with MEPA's inter rater reliability function. An overall Cohen's Kappa of 0.79 was obtained. Thereafter, both researchers each coded another 10 chat-protocols and all 29 coded protocols (17,781 lines) were merged into one MEPA-file for further analysis.

With a SPSS syntax the merged MEPA-file was transferred to SPSS, resulting in a SPSS file in which for all groups and each of their group members the number of displayed types of interpersonal behavior were reported. In SPSS the eight different kinds of interpersonal behavior were related to the two utilized interpersonal skills, namely agency and communion. Since a specific type of behavior is more representative for the agency than for the communion skill (see Table 1), the eight types of behavior were scored on a four-point scale varying from (1) "very little representative for the skill" to (4) "very much representative for the skill". That is, if a group member utilized a specific type of interpersonal behavior he/she received two additional scores in the SPSS file, namely a score for agency and a score for communion. For example, utterances as "Peter can you take a look at task description of problem phase 2" (leadership behavior) received a higher score for agency (score 4) than utterances such as "What should I do next?" (compliant behavior, agency score 1). Utterance as "Yes, that looks good, but what machine will we use?" (understanding behavior) received a higher score for communion (score 4) than utterances such as "Do you think I'm stupid or something?" (confrontational behavior, communion score 1). The rationale for this is that all types of behavior have different positions in the interpersonal circle (see Fig. 1). In both examples, the types of behavior are each other opposites and are, thus, more or less representative for utilizing a specific interpersonal skill. That is, agency is represented by the vertical axis; the higher a type of behavior is placed on the axis (top of Fig. 1), the more representative it is considered. Communion is represented by the horizontal axis; the higher a type of behavior is placed on the axis (right side of Fig. 1), the more representative it is considered. Consequently, all types of behavior received a score for agency as well as communion.

Table 2
Coding scheme group performance.

Criteria	Description	Item(s)	Cronbach's alpha
Suitability	Whether decisions were suited for a specific problem phase	6	0.67
Elaboration	Number of different business-economics concept incorporated in the decisions for a specific problem phase	6	0.52
Justification	Whether the decisions for a specific problem phase were justified	6	0.34
Correctness	Whether the business-economics concepts were used correctly in the decisions for a specific problem phase	6	0.58
Continuity	Whether the decisions from a prior problem phase were used	1	—
Quality final advice	Whether a proper final advice was provided	3	0.78

For example, leadership behavior takes the highest, fourth, position on the vertical axis (agency score 4) and the third position on horizontal axis (communion score 3).

After computing the agency as well as the communion score for all types of behavior, we added up all scores, per interpersonal skill and divided the total score by the number of coded chat-utterances. This – as with the perception of the interpersonal skills – resulted in a weighed average for the agency and communion skill for each group member.

4.3.3. Individual achievement

Recall and understanding of the subject matter was measured with a pre-test (27 items) and a post-test (27 items) administered before and after the problem-solving task (see also Slof et al., 2013). The multiple-choice items in both tests were drawn from a pool of items and were unique for each test. Students, for example, were asked to answer questions such as "Entrepreneur Y has an electronic store. At the end of the week Y has sold five TVs with a selling price of 1550 EUR and six TVs with a selling price of 1350 EUR. What was the turnover Y made last week for selling the TVs?" The four alternatives for this question were: a) 6750.00 EUR, b) 7750.00 EUR, c) 8100.00 EUR, d) 9300.00 EUR. After deleting seven items for the pre-test as well as the post-test internal consistency (Cronbach's alpha) scores were 0.44 and 0.50 respectively. Internal consistency was possibly low because each item of the multiple-choice test targeted a different skill. The individual items therefore were expected not to correlate substantially with each other. The pre-test and the post-test performance scores were determined by computing the average score for the remaining 20 items.

4.3.4. Group performance

Each groups' solution to the problem groups provided in the co-writer tool (see Fig. 1) was transferred from the VCRI log-files into a Word-file. Group performance was assessed by one of the authors, a former business-economics teacher. Table 2 (see also Slof et al., 2013) provides a description of the aspects on which the decisions were evaluated, the number of items, and their internal consistency scores (i.e., Cronbach's alpha). The group task consisted of two problem phases in which the teams each had to take three decisions (i.e., nature of the problem, appropriate interventions and effectiveness intervention). All six decisions were evaluated based on their "suitability", "elaboration", "justification", and "correctness", resulting in 24 items (6 decisions × 4 criteria). We also evaluated whether teams used decisions from a subsequent phase and altered their way of reasoning (i.e., "continuity"). There was one phase transition (i.e., transition from problem-orientation to problem-solution) and, therefore, two items. Finally, the "quality of the advice" was evaluated by three items; number of concepts incorporated in the advice, financial consequence of the advice, and whether the definitive advice was in line with the guidelines provided in the original task description. This resulted in a total of 28 items which all could be coded as "0" (wrong), "1" (adequate) or "2" (good); the higher the code, the higher the quality of the decision. In total, a group could score a maximum of 56 points for their problem-solution. The internal consistency (Cronbach's alpha) score for the six criteria ranged from 0.34 to 0.78. Due to several low internal consistency scores (i.e., elaboration and justification) we decided to use the overall score, based on 28 items with an internal consistency score of 0.82, as an indicator for group performance.

Table 3
Descriptive statistics analysis individual achievement.

Variable		N	M	SD
Individual achievement	Pre-test	79	11.52	1.79
	Post-test	85	12.68	1.69
Interpersonal behavior	*Agency*	87		
	1 (compliant + uncertain)		4.67	7.23
	2 (dissatisfied + understanding)		4.00	3.32
	3 (confrontational + helpful)		15.01	11.64
	4 (imposing + leadership)		18.08	16.26
	Communion	87		
	1 (confrontational + dissatisfied)		1.39	3.63
	2 (imposing + uncertain)		4.00	7.49
	3 (compliance + leadership)		19.31	12.77
	4 (helpful + understanding)		17.68	12.52
Interpersonal skills	Agency skill	87	3.02	0.57
	Communion skill	87	3.28	0.39
Perception of interpersonal behavior	Leadership behavior	87	3.58	0.68
	Helpful behavior	87	3.58	0.68
	Understanding behavior	87	3.67	0.68
	Compliant behavior	87	3.40	0.58
	Uncertain behavior	87	2.25	0.63
	Dissatisfied behavior	87	1.79	0.71
	Confrontational behavior	87	2.06	0.61
	Imposing behavior	87	2.48	0.65
Perception of interpersonal skills	Agency skill perception	87	3.12	0.26
	Communion skill perception	87	3.89	0.43

Table 4

Multilevel analysis for individual achievement.

Parameter	Model 1		Model 2	
Fixed effects				
γ_{00} = Intercept	12.74	(0.30)	−2.28	(6.38)
Interpersonal skills				
γ_{01} = Agency skill			1.86**	(0.41)
γ_{02} = Communion skill			3.52**	(0.51)
Perception of interpersonal skills				
γ_{03} = Agency skill perception			−0.19	(0.88)
γ_{04} = Communion skill perception			−0.75	(0.51)
Corrected for				
γ_{05} = Pre-test			0.20*	(0.08)
γ_{06} = Age			−0.07	(0.36)
γ_{07} = Gender			0.19	(0.42)
Random effects				
U_{0j} = Group-level variance	0.51	(0.71)	0.45	(0.67)
R_{ij} = Individual-level variance	5.91	(2.43)	2.44	(1.56)
Deviance (−2* log likelihood)	397.7		294.1	
Df			7	
Decrease in deviance			103.6**	

*p < 0.05, **p < 0.001.

Table 5

Descriptive statistics analysis group performance.

Variable		N	M	SD
Learning results	Pre-test	29	11.52	1.79
	Group performance	29	31.31	6.59
Interpersonal skills	Agency skill	29	3.02	0.21
	Communion skill	29	3.28	0.27
Perception interpersonal skills	Agency skill perception	29	3.12	0.15
	Communion skill perception	29	3.89	0.34

Table 6

Multiple regression analysis for group performance.

Predictors	B [95% CI]	β	t
Interpersonal skills			
Agency skill	5.32 [−6.16, 16.80]	0.17	0.96
Communion skill	4.19 [−4.79, 13.17]	0.17	0.97
Perception interpersonal skills			
Agency skill perception	−13.86 [−34.26, 6.55]	−0.32	−1.41
Communion skill perception	−1.50 [−10.09, 7.10]	−0.08	−0.36
Corrected for			
Pre-test	1.14 [−0.50, 2.78]	0.31	1.44

Note. CI = confidence interval.

4.4. Analyses

Due to missing data (i.e., ≤ three perception questionnaires per group, which was the case for three groups) and un-willingness to participate seriously (one group), four groups were not included in the analyses. The analyses were, thus, based on 29 groups (i.e., 87 students) instead of the 33 groups that participated in this study. Unfortunately, not all 87 of the selected students were present when the pre-test (six students) and the post-test (2 students) were administered. Analysis of *student' achievement* was, thus based on 79 pre-test scores and 85 post-test scores. Since none of the students missed both the pre-test as well as post-test, data about age and gender for all 87 selected students could be included in the analyses.

When investigating the impact of interpersonal skills and students' perception of their group members' interpersonal skills on individual achievement, the data-analytical problem of non-independence had to be taken into account (Kenny, Mannetti, Pierro, Livi, & Kashy, 2002). This is because group members' shared experiences and collaborative discussions affected students' post-test performance. As a result, within a group, group members' post-test performance scores may be correlated. This violates the assumption of non-independence of observations of individuals, making the results of traditional analytical techniques, such as ANOVA or MANOVA, unreliable (Kenny et al., 2002). Multilevel analysis (MLA) can cope with non-independence and is therefore a more appropriate technique in those cases (Snijders & Bosker, 1999). MLA is, thus, used for the analyses of the impact of interpersonal behavior and perceptions on individual achievement. The data for individual achievement were analyzed using a random intercept multilevel model that included seven fixed predictor variables: (1)

agency skill, (2) communion skill, (3) agency skill perception, (4) communion skill perception, (5) pre-test performance, (6) age, and (7) gender. The last three variables were included as covariates. Since MLA has no restrictions handling missing data, data from all 29-student group members could be included in the analysis. Regarding the *analyses of group performance*, multiple regression analysis was used, because the analysis involved a dependent variable at the level of the group. In this analysis, the group members' average scores from the post-test and the average age were also taken into account. SPSS was used to conduct the MLA as well as the multiple regression analysis.

5. Results

5.1. Individual achievement

The descriptive statistics for interpersonal skills, student perception of group members' interpersonal skills, and individual achievement are described in Table 3.

The results of the random intercept model investigating the impact of interpersonal skills and student perception of interpersonal skills on post-test performance are described in Table 4. Compared to the empty model (Model 1 in Table 4), the fit of the model is significantly improved by adding the four predictor variables and the three control variables, $\chi^2 = 103.6$, $p < 0.001$. Table 4 shows that both the agency and communion skill significantly predict post-test performance, $\beta = 1.86$, $p < 0.001$, and $\beta = 3.52$, $p < 0.001$, respectively. This means that as members engage in agency and communion related types of behavior, their post-test performance increases. In contrast, no effect of student perception of interpersonal skills was found, $\beta = -0.19$, $p = 0.83$ for agency skill perception, and $\beta = -0.75$, $p = 0.14$ for communion skill perception respectively. Regarding the control variables included in the model, only pre-test performance was found to significantly predict post-test performance, $\beta = 0.20$, $p = 0.02$. In contrast, no relationship was found between post-test performance and age, $\beta = -0.07$, $p = 0.85$, and gender, $\beta = 0.19$, $p = 0.65$.

5.2. Group performance

The descriptive statistics for interpersonal skills, student perception of the interpersonal skills, and group performance are described in Table 5.

Table 6 shows the results of a multiple regression analysis using interpersonal skills and student perception of interpersonal skills as predictor variables, while controlling for average pre-test performance within in the group. The results show that neither interpersonal skills, nor student perception of group members' interpersonal skills predict group performance, $R^2 = 32$, $p = 0.10$.

6. Discussion

The premise in this study was that (online) collaborative learning is ineffective unless group members overcome barriers such as free riding, social loafing, and a lack of psychological safety (Cheruvelil et al., 2014; Meslec & Curşeu, 2015; Raes et al., 2015). Inadequately resolving such interpersonal conflicts may negatively affect their group problem solving performance as well as their individual learning achievement (Behfar et al., 2010; DeDreu & Weingart, 2003). Overcoming interpersonal conflict and, thus, maintaining positive interpersonal relationships with other group members requires the use of interpersonal skills (Johnson & Johnson, 2009; Notari et al. 2013; Phielix et al., 2010). This study conceptualized students' interpersonal skills in terms of agency and communion and examined whether these skills and student perception of group members' interpersonal skills predicted group performance and individual achievement in a CSCL-environment.

The multi-level analyses showed that utilizing the communion as well as the agency skill affects post-test performance. This study reveals that a low score on the agency skill (i.e., displaying uncertain and compliant behavior) predicts lower individual achievement scores, but also that a high score on the communion skill (i.e., displaying helpful and understanding behavior) predicts higher individual achievement scores. When interpreting the results, it is important to notice that the magnitude of the effect of the communion skill is almost three times higher than the effect of the agency skill when it comes to predicting individual achievement. In contrast, individual achievement was not affected by the perception of the interpersonal skills of the other group members. Regarding the control variables included in the model, only pre-test performance was found to significantly predict post-test performance.

The multiple regression analysis, while controlling for average pre-test performance within in the group, showed that neither interpersonal skills nor student perception of group members' skills predict group performance. This means that on a group level, agency and communion skills and student perception of interpersonal skills do not affect the performance on the group task.

6.1. Interpretation of the findings

The obtained findings align with prior research stating that utilizing interpersonal skills may be a mediating factor to positively resolve interpersonal conflicts and, thus, improve group performance and individual achievement (Behfar et al., 2010; Linnenbrink-Garcia et al., 2011). Similar to results in the field of teacher education (McAlpine & Norton, 2006;

Wubbels et al., 2012), our findings indicate that displaying dominant (i.e., utilizing the agency skill) as well as empathic behavior (i.e., utilizing the communion skill) positively affect student learning. Applying interpersonal theory from teacher education to the field of CSCL research seems useful to further develop our theoretical and methodological framework for studying the impact of students' interpersonal skills. This seems warranted since personal conflicts and the associated social emotional process need to be taken into account when designing CSCL-environments and examining its effect on student learning (Arvaja & Häkkinnen, 2002; Lee et al., 2015; Phielix et al., 2010). However, when interpreting the findings at least three issues remained unaddressed.

Firstly, although students' interpersonal skills predicted their individual achievement, no effects were obtained for students' perceptions of their group members' interpersonal skills. This contradicts results of prior research into teacher—student relations that demonstrating a positive relationship between positive perceptions of teachers' agency and communion skill and individual achievement (Wubbels et al., 2012). This may be explained by the way the data were collected and analyzed. The perception of interpersonal skills is often affected by personal preferences (den Brok et al., 2004; Hughes, Cavell, & Willson, 2001). When studying the perception of interpersonal skills in the context of triads of students personal preferences may have a bigger impact on the average perception score compared to a setting in which the average score is based on the rating of all the students in the class. To address this, Kenny's (1994) Social Relationships Models could be used in order to partition the source of variance in the actor (i.e., tendency of raters to rate all member similarly), partner (i.e., tendency of rates to elicit similar rating from all peer rater), and dyadic variance (i.e., variance caused by an unique relationship between two group members).

Secondly, whereas students' interpersonal skills predicted individual achievement this was not the case for group performance. This might be explained by the quality of the interaction. As many other studies indicated, the quality of the interaction between group members determines how well a group performs (Barron, 2003; Johnson & Johnson, 2009; van den Bossche et al., 2006). As described in Lee et al. (2015), three types of conflicts (i.e., task, process, and interpersonal relationship) have shown distinct effects on group effectiveness. Since this study solely focused on interpersonal conflicts it did not address the coordination-related and task-related conflicts. It is unclear whether groups were able to coordinate their collaborative problem solving process by carrying out focusing (i.e., determining and maintaining discourse topic), checking (i.e., maintaining the coherence and consistency of their shared understanding), and argumentation (i.e., coming to a mutual consensus) activities (Dillenbourg & Traum, 2006; Erkens, Jaspers, Prangsma, & Kanselaar, 2005). The same applies to the discussion of the domain-content; the present study does not provide insight into how well the groups were able to discuss the domain-content and apply it to the task at hand (see also Hmelo-Silver et al., 2007; Slof, Erkens, Kirschner, & Jaspers, 2010). If groups were not able to resolve these coordination- and task-related conflicts, this might explain why students' interpersonal skills did not predict group performance. An alternative explanation might be that the present study focused on the interpersonal skills of the individual group members. By doing so, the effects of group composition were neglected. Studies conducted by Lee et al. (2015) and Notari et al. (2013) revealed that personal skills played only a minor role compared to group level compositions when predicting group performance. Although these studies measured both skills and group performance with self-assessment questionnaires their results align with studies (e.g., Meslec & Curşeu, 2015; Raes et al., 2015) in which the utilized interpersonal skills and actual group performance were measured.

Finally, when generalizing the findings, one should take the sample size, group size and reliability of the knowledge test into account. Since this study was conducted with 29 triads of secondary education students (pre-university) in business-economics it remains to be seen whether the obtained findings can be replicated in or generalized to other settings. Furthermore, it is possible that group size affected student interaction. According to Bonito (2000), the pressure to contribute is higher in smaller groups and there is less competition for attention in smaller groups. In groups with three members, there are only three possible interaction routes, making it more likely that each member will take part in the discussion (Laughlin et al., 2008) than when the group size is larger. Additionally, when tailoring the measurement of the learning gains to the specifics of the curriculum there are often no suitable standardized measurement instruments available. These instruments, therefore, had to be developed in cooperation with the teachers, which made them more ecologically valid for measuring individual achievement and group performance. Although this is how teachers usually work and assess their students, this approach might have compromised the internal consistency of the knowledge tests used.

6.2. Implications and suggestions for future research

Until now, research on interpersonal behavior and perceptions mainly concentrated on the interpersonal relations between teachers and students. This study reveals that the model for interpersonal teacher behavior (de Kleijn et al., 2012; Pennings et al., 2014; Wubbels et al. 2012) can also be applied to examine students' interpersonal relationships in CSCL-environments. The findings indicate that different types of interpersonal skills are identifiable within a group and that the utilization of interpersonal skills affects student learning in CSCL-environments. It seems that especially utilizing the communion (i.e., being emphatic) but also the agency (i.e., taking the lead) skill predict individual student achievement. It is, therefore, important for research into CSCL to look more closely at students' interpersonal skills during collaborative problem solving. Based on the findings and limitations of this study, future research might address how students can be made (more) aware of their interpersonal skills and how they affect others. To this end, the utilization and perception of interpersonal skills should be measured and the outcomes should be made explicit to others during their collaborative problem solving process (see for example Phielix et al., 2010). Especially when the perceptions are related to the interpersonal skills and other

displayed activities, this could foster group effectiveness (Johnson & Johnson, 2009; Lee et al., 2015). Another interesting line for future research would be to study the effects of interpersonal skills from a group composition perspective (Meslec & Curşeu, 2015; Notari et al., 2013; Raes et al., 2015). In this respect one might want to examine the effects of how the a) interpersonal skills develop within groups and b) utilization of the interpersonal skills is divided between the group members on the collaboration process and, thus, group performance.

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