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Awareness of cognitive and social behaviour in a CSCL environment

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Abstract Most distributed and virtual online environments for and pedagogies of computer-supported collaborative learning (CSCL) neglect the social and social-emotional aspects underlying the group dynamics of learning and working in a CSCL group. These group dynamics often determine whether the group will develop into a well-performing team and whether a sound social space emerges. Using a theory-based CSCL framework, two studies evaluated whether two tools, Radar and Reflector, supported cognitive, social and socio-emotional aspects of team development, encouraging promotive interaction and group processing in the teams. While not affecting product quality, tool use did lead to groups who perceived their team as being better developed, as having higher levels of group satisfaction and lower levels of conflicts. The results support that promotive interaction and group processing was increased by using Radar and Reflector.

Keywords CSCL, group processing, promotive interaction, social interaction, social space.

Introduction

Collaborative learning is a pedagogy that usually is applied in contiguous learning groups in face-to-face settings such as classrooms. Johnson and Johnson (1999, 2009) pointed out that pedagogies for collaborative learning should take care of five conditions that should be satisfied because otherwise 'collaborative learning' will not be effective in achieving the learning goals. Johnson and Johnson on their website[1] warned that '[p]lacing people in the same room, seating them together, telling them they are a group, does not mean they will cooperate effectively. To be cooperative, to reach the full potential of the group, five essential conditions need to be carefully structured into the situation: positive interdependence, individual and group accountability, promotive interaction, appropriate use of social skills, and group processing' (Johnson & Johnson, 2004, p. 793, 2009). Indeed, some scholars (e.g., Fischer, Bruhn, Gräsel, & Mandl, 2002; Gräsel, Fischer, Bruhn, & Mandl, 2001; Hewitt, 2005; Weinberger, 2003) have found evidence that supported the claim of Johnson and Johnson in that putting individuals together in a group to work on a task is not enough to insure that the group members will work together as a team. Group processing, as described by Johnson and Johnson, requires reflecting on and regulating one's own actions (self-reflection and regulation) with respect to the needs and goals of the others in the group (co-reflection and regulation) and the group as a whole (socially shared reflection and regulation). This reflection and regulation at these three levels (Järvelä & Hadwin, 2013) are meta-cognitive skills requiring meta-cognitive evaluations: members must give feedback to each other and reflect on these to elicit which individual or group actions were helpful or unhelpful

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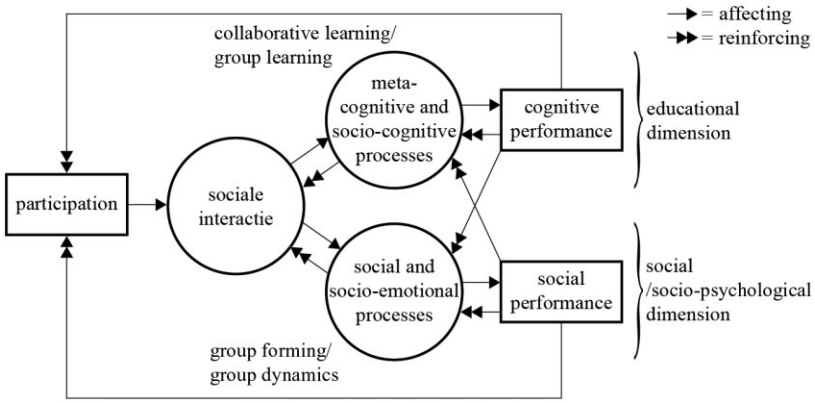

Figure 1 The dual function of social interaction. Rectangles represent variables and circles represent processes.

and to make decisions as to whether to continue or to change particular actions.

When these five conditions are realized, group members are interdependent during collaboration and, therefore, have to plan task-related activities, discuss collaboration strategies, monitor collaboration process, and evaluate and reflect on how they collaborated. Processes that involve coordination, regulation, monitoring, evaluation and reflection of both the cognitive (task-related) and social (non-task-related) processes can also be referred to as meta-cognitive processes and are considered important to successful group performance (Artzt & Armour-Thomas, 1997; Van Meter & Stevens, 2000).

Through the advent of Internet technology in the previous century, it became possible to deploy collaborative learning in non-contiguous groups wherein the group members are geographically distributed. Computer-based online (often referred to as 'virtual') environments were used for communication through e-mail and discussion groups. Since that time, computer-supported collaborative learning (CSCL) has become a fact (Koschmann, 1994). However, the use of technology to communicate and collaborate introduced a new set of problems. Whereas in face-to-face setting these problems were also present, the CSCL online setting or any setting that uses telecommunication within groups exacerbated these problems. These problems pertain to the social interaction between group members as pointed out by Kreijns, Kirschner, and Jochems (2003). According to them, social interaction has a dual purpose in all learning groups and it is important to notice this first before discussing the problems.

First, social interaction is needed for cognitive processes to take place as only then can new ideas, critical comments, other viewpoints, feedback, shared understanding and so on be exchanged (Kreijns *et al.*, 2003; Liaw & Huang, 2000). These cognitive processes are essential for a group's cognitive performance, such as effective and efficient problem solving, task accomplishment and knowledge construction (Gilbert & Moore, 1998; Guanawardena, Lowe, Constance, & Anderson, 1997; Gunawardena, 1995; Liaw & Huang, 2000). Johnson and Johnson's five conditions should inform the design of the pedagogical techniques to stimulate social interaction and, thus, group performance. In particular, positive interdependence and individual accountability are key conditions. The second purpose of social interaction is that it is needed for the social and socio-emotional processes that underlie the group dynamics and for achieving a sound social space. The group dynamics eventually determine whether or not the CSCL group will develop into an effective performing team. The dual purpose of social interaction is depicted in Figure 1. In this figure, the variables are depicted as rectangles and the processes as circles. Between them, one headed arrow denotes affecting or influencing and two headed arrows means reinforcing. Active participation in the CSCL group means that members are socially interacting with each other. When social interaction serves the meta-cognitive (i.e., via group processing) and socio-cognitive processes collaborative learning takes place. This may result in cognitive performance outcomes (e.g., made tangible in a group report) or social and socio-emotional processes [e.g., exhibition of trusting, helping behaviour (i.e., promotive interaction), a sense of cohesion and resolution of group conflicts]. Such positive characteristics are collectively designated as sound social space; a social performance outcome of

the group. Reinforcement of the two processes can be expected when both cognitive performance and social performance are positive as is the case when group members feel that the group goals will be achieved (e.g., the report is progressing well). Such a feeling will make them content, motivating them to continue their participation to achieve group goals.

However, as Kreijns *et al*. (2003; see also Kirschner, Beers, Boshuizen, & Gijselaers, 2008) pointed out, the use of a virtual distributed CSCL environment with all its means for electronic communication does not guarantee participation of all group members and, thus, that social interaction will occur. This has not changed even when more sophisticated communication tools including social media were used. Yet, most teachers take it for granted that social interaction will take place in these CSCL environments just because in face-to-face settings it happens most of the time (Dirckinck-Holmfeld & Sorensen, 1999; Kreijns *et al*., 2003). Furthermore, the social interaction that occurs is restricted to the cognitive processes (insofar as they are happening), neglecting that social interaction is also important for social and socio-emotional processes. Indeed, current CSCL environments continue to implement functionalities primarily to support these cognitive processes and not the needed social and socio-cognitive processes. As a result of the lack of needed social functionalities in virtual distributed CSCL environments, group members may experience difficulties in becoming a well-performing team and in achieving a sound social space (Kreijns, Kirschner, Jochems, & van Buuren, 2011).

In addition to this neglect, we must also take into account that the moments in which the CSCL group members have the opportunity to socially interact are often limited. Social interaction only occurs in CSCL when group members work on the group tasks because it is only then that a communication episode begins. *Off-task* occasions that exist in face-to-face settings (e.g., the hallway, the coffee corner, different courses) do not really exist in CSCL. Though a high degree of *on-task behaviour* may be 'efficient' as no time is wasted on off-task discussions, it does not contribute to the also needed social and socio-emotional processes. Finally, unless a CSCL virtual environment also makes use of video, group members are deprived of non-verbal and visual cues that impede impression formation and feelings of social presence (Walther, 1993, 1996). Social presence is the 'degree of illusion that others appear to be a "real" physical persons in either an immediate (i.e., real time/synchronous) or a delayed (i.e., time-deferred/asynchronous) communication episode' (Kreijns, Kirschner, Jochems, & van Buuren, 2011, p. 366).

This article employs Kreijns, Kirschner, and Vermeulen's (2013) theoretical CSCL framework that pays attention to all the social aspects described here by focusing on *social affordances* explicitly oriented towards facilitating social and socio-emotional processes. In the current study, this CSCL framework also attends to the cognitive aspects as it is augmented with *educational affordances* explicitly oriented towards facilitating required socio-cognitive and meta-cognitive processes. To this end, two tools – Radar and Reflector with both social and educational affordances – were implemented. Radar is meant to enhance awareness of group members' social and cognitive behaviours by eliciting information from group members on social and cognitive behaviours and visualizing this information in a radar diagram (see Figure 5). This, in turn, enhances social and cognitive group performances (see Figure 1). Reflector was designed to, based upon the awareness, stimulate meta-cognitive processes (i.e., setting goals and formulating plans) also to enhance social and socio-cognitive group performances. Radar and Reflector may enhance social interaction between group members by facilitating Johnson and Johnson's (2004) *promotive interaction* and *group processing* and by facilitating the *norming* and *performing* stages of group formation (Tuckman & Jensen, 1977).

The research question to be answered is: Does the use of tools for coercing assessment of individual and group behaviours (i.e., Radar) and reflection on that behaviour (i.e., Reflector) enhance the social interaction in CSCL groups and in particular *promotive interaction* (enabled by the sound social space, which is a social performance outcome; see Figure 1) and *group processing* (which is a meta-cognitive process; see Figure 1). The sound social space emerges in the group forming/group dynamics which is a social and socio-emotional process.

Theoretical framework

The CSCL framework

In Kreijns *et al*.'s (2013) framework, CSCL virtual environments are characterized by their *sociability*; the

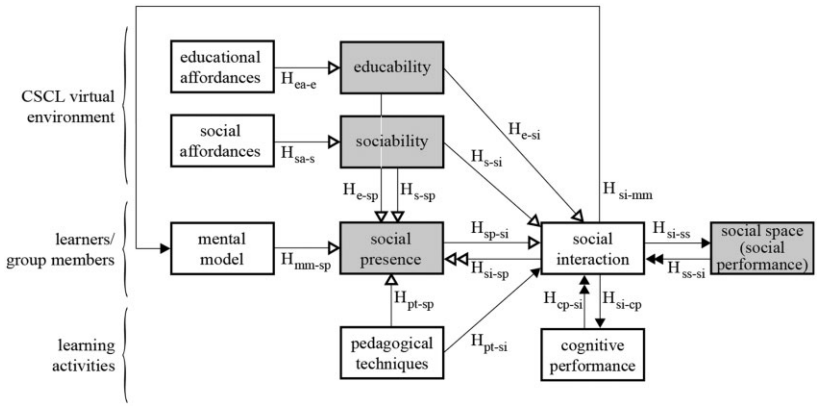

Figure 2 CSCL theoretical framework including both social and educational affordances

Note. Each relationship (either affecting or reinforcing) is represented as a labelled arrow. The label's subscript gives the relationship's direction. For example, the label H_{sa-s} refers to the relationship between social affordances (sa) and sociability (s), and the direction is from sa to s. An open arrowhead represents a hypothesized relationship and a closed one represents a relationship supported in existing empirical literature. Because the augmented CSCL framework considers the variables social presence, sociability, educability, and social space as the focus of the framework for influencing social interaction these variables are depicted in grey.

degree to which they allow for social and socio-emotional processes to take place via social interaction to assist in the emergence of a sound social space. In the framework, the *social affordances* of CSCL environments determine their sociability (Kreijns, Kirschner, Jochems, & van Buuren, 2004) and, thus, how group development is facilitated. Social affordances are those properties of the environment that allow for social interaction in the social and socio-emotional processes to happen. The canonical example of a social affordance device in real life is the water cooler where people gather and talk. Thus, a CSCL virtual environment needs a software version of the water cooler. The CSCL framework which originally was *technological* in nature (i.e., contained the technology tools to allow for CSCL; Kirschner, 2002) and which was expanded to include social affordances (Kreijns *et al*., 2004) is further augmented here to include educational affordances that determine the educability of the CSCL virtual environment. Kirschner (2002) defined *educational affordances* as the relationships between the properties of an educational intervention and the characteristics of the learner and learning group that enable particular kinds of learning by him/her and the group. They, thus, determine the degree to which these CSCL virtual environments allow for cognitive and meta-cognitive processes to happen (i.e., its educability). The augmented framework is presented in Figure 2.

In Figure 2, variables that influence the social interaction in a CSCL group are social presence, sociability, educability, social space and CSCL pedagogical techniques. Sociability and educability are characteristics of the CSCL virtual environment and directly influence the degree of social interaction in CSCL groups and all communication and learning happening through this CSCL virtual environment (relationships H_{s-si} and H_{e-si}). As is made clear here, social affordances affect the degree of sociability (relationship H_{as-s}) and educational affordances affect the degree of educability (relationship H_{ea-e}). Many scholars (e.g., Oztok & Brett, 2011) see social presence as a crucial factor for encouraging the social interaction in a CSCL group (relationship H_{sp-si}). According to Walther (1993), social presence is co-determined by the mental model of the other (relationship H_{mm-sp}) constructed through accumulated messages over time and that emerged from the social interaction (relationship H_{is-mm}). The degree of social presence also depends on the characteristics of the environment (i.e., its sociability and educability resulting in the relationships H_{s-sp} and H_{e-sp}), by the pedagogical techniques used (relationship H_{pt-sp}) (Gunawardena, 1995), and it will be reinforced when social interaction takes place (relationship H_{is-sp}). As social presence is not part of the current study, it is not further discussed here. Pedagogical techniques also contribute to the social interaction in groups when designed with Johnson and Johnson's (2009) five conditions in mind; ultimately, this is why these pedagogical techniques are used. All social interactions should result in a social and cognitive performance outcome

(relationships $H_{si\text{-}ss}$ and $H_{is\text{-}cp}$; see also Figure 1), the aim of collaborative learning. Good performances will result in reinforcing the social interaction in the CSCL group (relationships $H_{cp\text{-}si}$ and $H_{ss\text{-}si}$). More in-depth discussion about the relationships can be found in Kreijns *et al*. (2013).

Group development

According to Salas, Sims, and Burke (2005), teamwork is '. . .a set of interrelated thoughts, actions, and feelings of each team member that are needed to function as a team and that combine to facilitate coordinated, adaptive performance and task objectives resulting in value-added outcomes' (p. 562). These qualities, however, do not spontaneously emerge when a group is formed. According to Tuckman and Jensen (1977), groups progress through five phases: forming, storming, norming, performing and adjourning. The performing phase is only achieved when the preceding phases have successfully taken place (Kreijns, Van Acker, Vermeulen, & van Buuren, 2014). While Tuckman (1965) and Tuckman and Jensen (1977) saw these phases as linear, Bales (1988) suggested a cyclic version of Tuckman in which the group is allowed to cycle through the phases of storming, norming and performing. The latest insights (Bonebright, 2010) also suggest that it is possible to step back from the performing phase to an earlier phase. It is thus possible that a group that has initially reached the performing phase falls back into the norming or the storming phase, depending on what has caused the fallback. What often is seen is that if a group starts believing that the task will not be finished on time, the group may decide that new leadership is called for – thus falling back into the storming phase – or may accept behaviour not originally accepted – thus falling back into the norming phase. In extreme cases, conflict while storming can even lead to adjourning (see Figure 3).

Kreijns *et al*. (2004) have linked their definition of social space to the norming phase; the phase where group structures become stable. Recalling their definition of social space as 'the network of social relationships amongst the group members embedded in group structures of norms and values, rules and roles, beliefs and ideals' (p. 608), a *sound* social space is manifest when affective work relationships, shared social identity, an open atmosphere, mutual trust and a sense of belonging exist. A sound social space, therefore, is linked to the performing phase because only then when these social qualities exist it can enable, among others, promotive interaction and group processing. In other words, the performing phase is the phase a CSCL group performs well and thus becomes an effective team (see Figure 3).

Radar and Reflector

As already pointed out before, Radar and Reflector enhance social interaction between group members by *promotive interaction* and *group processing* and by facilitating the *norming* and *performing* stages of group formation. For a full discussion of the theoretical underpinnings of Radar and Reflector, the reader is referred to Phielix, Prins, and Kirschner (2010) and Phielix, Prins, Kirschner, Erkens, and Jaspers (2011). Radar is a peer assessment tool that provides group

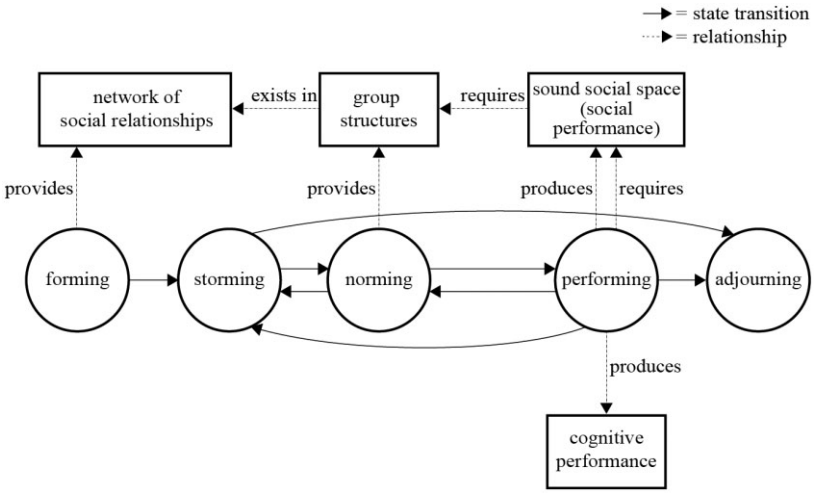

Figure 3 Group dynamics according Tuckman and Jensen and how it is linked with social relationships and group structures (which it provides) and a sound social space (which it produces and, at the same time, needs) as well as how it is linked with cognitive performance.
Note. Solid arrows represent state transitions and dotted arrows represent relationships. The word associated with the dotted arrow specifies the relationship (e.g., group structures exist in network of relationships).

members with information (i.e., awareness) of their functioning individually and as a team, and visualizes this information in an easy to interpret way. Reflector is a tool to stimulate meta-cognition of CSCL group members about this functioning to deepen their awareness. As such, Radar and Reflector are, thus, group awareness widgets or tools (see, e.g., Buder & Bodemer, 2008).

Radar

Radar is a peer assessment tool that allows group members to rate themselves and their peers on four social aspects (i.e., influence, friendliness, cooperation and reliability) and two cognitive aspects of collaboration (i.e., productivity and quality of contribution). These traits are derived from studies on interpersonal perceptions, interaction, group functioning and group effectiveness (e.g., Bales, 1988; den Brok, Brekelmans, & Wubbels, 2006; Kenny, 1994; Salas *et al.*, 2005). The traits support promotive interaction and group processing. If a group member is helpful and willing to take over tasks of other members, his/her scores of the peer assessments on the friendliness and cooperative traits will be expected to be higher than when this group member is not helpful or not willing to take over tasks.

Along with assessing themselves, group members assessed the other group members on certain traits and are assessed by the others within their group on those same traits. As assessor (see Figure 4), to-be-assessed peers in the group could be selected and their profile appeared as dotted lines in the centre circle of the radar diagram. Each group member had a specific color. Assessors assessed themselves and group members – per trait – using a scale from 0 to 4 (0 = *none*, 4 = *very high*) by dragging the trait line intersect to a desired score. Each step in the range (e.g., from 0 to 1) was divided into tenths so that every scale contained 41 score points. Care was taken – via balloons that popped up when the cursor crossed the scale – to ensure that all assessors used the same definition of the traits. For example, when the cursor was moved across

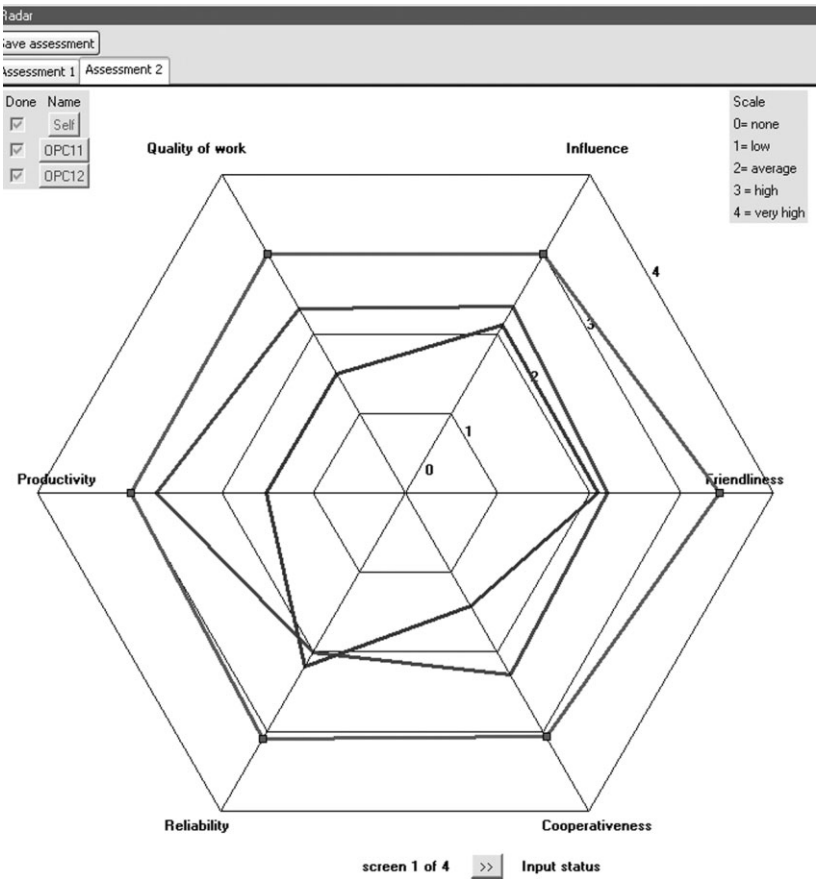

Figure 4 Example of Radar Input. Each group member is represented as a solid coloured line. With Radar input, a group member can assess her/himself and the other group members.

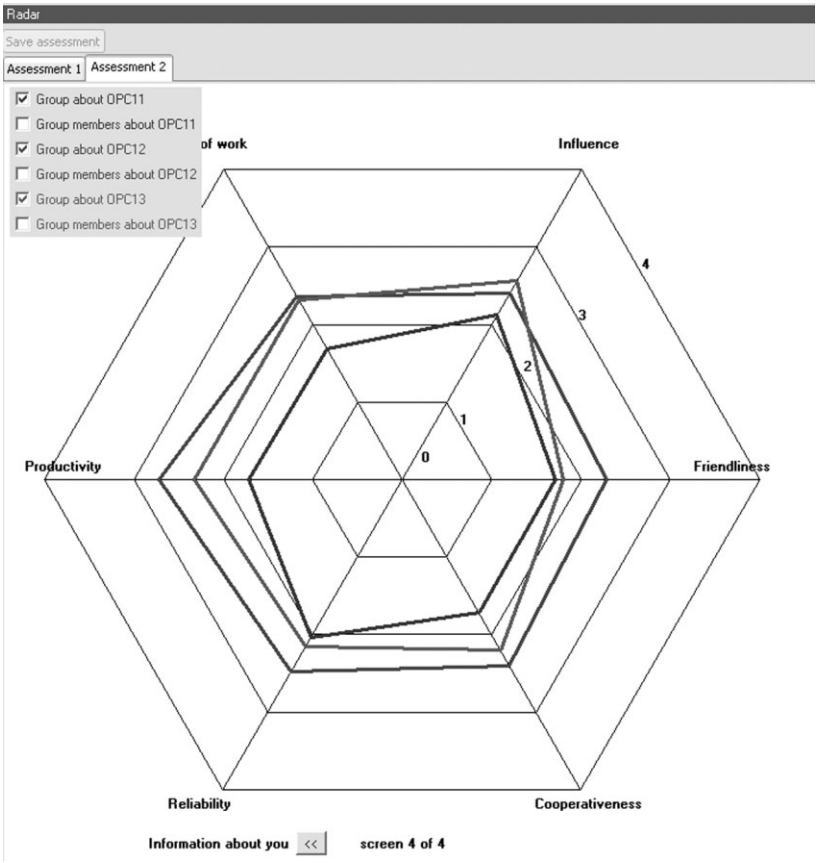

Figure 5 Example of Radar Output for a Group. Each group member is represented as a solid coloured line. With Radar output a group member can see the average scores of the peer assessments for him/her and for the other group members.

'influence', a balloon popped up with the text 'A high score on influence means that this person has an influence on what happens in the group, on the behaviour of other group members, and on the form and content of the group product (i.e., the paper)'.

Assessment is anonymous; group members could see the scores of the assessments of the other group members, but not who made them. Students could access individual and average scores of peers only after completing the assessment themselves. When all group members completed the self- and peer assessments, two modified radar diagrams became available. The first – information about yourself – showed the scores of the self-assessment (e.g., Group member Chris about Chris) along with the average scores of the peer assessments of him/her (e.g., Group about Chris). The self-assessment was not taken into account for computing average scores. To gain information about the variance in the average score, a student could also choose to view the individual scores of the peer assessments of him/her (e.g., Group members about Chris). The second diagram – information about the group (see Figure 5) – represented the average scores of each group member, so that group members can get a general impression about the assessment of the functioning of the group as a whole.

All group members were represented as a solid line in the diagram. Participants could complicate or simplify the Radar diagram by including or excluding group members from the view by clicking a name in the legend.

Radar makes implicit qualities (e.g., frustrations among peers) explicit for all group members. By doing so, Radar facilitates co- and socially shared reflection and regulation whereby group members can more clearly and effectively interact with each other (see CSCL framework in Figure 2: social interaction) creating a better social space.

Reflector

Reflector – by having group members reflect upon the Radar scores – provides group members with metacognitive awareness of their self-perceptions of their behaviours (i.e., self-ratings) their actual behaviours as

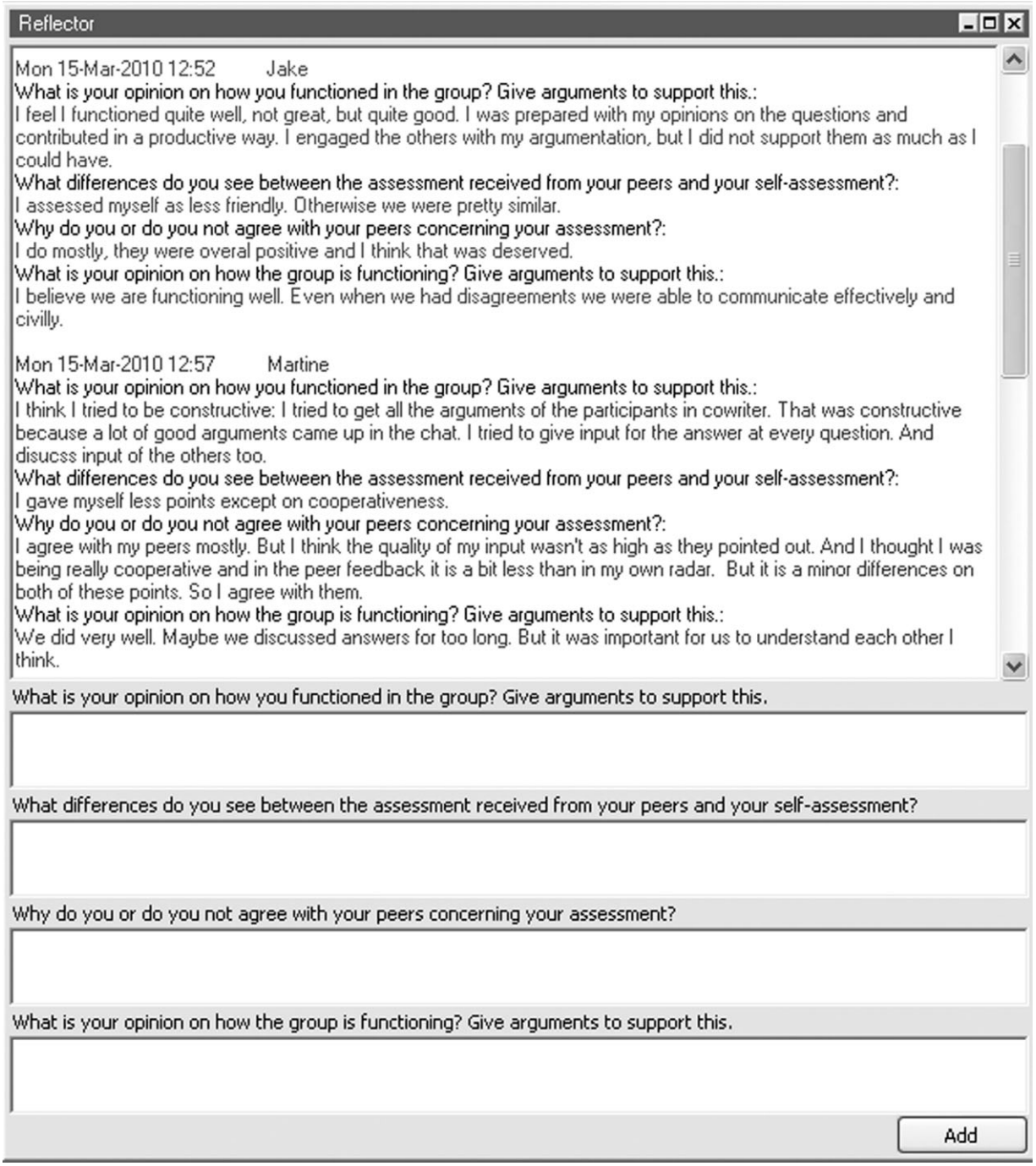

Figure 6 Screenshot of Reflector

perceived by others (i.e., received peer ratings) and the discrepancies between the two (see Figure 6). Group members reflect and provide information on: (1) their own perspective on their personal performance; (2) differences between their self-perception and the perceptions of their peers; (3) whether they agree with the perceptions; and (4) their individual perspective on group performance. Because successful group performance is determined to a large extent by the individual, interdependent efforts of all group members, Reflector

is also designed to encourage group members to collaboratively reflect (i.e., co-reflect) on the group performance and reach a shared conclusion on this. Based on this shared conclusion, group members are stimulated to plan and set goals to improve group performance. Co-reflection is defined as 'a collaborative critical thinking process involving cognitive and affective interactions between two or more individuals who explore their experiences in order to reach new intersubjective understandings and appreciations' (Yukawa, 2006, p. 206).

Thus, through Radar and Reflector, group members evaluate and reflect on the manner in which they collaborate. This information allows users to determine whether selected strategies are working as expected, and draw conclusions about the group's social performance (e.g., group satisfaction) and cognitive performance (e.g., equality of participation of all peers, product quality). Because of the cues provided, Radar and Reflector can facilitate promotive interaction and group processing.

The effects of Radar and Reflector on the groups' social and cognitive performances in a CSCL environment were studied in two studies. These studies are described in the following sections.

Study 1

Study 1 dealt with the effects of Radar and Reflector on social and cognitive performances during CSCL. Students worked in groups on a collaborative writing task in sociology. A 2×2 factorial between-subjects design was used to examine whether the awareness tools would lead to better team development, more group satisfaction, lower levels of group conflict, more positive attitudes towards problem-based collaboration, and a better group product as a result of increased promotive interaction and group processing.

Research questions and hypotheses

1. Do groups with Radar and Reflector perform better socially than groups without Radar and/or Reflector in terms of better team development, higher group satisfaction, lower levels of group conflict and more positive attitude towards collaborative problem solving? Expected is that both Radar and Reflector will positively affect social behaviour in the group, and that this should lead to an increase in the social performance. A combination of both tools should be most effective.
2. Do groups with Radar and Reflector perform better cognitively than groups without Radar and/or Reflector in terms of a higher quality product? Expected is that both Radar and Reflector will positively affect the social behaviour in the group and that this should indirectly lead to an increase in the cognitive performance of the group. A combination of both tools should be most effective.

Method

Participants

Participants were 39 sophomore high school students (19 male, 20 female) with an average age of 16 years ($M = 15.5$, $SD = .60$, $Min = 14$, $Max = 17$) from two classes.

Design

A 2×2 between-subjects factorial design was used with the factors Radar unavailable versus Radar available and Reflector unavailable versus Reflector available. This leads to four conditions (No tools, Radar only, Reflector only, Both tools). Students were randomly assigned by the researchers to groups of 3 or 4 to one of the four conditions which were heterogeneous in ability and gender. The condition using 'Both tools' consisted of 11 students (2 groups of 4 and 1 group of 3), the condition 'Reflector only' had 12 students (3 groups of 4), and the conditions 'Radar only' and 'No tools' consisted of 8 students (2 groups of 4).

Measures

Social performance Social performance was measured via previously validated instruments. The *Team Development* scale provides information on perceived level of group cohesion (Savicki, Kelley, & Lingenfelter, 1996; ($\alpha = .92$). The *Group-Process Satisfaction* scale provides information on perceived satisfaction with general group functioning (Savicki *et al.*, 1996; $\alpha = .79$). The *Intra-Group Conflicts* scale provides information on perceived level of conflict between group members (Saavedra, Early, & Van Dyne, 1993; $\alpha = .88$). The *Attitude Towards Collaborative Problem Solving* scale provides information on perceived level of group effectiveness and how group

Table 1. Social Performance Scales

Scale	*k*	Example	Cronbach's α
Team development	10	Group members contribute ideas and solutions to problems	.77
Group-process satisfaction	6	I felt that my group worked very hard together to solve this problem	.71
Intra-group conflicts	7	I found myself unhappy and in conflict with members of my group	.84
Attitude towards collaborative problem solving	7	Collaborating in a group is challenging	.74
Social performance (total)	30	See all items of four scales stated above	.90

members felt about working and solving problems in a group (Clarebout, Elen, & Lowyck, 1999; $\alpha = .70$). These four scales were translated into Dutch and transformed into 5-point Likert scales (1 = *totally disagree*, 5 = *totally agree*) by Strijbos, Martens, Jochems, and Broers (2007) (Table 1).

Cognitive performance The grade given to the groups' collaborative writing task was used as the performance measure. The essays were graded by two researchers, both experienced in grading essays. The inter-rater reliability was high ($n = 10$, Cronbach's $\alpha = .86$).

Instruments

Virtual Collaborative Research Institute Students used the *Virtual Collaborative Research Institute (VCRI)*, a groupware program that supports collaborative working and learning on research projects and inquiry tasks (Jaspers, Broeken, & Erkens, 2004). VCRI contains more than ten different tools, but only five were used for this experiment (see Figure 7).

The *Chat* tool (top left) allows synchronous communication between group members. The chat history was automatically stored and could be reread by

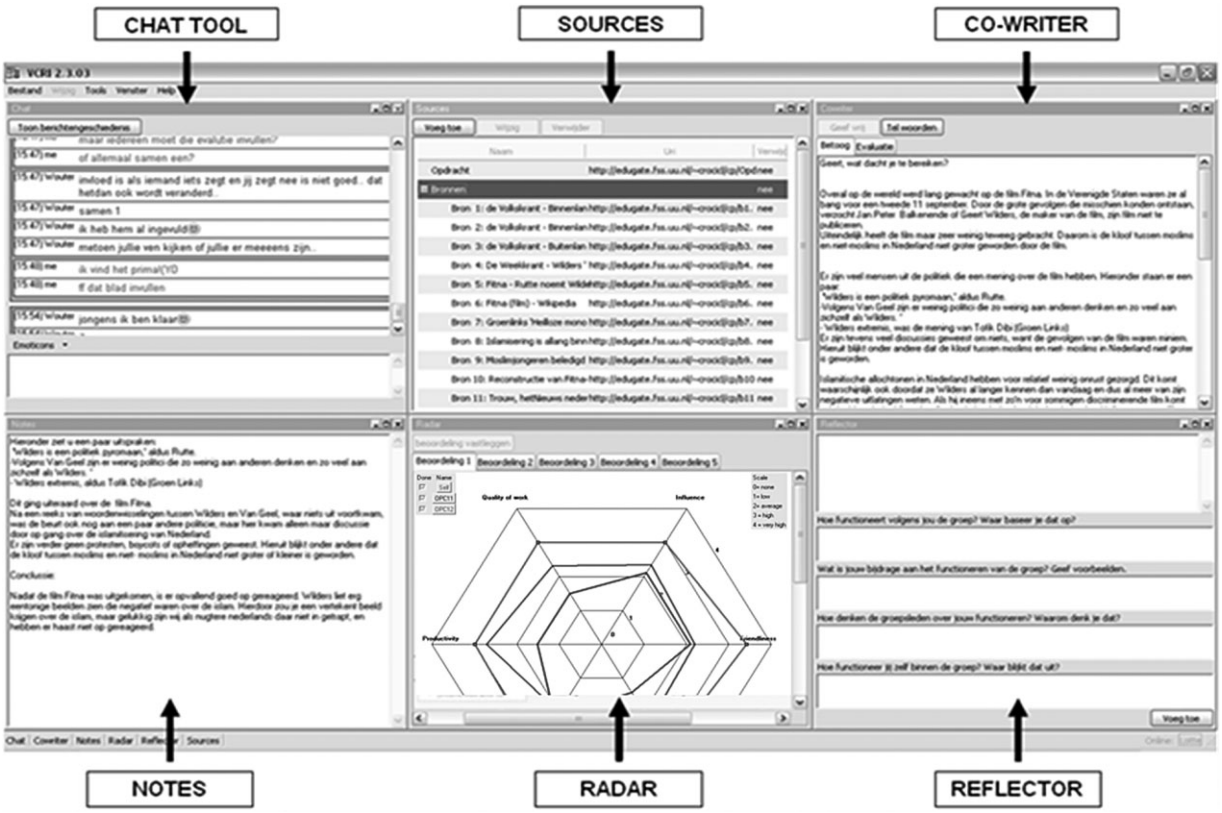

Figure 7 Screenshot of VCRI with the six tools used in the experiments

participants at any time. Students could search for relevant information concerning their collaborative writing task in sociology by using the *Sources* tool (top centre). The sources of information (data files) were the same for all groups. The *Co-Writer* (top right) is a shared word processor, which could be used to write a group text. Students could work simultaneously on different parts of the group texts. *Notes* (bottom left) is a non-shared notepad to make notes and copy/paste selected information. Radar for peer feedback (bottom centre) and Reflector for reflection (bottom right) are described in the following sections. Windows of the available tools were automatically arranged on the screen when students logged on to VCRI.

Peer assessment tool (Radar) VCRI was augmented with a peer assessment tool in the form of a radar diagram (see Figures 5 and 6) which provided users with information on how their social and cognitive behaviours are perceived by themselves, their peers (anonymous) and the group as a whole. It should be noted that in Study 1, Radar provided information on five traits. A sixth trait 'Quality of work' was added in Study 2 as a result of interviews with the students. To simplify data analysis, assessments were transformed to a 100-point scale by multiplying the assessments (0–4) by 25.

Reflection tool (Reflector) VCRI was also augmented with a tool containing five questions designed to stimulate reflection on different aspects of the group processes. Reflector required group members to individually reflect and provide information on (1) their own perspective on their personal performance (feed up), (2) differences between their self-perception and the perception of their peers concerning their personal performance (feedback), (3) whether they agree with those perceptions (feedback) and (4) their individual perspective on group performance (feed up). Because group performance is determined by the individual effort of all group members, Reflector also required group members to collaboratively (5) reflect (i.e., co-reflect) on group performance and reach a shared conclusion on this (feedback).

Task and procedure

Groups worked on a collaborative writing task in sociology with students working individually at a computer. Each group had to write one essay about a very controversial film which was very current at the time and considered highly relevant by the school. The task consisted of two 90-min sessions in VCRI separated by 1 week. Students were instructed to use VCRI to communicate with the other group members and to make complete use of the tools for peer feedback and reflection when the experimental condition allowed this. Students received content information and definitions regarding the five assessment traits. Students were told how much time they had to complete the task, that it would be graded by their teachers and that it would affect their grades for the course. The introduction to the task stressed the importance of working together as a group and pointed out that each individual group member was responsible for the successful completion of the group task. To successfully complete the task, all group members had to participate.

During collaboration, groups with Radar (i.e., Both tools, Radar only) used this tool at the beginning of the experiment (T1), halfway through (i.e., at the end of the first session; T2), and at the end of the second and final sessions (T3). The groups with Reflector (i.e., Both tools, Reflector only) used this tool twice, halfway through the experiment (T2) and at the end of the final session (T3). While groups with Radar and/or Reflector used the tools, groups without Radar and/or Reflector continued working on their collaborative writing tasks. Groups using the tools received extra time for their collaborative writing tasks so that time-on-task was equal for all conditions. At the end of the final session (T3), Radar and Reflector became available for all conditions so that all participants could assess their peers and reflect on their behaviours. Finally, all participants completed a 30-item questionnaire measuring the social performance of the group.

Results

Impact of tools on social performance

Because of a relatively small sample size ($N = 39$), unilevel analyses were used. Therefore, a two-way between-groups analysis of variance (ANOVA) explored the effect of Radar and Reflector on social performance with respect to team development, group satisfaction, group conflicts and attitude towards collaborative problem solving. This was chosen because the design contained two categorical independent variables (with/without Radar and with/without Reflector) and one continuous dependent variable (social perfor-

Table 2. Independent Samples *t*-Test Between Groups With and Without Radar

Scale	Radar	*N*	*M*	*SD*	*Mean difference*	*p*	η^2
Team development	With	16	4.08	.35	.26*	.04	.09
	Without	18	3.82	.48			
Group satisfaction	With	17	3.95	.55	.00	.49	.00
	Without	18	3.95	.70			
Level of group conflict	With	17	1.79	.37	–.38*	.03	.11
	Without	18	2.17	.71			
Attitude towards collaborative problem solving	With	17	3.89	.39	.32*	.04	.09
	Without	18	3.57	.62			

mance). There were no significant interaction effects between Radar and Reflector and no significant main effects for Reflector. There was a main effect for Radar on team development, $F(1, 30) = 4.19$, $p = .05$, partial $\eta 2 = .12$, level of group conflict, $F(1, 31) = 4.49$, $p = .04$, partial $\eta 2 = .13$, and attitude towards collaborative problem solving, $F(2, 31) = 1.44$, $p = .04$, partial $\eta 2 = .13$.

An independent *t*-test examined the main effects of Radar on team development, group conflict and attitude towards problem-based collaboration. The Radar only and Both tools conditions were combined into a new group named 'With Radar', and conditions Reflector only and No tools were combined into group 'Without Radar' (see Table 2).

The results in Table 2 show that groups With Radar scored significantly higher on team development, $t(32) = 1.79$, $p = .04$, experienced significantly fewer group conflicts, $t(36) = –2.03$, $p = .03$, and had a significantly more positive attitude towards collaborative problem solving, $t(29) = 1.84$, $p = .04$, than groups Without Radar.

Impact of tools on cognitive performance

A two-way between-groups ANOVA was conducted to explore the effect of Radar and Reflector on group cognitive performance, as measured by the essay grade. There were no significant interaction effects between Radar and Reflector, and no significant main effects for Radar or Reflector. Table 3 shows the mean and standard deviations for cognitive performance per condition.

Conclusions and discussion

With respect to the effects of the tools on social aspects, positive main effects were found for Radar on team development, group conflict and attitude towards collaborative problem solving; no effects were found for group satisfaction. One reason for this could be that students tend to emphasize their strengths and positive performances, and perceive weakness and negative performances as common in and caused by others (e.g., Klein, 2001; Saavedra & Kwun, 1993). This tendency, also known as attribution (e.g., Eccles & Wigfield, 2002; Weiner, 1985), could temper the satisfaction about working in a group. In other words, Radar enables group members to become aware of dissatisfaction about the functioning of their peers or the group as a whole. It could also be the case that this lack of a significant main effect for Radar on group satisfaction is due to the short period of time in which groups collaborated. Deadlines and the task at hand influence group development (Gersick, 1988). The short amount of time could 'force' group members to fulfil a role or task in which they do not feel comfortable or satisfied with. Changing circumstances, such as desired role changes or disappointing level of task accomplishment, may cause group development to revert to the stage of storming (Bales & Cohen, 1979), which can be contentious, unpleasant and even painful to group members who do not like conflicts (Tuckman &

Table 3. Mean and Standard Deviations for Cognitive Performance per Condition

	Cognitive performance (essay grade)			
Condition	*M*	*SD*	*Min*	*Max*
No tools	6.00	0.71	5.5	6.5
Reflector only	5.83	1.04	5.0	7.0
Radar only	6.25	2.47	4.5	8.0
Both tools	5.17	1.61	4.0	7.0

Jensen, 1977). In the same vein, the period of time may be too short to find the effects of the tools on cognitive performance.

As to why no significant main effects for Reflector on social group performance were found could be that Reflector focused exclusively on past and present group functioning and not future functioning. It may be the case that Reflector needs to focus on future group functioning and, thus, also stimulate group members to formulate plans and set goals for improving social and cognitive group performances. Research has shown, for example, that outcome feedback can increase individual and group performances, especially when combined with goal setting (Mento, Steel, & Karren, 1987; Neubert, 1998; Tubbs, 1986). There is no reason that this should not also be the case for process feedback.

It should be noted that Radar is both an intervention and a measurement tool. Therefore, the design of this study did not allow determination of whether the decrease of self- and peer assessment scores halfway collaboration at T2 was caused by Radar or Reflector, or whether this also occurred in the control group. Thus, an extra control group will be added in the second study where Radar will become available at T2.

A limitation of this study is the relatively small sample size ($N = 39$), which causes low statistical power. However, even with this small sample, significant main effects were found for Radar on team development, level of group conflict and attitude towards collaborative problem solving.

In sum, the effects of Radar on group functioning look promising. Social group performance in CSCL environments can apparently be enhanced by this tool.

Study 2

In this second study, a redesigned Radar and Reflector were used to enhance group performance in a CSCL environment. In the first study, Radar asked for assessments on five behaviour traits. In Study 2, Radar was expanded with a sixth that also relates to cognitive or task-related behaviour, namely 'quality of contribution'. During evaluation of Study 1, users noted that they did not only want to assess the quantity of fellow group members' performances, but also the quality. When the quality of a fellow group member's performance is poor, quantity becomes irrelevant. Adding this trait was also in line with other research, which showed that group members monitor the quantity and quality of group member performances (e.g., Salas *et al*., 2005).

The lack of results from Reflector was ascribed to the fact that the tool focused on prior and not on future functioning and goal setting. Therefore, Reflector was redesigned to stimulate setting goals and formulating plans to enhance social and cognitive group performances.

Research question and hypotheses

1. Do group members who use the tools throughout perceive higher social performance (i.e., better team development, higher group satisfaction, less group conflict and more positive attitudes towards collaborative problem solving) at the end than group members in the other conditions? Expected is that both Radar and Reflector will positively affect the social behaviour in the group, and that this should lead to an increase in the social performance. Those using tools throughout should perceive higher social performance at the end than those who do not. Furthermore, those who use the tools halfway should perceive higher social performance at the end than those not using the tools.
2. Do groups who use the tools throughout exhibit higher cognitive performance (i.e., produce higher quality group products) at the end than group members in the other conditions? Those using tools throughout should exhibit a higher cognitive performance at the end than those who do not. Furthermore, those who use the tools halfway should exhibit higher cognitive performance at the end than those not using the tools.

Method

Participants

Participants were 108 sophomore Dutch high school students (58 male, 50 female) in four classes with an average age of 16 ($M = 15.8$, $SD = .50$, $Min = 15$, $Max = 18$). Students were randomly assigned by a teacher to dyads ($n = 16$), triads ($n = 84$) and groups of 4 ($n = 8$). Groups were heterogeneous in ability and gender.

Design

Two experimental conditions and one control condition were used. Students' groups were randomly assigned to one of these three conditions by the researcher. The first experimental condition (C1: $n = 59$) received Radar and Reflector at the beginning (T1), at the halfway point (T2) and at the end (T3) of the collaboration process. The second (C2: $n = 23$) received the tools halfway (through T2) and at the end (T3) of the collaboration. The control condition (Control: $n = 26$) did not receive the tools during collaboration but completed them at the end of the collaboration (T3) as measurement instruments. The second experimental condition originally contained 60 students. However, because of technical problems, one full class of 27 students had to be excluded.

Measures

Social and cognitive performances Measurement of social and cognitive performances was the same as in Study 1. Additionally, in Study 2, the 30 items in the four 'Social Performance' scales were subjected to principal component analysis (PCA). Prior to this, the suitability of data for factor analysis was assessed. In the correlation matrix, all coefficients were ≥.5. The Kaiser–Meyer–Olkin value was .73 (recommended value = .6) and Bartlett's test of sphericity reached statistical significance, supporting the factorability of the correlation matrix. PCA revealed the presence of one main component with eigenvalues ≥1, explaining 76.6% of the variance. Cronbach's α of the composed 'Social Performance (total)' scale was .90 (see Table 1).

Instruments

Virtual Collaborative Research Institute Students used the same VCRI as in Study 1.

Peer assessment tool (Radar) In Study 1, Radar provided information on five traits deemed important for assessing behaviour in groups (i.e., influence, friendliness, cooperation, reliability and productivity). In Study 2, the tool was complemented with a sixth trait that represents cognitive or task-related behaviour: quality of contribution.

Reflection tool (Reflector) In the first study, the fact that no significant main effects were found for Reflector on group performance was ascribed to the fact that the tool was not focused on future functioning and goal setting (Hattie & Timperley, 2007). According to Hattie and Timperley, for feedback to be effective, the receiver needs to answer three major questions: (1) Where am I going?/What are the goals? (feed up); (2) How am I going?/What progress is being made towards the goal? (feedback); and (3) Where to next?/What activities need to be undertaken to make better progress? (feedforward). Thus, in this follow-up study, Reflector was redesigned to make group members better aware of their individual and group behaviours, and to stimulate them to set goals and formulate plans to enhance social and cognitive group performances. Group members using Reflector individually reflect and provide information on (1) their own perspective on their personal performance (feed up), (2) differences between their self-perception and the perception of their peers concerning their personal performance (feedback), (3) whether they agree with those perceptions (feedback) and (4) their individual perspectives on group performance (feed up). Because group performance is determined by the individual effort of all group members, Reflector also (5) stimulates group members to collaboratively reflect (i.e., co-reflect) on group performance and reach a shared conclusion on this (feedback). Based on their shared conclusion, group members (6) set goals to improve group performance (feedforward).

Task and procedure

Task and procedure differed from Study 1 only in that prior to the collaborative writing task, students worked collaboratively in small groups for 1 month choosing a topic, searching for relevant information, writing a short paper and giving a presentation. Thus, all information needed to write the essay was available for all groups. For the rest, the procedure was the same as for Study 1 including keeping time-on-task (i.e., writing the essay) equal for all conditions.

Results

Impact of tools on social performance

Significant intra-class correlations were found for all measures except for attitude (see Table 4), indicating that the group has an effect on the perceived social performance of individual group members. Multilevel analyses were thus used to examine the effect of condition on perceived social performance (see Table 4).

Table 4. Means and Standard Deviations for Scores on Social Performance Scales

	Intra-class correlation	Comparing condition 1 versus 2		Comparing condition 1 versus 3			Comparing condition 2 versus 3		
Scale	*rI*	*β*	*SE*	*β*	*SE*	Deviance	*β*	*SE*	Deviance
Team development	.66***	.63***	.18	.27	.18	7.84**	–.32	.18	2.01
Group-process satisfaction	.41**	.41**	.17	.31*	.17	3.90	–.13	.20	–1.00
Intra-group conflicts	.62***	–.49*	.21	–.27	.20	3.07	.20	.22	–0.19
Attitude	.03	.26*	.14	.19	.13	–0.07	–.06	.17	–1.57
Social performance (total)	.49***	.45**	.15	.26*	.14	4.88*	–.17	.17	–0.49

*$p < .05$ (1-tailed).
**$p < .01$ (1-tailed).
***$p < .001$ (1-tailed).

The column 'deviances' indicates the difference in goodness of fit of new model (with tools) versus the old model (without tools). A negative deviance indicates that the goodness of fit for the new model with tools is less than the old model without tools. A chi-square test was used to examine whether the deviances are significant, which are indicated by asterisks in the column.

As expected, groups in C1 (tools throughout) perceived their team as better developed than groups in C2 (tools at midpoint), as indicated by a significant β-value. This effect was caused by availability of the tools, as indicated by a significant χ^2 value (7.84). However, no significant differences were found for team development between C1 and C3 (the Control). For group satisfaction, groups in C1 experienced significantly higher levels of group satisfaction than groups in C2 and the Control. However, this effect cannot be fully ascribed to the availability of the tools because the associated χ^2 value (3.90) was not significant ($p = .07$). With respect to conflicts, as expected, groups in C1 experienced lower levels of conflict than groups in C2, but no significant differences were found between C1 and the Control. Furthermore, this effect should be interpreted with caution, as the associated χ^2 value was not significant ($p = .11$). With respect to attitude, groups in C1 had a significantly more positive attitude towards collaborative problem solving than groups in C2, but no significant differences were found between C1 and the control condition. Also here, the associated χ^2 value was not significant. Finally, groups in C1 experience significantly higher social performances than groups in C2 and the Control condition. No significant differences were found between groups in C2 and the Control.

Impact of tools on cognitive performance

A one-way between-groups ANOVA (one tailed) with planned comparisons was conducted to explore the effect of Radar and Reflector on group cognitive performance, as measured by the grade given to their (group) essays. Table 5 shows the means and standard deviations for group performance per condition. No significant effects were found.

Conclusion and discussion

As expected, in comparing conditions 1 (tool use throughout) and 2 (tool use from the halfway point),

Table 5. Means and Standard Deviations for Cognitive Performance per Condition

		Cognitive performance (essay grade)			
Condition	n_{groups}	*M*	*SD*	*Min*	*Max*
1 – tools available at T1, T2 and T3	20	6.81	.71	4.0	8.5
2 – tools available at T2 and T3	8	6.54	1.04	4.5	8.5
3 – tools available at T3	9	6.36	1.61	4.0	8.5

learners in C1 perceived their team as being better developed, experienced higher levels of group satisfaction, lower levels of conflict, and were more positive about collaborative problem solving than learners in C2. Comparing C1 to the Control (no tool use), learners in C1 experienced higher levels of group satisfaction and higher social performance than those in C3. The associated χ^2 values indicate that though using tools throughout can have a positive effect on social performance, there are possible other factors (e.g., reciprocity, assessment bias) that influence assessment.

Unexpectedly, no significant differences were found between C2 and the Control. Using tools starting halfway had no effect on perceived social performance for C2. The time may have been too short for the tools to affect social performance. Group members in C2 had half the time to adapt their social and cognitive behaviours compared with those C1 who used the tools throughout.

The final question was whether using Radar and Reflector would lead to higher cognitive performance, measured by the essay grade. As found in Study 1, no significant effects were found for the grade. A possible explanation could be that a better social group performance (i.e., higher levels of team development and group satisfaction) does not necessarily directly lead to a higher cognitive performance (i.e., quality of group product). Furthermore, the time using the tools may have been long enough for groups to go through the norming phase and reach the performing phase (see Figure 3; Tuckman & Jensen, 1977) on a social performance level, but time may have been too short to also reach the performing phase on the cognitive performance level. Significant tool effects on social performance were found, but might have been stronger when more time was available. However, results did show that groups using the tools perceived higher levels of social group performance (i.e., group satisfaction) compared with groups not using tools (see Studies 1 and 2). These results indicate that these tools can be used to enhance social group performance (i.e., better team development and group process satisfaction), particularly for high school students (see Studies 1 and 2).

In future research, Radar and Reflector will be used for longer periods (e.g., 3 months) during which the tools will be available from the beginning for all conditions, and will have to be used several times.

Nevertheless, the presented results support the hypothesis that frequent Radar and Reflector use enhances group social performance.

Overall conclusions and discussion

This article indicates that social interaction is important for the cognitive and social-emotional processes that need to take place within CSCL groups (see Figure 1), so that these groups will go through the norming phase and reach the performing phase (Tuckman & Jensen, 1977) of working as a team, enabling promotive interaction and group processing as part of the collaborative learning activities (Johnson & Johnson, 1999, 2004, 2009; see Figure 3). As a result, high levels of cognitive performances (such as high grades for group results) and desired social performances (such as a sound social space and satisfaction) can be expected. CSCL environments, therefore, have to pay attention that the social interaction is not impeded by embedding social and educational affordances within the CSCL environment (Kreijns *et al*., 2013; see Figure 2). Group awareness tools such as Radar and Reflector implement these types of affordances, thereby contributing to the CSCL environment's sociability and educability.

The current study has shown that Radar and Reflector can influence the behaviours of learners in CSCL environments in two ways. First, it can influence *individual behaviour* by making group members aware of their own behaviours and that of others in the group. Radar coerces group members to assess their own social and cognitive behaviours and those of their fellow group members, and shares these assessments within the group, visualizing them anonymously in a Radar diagram. Reflector stimulates them to reflect on discrepancies between self-perceptions of their behaviours (i.e., self-assessments) and their behaviours as experienced by others (i.e., peer assessments), which can provide students with cues for behavioural change. This could lead, in turn, to an *awareness of group norms*. This process of *norming* (Tuckman & Jensen, 1977) is an import stage in group development and conditional for achieving a sound social space (see Figure 3).

Second, group awareness tools can raise students' *awareness of group functioning*. Radar enables group members to become aware of dissatisfaction among their peers about one of the group's members while

Reflector enables group members to collaboratively reflect upon group functioning and to reach a shared understanding on this. Radar and Reflector, thus, can be seen as devices that provide students with information to monitor, coordinate and regulate their own and the group's social and cognitive performances (i.e., meta-cognitive information).

In other words, these types of social awareness tools afford the type of self-regulation and motivation that according to Moreno (2006) are required for realizing promotive interaction and group processing so that effective, efficient and enjoyable learning can occur in a social, collaborative context.

Note

[1]http://www.co-operation.org/home/introduction-to-cooperative-learning/

References

Artzt, A. F., & Armour-Thomas, E. (1997). Mathematical problem solving in small groups: Exploring the interplay of students' metacognitive behaviors, perceptions, and ability levels. *Journal of Mathematical Behavior*, *16*(1), 63–74.

Bales, R. F. (1988). A new overview of the SYMLOG system: Measuring and changing behavior in groups. In R. B. Polly, A. P. Hare, & P. J. Stone (Eds.), *The SYMLOG practitioner: Applications of small group research* (pp. 319–344). New York, NY: Preager.

Bales, R. F., & Cohen, S. P. (1979). *SYMLOG: A system for the multiple level observation of groups*. New York, NY: Macmillan Publishing.

Bonebright, D. A. (2010). Perspectives. 40 years of storming: A historical review of Tuckman's model of small group development. *Human Resource Development International*, *13*(1), 111–120.

Buder, J., & Bodemer, D. (2008). Supporting controversial CSCL discussions with augmented group awareness tools. *International Journal of Computer-Supported Collaborative Learning*, *3*(2), 123–139.

Clarebout, G., Elen, J., & Lowyck, J. (1999). *An invasion in the classroom: Influence on instructional and epistemological beliefs*. Paper presented at the Eighth Bi-annual Conference of the European Association of Research on Learning and Instruction (EARLI), Goteborg, Sweden.

den Brok, P., Brekelmans, M., & Wubbels, T. H. (2006). Multilevel issues in studies using students' perceptions of learning environments: The case of the Questionnaire on Teacher Interaction. *Learning Environments Research*, *9*, 199–213.

Dirckinck-Holmfeld, L., & Sorensen, E. K. (1999). Distributed computer supported collaborative learning through shared practice and social participation. In C. Hoadley & J. Roschelle (Eds.), *Proceedings of the Computer Support for Collaborative Learning (CSCL) 1999 Conference* (pp. 12–15). Mahwah, NJ: Lawrence Erlbaum Associates.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*, 109–132.

Fischer, F., Bruhn, J., Gräsel, C., & Mandl, H. (2002). Fostering collaborative knowledge construction with visualization tools. *Learning and Instruction*, *12*, 213–232.

Gersick, C. (1988). Time and transition in work teams: Towards a new model of group development. *Academy of Management Journal*, *31*, 9–41.

Gilbert, L., & Moore, D. R. (1998). Building interactivity into web courses: Tools for social and instructional interaction. *Educational Technology*, *38*(3), 29–35.

Gräsel, C., Fischer, F., Bruhn, J., & Mandl, H. (2001). Let me tell you something you do know. A pilot study on discourse in cooperative learning with computer networks. In H. Jonassen, S. Dijkstra, & D. Sembill (Eds.), *Learning with multimedia – Results and perspectives* (pp. 111–137). Frankfurt, Germany: Lang.

Gunawardena, C. N., Lowe, X., Constance, A., & Anderson, T. (1997). Analysis of a global debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research*, *17*, 397–431.

Gunawardena, C. N. (1995). Social presence theory and implications for interaction and collaborative learning in computer conferences. *International Journal of Educational Telecommunications*, *1*(2/3), 147–166.

Hattie, J. & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, *77*, 81–112.

Hewitt, J. (2005). Toward an understanding of how threads die in asynchronous computer conferences. *Journal of the Learning Sciences*, *14*, 567–589.

Jaspers, J., Broeken, M., & Erkens, G. (2004). *Virtual Collaborative Research Institute (VCRI) (Version 2.0)*. Utrecht, The Netherlands: Onderwijskunde Utrecht, ICO/ISOR.

Järvelä, S., & Hadwin, A. (2013). New frontiers: Regulating learning in CSCL. *Educational Psychologist*, *48*(1), 25–39.

Johnson, D. W., & Johnson, R. T. (1999). *Learning together and alone: Cooperative, competitive, and individualistic learning* (5th ed.). Boston, MA: Allyn and Bacon.

Johnson, D. W., & Johnson, R. T. (2004). Cooperation and the use of technology. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology*

(pp. 785–811). Mahwah, NJ: Lawrence Erlbaum Associates.

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, *38*, 365–379.

Kenny, D. A. (1994). *Interpersonal perception: A social relations analysis*. New York, NY: Guilford.

Kirschner, P. A. (2002). Can we support CSCL? Educational, social and technological affordances for learning. In P. A. Kirschner (Ed.), *Three worlds of CSCL. Can we support CSCL* (pp. 61–91). Heerlen, The Netherlands: Open Universiteit Nederland.

Kirschner, P. A., Beers, P. J., Boshuizen, H. P. A., & Gijselaers, W. H. (2008). Coercing shared knowledge in collaborative learning environments. *Computers in Human Behavior*, *24*, 403–420.

Klein, W. M. (2001). Post hoc construction of self-performance and other performance in self-serving social comparison. *Society for Personality and Social Psychology*, *27*(6), 744–754.

Koschmann, T. (1994). Toward a theory of computer-support for collaborative learning. *Journal of the Learning Sciences*, *3*, 218–224.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior*, *19*, 335–353.

Kreijns, K., Kirschner, P. A., Jochems, W., & van Buuren, H. (2004). Measuring perceived quality of social space in distributed learning groups. *Computers in Human Behavior*, *20*(5), 607–632. doi:10.1016/j.chb.2003.11.002

Kreijns, K., Kirschner, P. A., Jochems, W., & van Buuren, H. (2011). Measuring perceived social presence in distributed learning groups. *Education and Information Technologies*, *16*, 365–381.

Kreijns, K., Kirschner, P. A., & Vermeulen, M. (2013). Social aspects of CSCL Environments: A research framework. *Educational Psychologist*, *48*, 229–242.

Kreijns, K., Van Acker, F., Vermeulen, M., & van Buuren, H. (2014). Community of inquiry: Social presence revisited [Special Issue: Inquiry into 'Communities of Inquiry': Knowledge, Communication, Presence, Community]. *E-Learning and Digital Media*, *11*(1), 5–19.

Liaw, S., & Huang, H. (2000). Enhancing interactivity in web-based instruction: A review of the literature. *Educational Technology*, *40*(3), 41–45.

Mento, A. J., Steel, R. P., & Karren, R. J. (1987). A meta-analytic study of the effects of goal setting on task performance: 1966–1984. *Organizational Behavior and Human Decision Processes*, *39*, 52–83.

Moreno, R. (2006). Does the modality principle hold for different media? A test of the method affects learning hypothesis. *Journal of Computer Assisted Learning*, *22*, 149–158.

Neubert, M. J. (1998). The value of feedback and goal setting over goal setting alone and potential moderators of this effect: A meta-analysis. *Human Performance*, *11*, 321–335.

Oztok, M., & Brett, C. (2011). Social presence and online learning: A review of the research. *Journal of Distance Education*, *25*(3). Retrieved from http://www.jofde.ca/index.php/jde/article/view/758/1299

Phielix, C., Prins, F. J., & Kirschner, P. A. (2010). Awareness of group performance in a CSCL environment: Effects of peer feedback and reflection. *Computers in Human Behavior*, *26*, 151–161.

Phielix, C., Prins, F. J., Kirschner, P. A., Erkens, G., & Jaspers, J. (2011). Group awareness of social and cognitive performance in a CSCL environment: Effects of a peer feedback and reflection tool. *Computers in Human Behavior*, *27*, 1087–1102.

Saavedra, R., Early, P. C., & Van Dyne, L. (1993). Complex interdependence in task-performing groups. *Journal of Applied Psychology*, *78*, 61–72.

Saavedra, R., & Kwun, S. K. (1993). Peer evaluation in self-managing work groups. *Journal of Applied Psychology*, *78*, 450–462.

Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there a 'Big Five' in teamwork? *Small Group Research*, *36*, 555–599.

Savicki, V., Kelley, M., & Lingenfelter, D. (1996). Gender, group composition, and task type in small task groups using computer-mediated communication. *Computers in Human Behavior*, *12*, 549–565.

Strijbos, J. W., Martens, R. L., Jochems, W. M. G., & Broers, N. J. (2007). The effect of functional roles on perceived group efficiency during computer-supported collaborative learning: A matter of triangulation. *Computers in Human Behavior*, *23*, 353–380.

Tubbs, M. E. (1986). Goal setting: A meta-analytic examination of the empirical evidence. *Journal of Applied Psychology*, *71*, 474–483.

Tuckman, B. W. (1965). Developmental sequence in small groups. *Psychological Bulletin*, *63*, 384–399.

Tuckman, B. W., & Jensen, M. A. C. (1977). Stages of small group development revisited. *Group and Organizational Studies*, *2*, 419–427.

Van Meter, P., & Stevens, R. J. (2000). The role of theory in the study of peer collaboration. *Journal of Experimental Education*, *69*(1), 113–127.

Walther, J. B. (1993). Impression development in computer-mediated interaction. *Western-Journal of Communication*, *57*(4), 381–398.

Walther, J. B. (1996). Computer-mediated communication: Impersonal, interpersonal, and hyperpersonal interaction. *Communication Research*, *23*(1), 3–43.

Weinberger, A. (2003). *Scripts for computer-supported collaborative learning. Effects of social and epistemic cooperation scripts on collaborative construction* (Doctoral dissertation, Ludwig-Maximilians-University, Munich, Germany). Retrieved from http://edoc.ub.uni-muenchen.de/archive/00001120/01/Weinberger_Armin.pdf

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review*, *92*, 548–573.

Yukawa, J. (2006). Co-reflection in online learning: Collaborative critical thinking as narrative. *International Journal of Computer-Supported Collaborative Learning*, *1*, 203–228.