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Investigating the effects of prompts on argumentation style, consensus and perceived efficacy in collaborative learning

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Abstract This paper investigates the effects of task-level versus process-level prompts on levels of perceived and objective consensus, perceived efficacy, and argumentation style in the context of a computer-supported collaborative learning session using Interactive Management (IM), a computer facilitated thought and action mapping methodology. Four groups of undergraduate psychology students (N=75) came together to discuss the negative consequences of online social media usage. Participants in the task-level group received simple, task-level prompts in relation to the task at hand, whereas the process-level group received both task-level prompts and more specific, and directed, process-level prompts. Perceived and objective consensus were measured before the IM session, and were measured again, along with perceived efficacy of the collaborative learning methodology, after the IM session. Results indicated that those in the process-level prompt groups scored significantly higher on perceived consensus and perceived efficacy of the IM methodology after the session. Analysis of the group dialogue using the Conversational Argument Coding Scheme revealed significant differences between experimental conditions in the style of argumentation used, with those in the process-level prompt groups exhibiting a greater range of argumentation codes. Results are discussed in light of theory and research on instructional support and facilitation in computer-supported collaborative learning.

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Introduction

Resolving complex scientific and social problems often requires the application of critical, collaborative and systems thinking skills (Hogan et al. 2015). It has been suggested that many people have limited critical thinking skills (Kuhn 2005), and that collaborative problem-solving and argumentation are rarely optimized in working groups (Tannen 1998). Furthermore, from an educational design perspective, third-level education generally focuses on the development of individual and domain-specific thinking skills, which do not often transfer well to other domains of enquiry and thus act as a barrier to multi-disciplinary, collaborative systems thinking. Scholars increasingly recognise the need for the development of generic, tool-supported, critical, collaborative and systems thinking skills (Hogan et al. 2014). The challenge of integrating computer support and collaborative learning, or technology and education, remains an important goal in the learning sciences - a challenge which according to Stahl et al. (2006) is one that the field of computer-supported collaborative learning (CSCL) seeks to address.

It has been suggested that the deployment of CSCL technologies in educational contexts and environments is most effectively advanced through design-based research, which takes the "group" as its fundamental, "paradigmatic unit of analysis" (Stahl 2015, p. 1). This entails "looking at how groups of students interact with various technological artifacts and observing their meaning-making processes, their enacting of the technologies and their problem solving as mediated by the technologies." (Stahl 2015, p.15). This paper reports on one of the first experimental demonstrations of the formative impact of prompt style on students' enacting of, and problem-solving in a CSCL context using a systems thinking technology, Interactive Management (IM). Importantly, Asterhan and Schwarz (2010, p.261) noted: "the extent to which students learn from collaborative activities depends on the depth and the quality of the dialogue peers engage in." Further, studies have shown the significant impact of prompting in scaffolding shared meaning-making in collaborative learning settings (Wen et al. 2015; Gelmini-Hornsby et al. 2011). The research reported here provides initial experimental insights into the effects of prompt style on outcomes in the application of IM – as a high-potential, technology-mediated thought and action mapping methodology - in a face-to-face, CSCL context.

Importantly, the CSCL literature highlights that merely bringing groups together to work on a problem does not guarantee effective collaboration. Successful collaboration requires the careful design of the learning environment for group interaction and the provision of instructional support, leadership, facilitation and prompts to promote meaning-making, problem solving, and consensus among students (Pea 2004; Strijbos et al. 2004). While the importance of good facilitation in collaborative learning environments is often highlighted by expert facilitators (Hmelo-Silver 2002), there has been limited experimental research focused on the effects of facilitator prompting styles on CSCL outcomes. Furthermore, different facilitator prompting styles may have different effects on different people within a group. Psychological variables, such as trust amongst group members, may impact on the collaborative efforts of groups. Notably, higher levels of group trust have been implicated in a range of behaviours associated with more effective collaboration, including social negotiation, critical thinking and solution finding (Kreijns et al. 2002). Similarly, dispositional trust is relevant in collaborative contexts as those with high dispositional trust generally assume that others are trustworthy, and presume that trusting others leads to positive outcomes (McKnight et al. 1998). In light of the above, the current study investigated the effects of task-level versus process-level prompts, on processes and outcomes in a CSCL environment, while controlling for dispositional trust as a covariate.

Instructional support in collaborative learning environments

Collaborative work and collaborative learning are becoming increasingly prevalent within educational, organisational, and business settings. It has been argued that a team approach to work is often more suitable for complex tasks, rather than assigning these tasks to one individual expert (Barron 2000; Dillenbourg 1999; Gabelica et al. 2012; Kirschner 2009). A number of important conclusions have been derived from analyses of collaborative teams in work and educational settings. For example, when left to their own devices, teams often fail to reach their full potential, and they may consider collaborative work to be too time-consuming and thus fail to sustain quality interactions and exchanges (Dickinson and McIntyre 1997; Rummel and Spada 2005). Therefore, it is necessary to provide collaborative teams with skilled facilitation and instructional support, which includes prompts designed to sustain quality interactions during the collaborative learning process (Gabelica et al. 2012). While the literature regarding the benefits of individual-level instructional support in learning contexts is well-established (Gabelica et al. 2012; Hattie and Gan 2011), less research has been devoted to the analysis of prompts and facilitation effects in collaborative learning settings and the specific types of prompts that promote collaborative argumentation and consensus-building in these settings.

Generally, prompts are used as part of instructional support and scaffolding protocols (e.g., Stevenson et al. 2013; Gamlem and Munthe 2014) and come in many forms, including guiding questions, sentence openers, or question stems which provide learners with hints, clues, suggestions or reminders that help them to complete a task. Prompts act as scaffolding that support and inform the learning process (Gan and Hattie 2014). Prompts may also be considered as "strategy activators" which "induce productive learning processes" (Berthold et al. 2007, p. 566). Prompts may be used to elicit explanations (Chi 2000; Chi et al. 1994), elaborations (Brown and Palincsar 1989) or collaborative thinking aloud (Hogan 1999).

Prompts have been used across a variety of instructional domains with diverse student groups, including to increase reflection and knowledge integration in middle school science students (Davis 2003), to increase knowledge representation, problem-solving, evaluation, and monitoring skills in undergraduate information technology students (Ge and Land 2003), and improve the quality of written peer feedback in secondary student's chemistry reports (Gan and Hattie 2014). Such feedback and scaffolding protocols can take various forms, utilizing various forms of prompts, for example: task-level prompts, process-level prompts, and self-regulatory prompts, amongst others (Hattie and Timperley 2007). For example, in their study, Gan and Hattie (2014) provided students with prompts designed to elicit peer feedback, such as "What other questions can he/she ask about the task?". These types of questions provided learners with a type of process-level prompt that facilitated collaborative enquiry and problem solving. The current study uses similar prompts, modelled on the work of Hattie and Timperley (2007), and Gan and Hattie (2014).

Notably, many reviews and meta-analyses have demonstrated the benefits of task-level instructional support for individual learning outcomes (e.g., Alvero et al. 2001; Balcazar et al. 1989; Denson 1981; Guzzo et al. 1985; Ilgen et al. 1979; Kluger and DeNisi 1996; Mento et al. 1987; Neubert 1998). Task-level prompting provides information on how well a task is being performed. Task-level prompts may focus on, for example, distinguishing correct from incorrect answers, acquiring more or different information, and building more surface knowledge (Gabelica et al. 2012; Hattie and Timperley 2007). However, research suggests that such task-level prompting does not always have beneficial effects on individual learners and can result in negative performance effects in some situations (see Kluger and DeNisi 1996 for a review).

According to Hattie and Timperley (2007) one of the main shortcomings of task-level instructional support is that it often does not transfer well to other tasks or problems and is therefore limited in its value beyond the specific task at hand. One explanation for this is that when prompts, or other instructional support, are heavily focused on immediate task goals, individuals may not reflect upon the cognitive strategies involved in the learning or problem-solving process. For example, in a LOGO-based angle and rotation mathematics tasks, Simmons and Cope (1993) found that students (ages 9–11) who were provided with immediate, visual, task-level feedback by being able to see their rotation on a computer, spent less time developing strategies for solving the problem, and engaged in more simple trial and error, than students who performed the task via pen and paper.

Process-level approaches seek to address the shortcomings of task-level approaches. At the process-level, prompts are used to address processes and strategies necessary to complete the task (Ketelaar et al. 2012). Process-level support targets procedural knowledge and may provide support for error detection, information searching, and steps for revision of work done (Gan and Hattie 2014, Gan (2011). Process-level prompts have been found to be effective in many domains. For example, Schoenfeld (1985) found that prompting students to provide justifications for their learning was effective for knowledge use in mathematical problem solving tasks. Process-level prompts which promote reflection on learning have also been found to have positive effects on writing-to-learn tasks (Hübner et al. 2010), teacher education (Harford and MacRuairc 2008) and e-learning (Krause et al. 2009). The design of the task-level and process-level prompts used in the current study was informed by both the prompting, and feedback, literature in relation to types of instructional support.

While prompting has been argued to be powerful and effective in shaping team learning and team performance (Kozlowski and Ilgen 2006; Woolley 2009), the application of these methods to CSCL settings has not been explored as extensively as in individual learning settings. Importantly, results and insights from studies of instructional support at the individual level cannot simply be transferred and applied to teams or other collaborative groups (Gabelica et al. 2012; Barr and Conlon 1994; Dewett 2003; Nadler 1979). For example, Barr and Conlon (1994) suggest that the unique effects of instructional support in a team environment may be due to the distribution of prompts among team members, a process which is dependent on the interaction of a number of individual-level and team-level variables including: the interaction between team members; the nature and efficacy of group communication; and individual perceptions of information. The potential discrepancy between individual and group level support may be especially relevant in the case of process-level prompting. In a collaborative context, process-level prompting may address individual and group behaviours, actions and strategies during the course of team learning, however, research examining the impact of process-level support in teams is still in its infancy (Gabelica et al. 2012; Hattie and Timperley

2007). As such, in the current study we investigated the effects of task-level versus process-level prompting in the context of a group decision-making process that involves collaborative argumentation, consensus-building and the development of a systems-based understanding of a common problem.

Prompting, argumentation, and group decision making

A core focus of the current study is collaborative argumentation. The ability to engage in dialogue, debate and collaborative argumentation is an essential human skill. The utility of this skill is evident in many scenarios - an academic engaging in debate, a researcher positing a theory, a politician lobbying for a policy, an entrepreneur pitching a product idea, to name but a few. In scenarios such as these, an individual must cite relevant facts, coordinate reasons and objections in relation to 'factual' claims, respond to rebuttals and counterclaims in a logical manner, and make full use of their powers of persuasion to convince others of their position and justify their conclusions (Scheuer et al. 2010). However, argumentation is more than just a method for persuading others, it is also an essential tool which individuals employ collaboratively in order to arrive at rational decisions and conclusions that promote the adaptive success of the group. The power of collaborative learning derives, in part, from its potential to facilitate cognitive coherence in groups (Stahl 2010). Stahl points out that there currently exist multiple theoretical frameworks, each with its own model of the influences on collaborative learning. Importantly, in an attempt to synthesize the major categories of influences in this context - including team knowledge artifacts, team outcomes, tasks, technology and media, interaction context, culture of discourse community, individual voices, and individuals' resources and experiences - Stahl places dialogical interaction at the centre of these influences. This dialogical interaction represents the means by which learners enter into a collective knowledge-building agency. Given the importance of such dialogical interaction in collaborative learning settings, it is imperative that research attend to the means and methods by which such dialogue, collaborative argumentation and consensus building can be supported and facilitated.

However, as noted above, people often demonstrate limited argumentation skills (Tannen 1998). This has been documented in various studies which report problems with argumentation in informal settings (Kuhn 1991), as well as in specific, professional and scientific domains (Stark et al. 2009). In order to address these limitations, there is a growing trend in the use of instructional support to enhance argumentation skills, particularly in collaborative learning settings (Scheuer et al. 2010). Collaborative argumentation is not a simple process whereby individuals provide a series of reasons and objections in relation to a set of claims - it may involve many and diverse types of talk that are coordinated in a more or less coherent manner. For example, the Conversational Argument Coding Scheme (CACS), used in the current study, identifies 16 conversational codes grouped under 5 argumentation categories, with the codes representing different levels and types of argumentation (see Method section).

Instructional support designed to facilitate dialogic argumentation in collaborative learning classrooms can take many forms. One commonly used strategy is question asking, a strategy which has been found to have positive effects on argumentation in both university and high-school students (Graesser et al. 1993). Graesser et al. refer to question asking as a fundamental strategy of engaging with learners in collaborative learning settings. Question asking can serve a number of functions, including: prompting students to check each other's information, prompting provision of further explanation and encouraging justification of assertions (Webb 1995). King (1990), in a sample of undergraduate and graduate university students taking an education methods course, found that higher-order questions - including open-answer questions, deep-reasoning questions aimed at causes and consequences, and goal-oriented questions - are effective in eliciting explanations, in which justifications may be enclosed. Furthermore, Veerman et al. (2000), in the context of teaching about effective pedagogical interactions in a university student sample found that asking open questions, as well as questions aimed at inferring knowledge, were positively associated with argumentation performance, measured by reference to frequency of information exchange (e.g., checking, challenging, and countering) and constructive activities (e.g., explaining, evaluating, and summarising). In this way, question asking can be used as a form of process-level prompt, as questions can be used to move beyond an assessment of the correctness of a student's response, to address the process, strategy or logic used by the student. As such, question asking, at different levels of complexity is central to our definition of both task-level and process-level prompts in the current study.

From a technological perspective, researchers have sought to develop computer-supported tools to both teach and support argumentation. The field of CSCL has, in particular, been interested in argumentation and how students can benefit from it (Baker 2003; Schwarz and Glassner 2003; Andriessen 2006; Stegmann et al. 2007; Muller Mirza et al. 2007). Collaborative argumentation is viewed as a key way in which students can acquire critical and reflective thinking skills (Andriessen 2006). Several researchers have investigated the use of CSCL tools in supporting argumentation, using tools such as Belvedere (Paolucci et al. 1995), SenseMaker (Bell 2004), Drew (Baker et al. 2003), pro–con tables (Schwarz and Glassner 2003), and matrices (Suthers and Hundhausen 2003). One of the primary reasons for using these tools is that they provide visual representations of the thinking and argumentation learners are engaged with, and thus stimulate collaboration and sharing of ideas (Bell 2004; Van Bruggen et al. 2003). Furthermore, these tools often require students to make explicit their assertions, claims and arguments, and support collaborative consideration of shared ideas, allowing for the recognition of gaps or contradictions in argument structures (Suthers and Hundhausen 2003).

Importantly, argumentation tools are used in specific pedagogical contexts; hence success is determined not only by the specific software tools that are used, but also by the overall setting in which the software is employed. Inevitably, it is necessary to guide students in their use of CSCL tools if learning gains at the level of the individual and group are to be maximised. For this reason, understanding the impact of facilitation and instructional support on the development of argumentation skills and problem solving in collaborative settings is critical.

Interactive management

One CSCL tool which can be used to facilitate problem-solving and collaborative argumentation skills is Interactive Management (IM). IM is a computer facilitated thought and action mapping methodology designed to facilitate group creativity, group problem solving, group design and collective action in the context of complexity (Warfield and Cardenas 1994). Interactive Management is designed to facilitate cooperative inquiry and consensus in relation to a problem. Established as a formal system of facilitation in 1980 after a developmental phase that started in 1974, IM was designed to assist groups in dealing with complex issues (see Ackoff 1981; Argyris 1982; Deal and Kennedy 1982; Rittel and Webber 1973; Simon 1960). The theoretical constructs that inform IM draw from both behavioural and cognitive sciences, with a strong basis in general systems thinking. Emphasis is given to balancing behavioural and technical demands of group work (Broome and Chen 1992), while honouring design laws concerning variety, parsimony, and saliency (Ashby 1958; Boulding 1966; Miller 1956).

There are a series of steps in the process (see Fig. 1). First, a group of (typically, between 12 and 20) people, with an interest in resolving a problematic situation come together and are asked to compile a set of raw ideas which they feel might have an influence on the problem in question. Group discussion and voting helps the group to identify the factors they agree have the most critical impact on the problem. Next, using IM software, Interpretative Structural Modelling (ISM), each of the critical issues is compared systematically in pairs by asking the question: "Does issue A significantly influence issue B?" Unless there is a clear majority consensus that A impacts on B, the relation does not appear in the final analysis. This process continues until all of the critical issues have been compared. The ISM software then generates a problematique, which is a graphical representation of the problem-structure, showing how all the critical problem factors are interrelated. This consensus-based problematique becomes the catalyst for discussion, planning of solutions and collective action in response to the problem (Warfield 2006). Although Warfield designed IM as a consensus-based problem-solving tool, there remains a paucity of research investigating the role of facilitation and prompting in an IM systems thinking environment

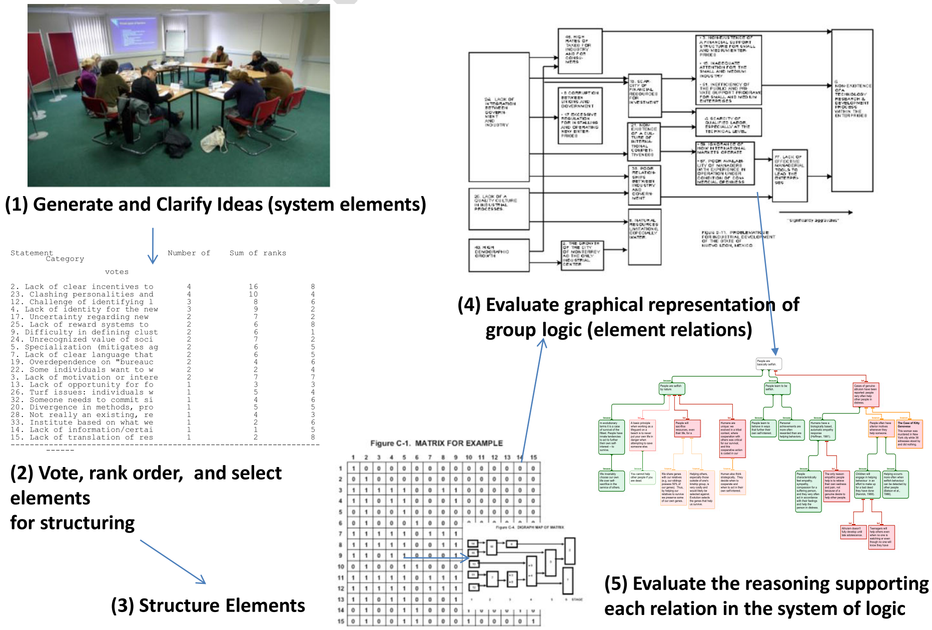

Fig. 1 Steps in the Interactive Management process

Social psychological factors in collaborative settings

Stahl (2010) contends that the power of collaborative learning stems from its potential to unite multiple people in achieving the coherent cognitive effort of a group. A primary goal of CSCL is to explore how this synergy occurs and seek to design and implement methodologies which can support and enhance this process. With this in mind, a number of social psychological variables were considered in the current study.

One outcome of interest in the current study is consensus. Both perceived and objective consensus are potentially critical variables which need to be considered in efforts to enhance the successful workings of groups using CSCL tools, particularly if the goal is to use CSCL tools to enhance group problem solving and decision making. The term consensus refers to the extent to which two or more people agree in their ratings of a target (Kenny et al. 1994). Reaching consensus on a solution to a problem is advantageous for many reasons, especially with regard to implementing an action plan designed to resolve a problematic situation. If there is a high level of consensus amongst group members as to key decisions and conclusions, progress toward a solution to a shared problem may be easier to achieve. For example, Mohammed and Ringseis (2001) found that groups who reported higher levels of consensus in relation to a problem had greater expectations about the implementation of decisions reached by the group, and also experienced higher levels of overall satisfaction. The authors also found that the highest levels of consensus were evident in groups in which the members questioned each others' suggestions, accepted legitimate suggestions and incorporated others' viewpoints into their own perspective. What is less clear from such results is whether the facilitation and support provided to groups during collaborative discussions influences consensus-building, and if these effects are similar for both perceived and objective consensus. Perceived consensus refers to the extent to which members of a group report feeling that consensus exists within the group. Objective consensus, on the other hand, refers to actual levels of agreement, as opposed to perceived levels of agreement.

Another important outcome considered in the current study is the group's judgment of the efficacy of the CSCL tool that they are using. Higher levels of perceived efficacy of the CSCL tool are an important social outcome. If CSCL tools such as IM are to be adopted by groups for use in educational and professional settings, it is imperative that they are perceived as efficacious by the user group. Again, it is unclear if specific types of facilitation and prompts influence the perception that group members have in relation to the tools and methodologies that they are using.

Finally, an important social psychological variable to consider in the context of dialogic interaction group consensus, and perceived efficacy of group processes, is the level of trust that exists amongst group members. Research suggests that higher levels of shared trust in a group leads to increased levels of knowledge sharing (Roberts and O'Reilly 1974), with individual group members perceiving knowledge sharing as less costly (Currall and Judge 1995). Furthermore, higher levels of shared trust in a group may increase the likelihood that knowledge received is adequately understood and absorbed so that the individual can put it to use (Mayer et al. 1995). This research suggests that both trust and the facilitation of dialogue may influence other important outcomes in collaborative learning environments, including perceived and objective consensus and perceived efficacy of the methodologies and tools that support learning. Consistent with this view, Harney et al. (2012) found that collaborative groups working in an environment that encouraged open dialogue and discussion, and groups higher in dispositional trust, reported higher levels of perceived consensus, objective consensus and perceived efficacy of collaborative learning methodologies, when compared with groups where levels of dispositional trust were lower and where open dialogue and discussion was restricted. However, the study by Harney et al. (2012) did not manipulate facilitator prompting strategies. Facilitator strategies warrant investigation in CSCL contexts as they may interact with levels of dispositional trust in a group to influence outcomes such as the nature of group argumentation, the level of perceived and objective consensus achieved by a group, and the perceived efficacy of the CSCL tool used by the group. Therefore, the current study included dispositional trust as a covariate in the analysis of experimental prompting effects.

The current study

The current study investigates the effects of task-level versus process-level prompts on perceived and objective consensus, perceived efficacy, argumentation style, and collaborative systems model complexity in the context of an IM session. In light of the evidence reviewed above, it was hypothesised that prompting style during collaborative dialogue and argumentation is a critical factor in shaping key outcomes of collaborative learning. Specifically, it was hypothesised that:

1. Process-level prompts would produce higher levels of perceived and objective consensus and higher perceived efficacy of the IM CSCL tool.
2. Groups that receive task-level prompts would report lower levels of perceived and objective consensus, and perceived efficacy of the IM collaborative learning tool.
3. Process-level prompts would result in more complex and varied forms of argumentation in groups. In particular, it is hypothesised that the process-level prompt condition would result in higher frequency use of propositions, amplifications, justifications, acknowledgements and challenges (see Table 1).
4. Process-level prompts would result in the development of more complex systems models. If, as hypothesised, the process-level prompts cultivate more diverse, sophisticated forms of argumentation, then it follows that this would lead to more complex and differentiated relational thinking that is less likely to be biased in any simple heuristic manner by previous relational judgements, and thus result in more complex representations of the relationships between ideas in the systems structuring phase. With a more diverse pattern of voting, the matrix structures are likely to be more differentiated and thus result in more complex systems representations.

Method

Design

A one way ANCOVA was used to assess the effects of prompting style (task-level versus process-level) on perceived efficacy of IM, while controlling for dispositional trust. A 2 (condition: task-level versus process-level) x 2 (time: pre-intervention versus post-intervention) mixed ANCOVA was used to assess the effects of task-level versus process-level prompts on perceived consensus, again controlling for dispositional trust. A Statistica™ coefficient comparison test was used to assess the statistical significance of differences in objective consensus across groups before and after the experimental manipulation (i.e., differences in Kendall's W). Finally, a series of 2 (condition: task-level versus process-level) ×2 (present versus not present) chi-squared tests were used to examine frequency differences in dialogic argumentation events across prompting conditions using the CACS coding system.

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t1.1 **Table 1** Conversational Argument Coding Scheme (Seibold and Meyers 2007)

	Code	Example from transcript
t1.2	Code	Example from transcript
t1.3	I. Arguables	
t1.4	A. Generative Mechanisms	
t1.5	1. Assertions: Statements of fact or opinion	"I just suggested increased feelings of anger towards yourself and others"
t1.6	2. Propositions: Statements that call for support, action, or conference on an argument-related statement	"Wouldn't this just be related directly to being self-conscious about your image anyways?"
t1.7	B. Reasoning activities	
t1.8	3. Elaborations: Statements that support other statements by providing evidence, reasons, or other supports	"..because, you know, sometimes you're emotionally affected and a lot of the time people will feel angry"
t1.9	4. Responses: Statements that defend arguables met with disagreement	"..but then whoever has been left out just ends up being paranoid about people that they thought they could trust and things"
t1.10	5. Amplifications: Statements that explain or expound upon other statements to establish the relevance of the argument through inference	"Em, I guess what's been suggested is that you might have less time to engage in other activities and from the range of interests you might have, you might not have time for them anymore"
t1.11	6. Justifications: Statements that offer validity of previous or upcoming statements by citing a rule of logic (provide a standard whereby arguments are weighed)	"Just putting yourself in that situation like, if you just put yourself in the shoes of a person who wouldn't be invited and just think about what they would feel?"
t1.12	II. Convergence-seeking activities	
t1.13	7. Agreement: Statements that express agreement with another statement	"Yeah, I think what she said is right"
t1.14	8. Acknowledgement: Statements that indicate recognition and/or comprehension of another statement but not necessarily agreement with another's point	"I think that it could be, for some people, but I've never experienced guilt from Facebook"
t1.15	III. Disagreement-relevant intrusions	
t1.16	9. Objections: Statements that deny the truth or accuracy of an arguable	"I don't think it's significant"
t1.17	10. Challenges: Statements that offer problems or questions that must be solved if agreement is to be secured on an arguable	"Is it increased perception of being judged in a positive way though? You change your personality to be judged in a positive way, because you think you were being judged in a negative way?"
t1.18	IV. Delimitors	
t1.19	11. Frames: Statements that provide a context for and/or qualify arguables	"Em, it's probably within themselves, that they doubt themselves so much more."
t1.20	12. Forestall/secure: Statements that attempt to forestall refutation by securing common ground	*No examples in transcript*
t1.21	13. Forestall/remove: Statements that attempt to forestall refutation by removing possible objections	*No examples in transcript*
t1.22	V. Nonarguables	*No examples in transcript*

t1.24 **Table 1** (continued)

	Code	Example from transcript
t1.23	14. Process: Non-argument-related statements that orient the group to its task or specify the process the group should follow	
t1.24	15. Unrelated: Statements unrelated to the group's argument or process (tangents, side issues, self-talk, etc.)	*No examples in transcript*
t1.25	16. Incompletes: Statements that do not contain a complete, clear idea because of interruption or a person's discontinuing a statement	"I don't know, eh…(discontinued)"

Participants

Participants were first and second year psychology students (N=75) comprising 28 males and 47 females, aged between 18 and 27 years (M=19.60, SD=3.15), from the National University of Ireland, Galway. Participants were offered research participation credits in exchange for their participation.

Measures/materials

Trust

Dispositional trust was measured using a combination of the scales developed by Pearce et al. (1992) and that of Jarvenpaa et al. (1998). The Pearce et al. scale included 5 items; the Jarvenpaa, Knoll and Leidner scale included 6 items. The 11 items were rated on a 5-point Likert scale (1=strongly agree, 5=strongly disagree; e.g., "Most people tell the truth about the limits of their knowledge", "Most people can be counted on to do what they say they will do", and "One should be very cautious to openly trust others when working with other people"). The scale had good internal consistency in the current study (α=0.72).

Perceived efficacy

Perceived efficacy of the IM process itself was measured using a scale developed for use in a previous (Harney et al. 2012). The scale included 7 items rated on a 5-point Likert scale (1= strongly agree, 5=strongly disagree; e.g., "I believe that Interactive Management can be used to solve problems effectively"). The scale had good internal consistency (α=0.88).

Perceived consensus

The method of measurement used in this study was similar to that used by Kenworthy and Miller (2001): participants first gave their opinion (via the voting of problems relations) and were then asked to rate how representative their opinions were in relation to the opinion of other members of their group. While Kenworthy and Miller asked participants for a percentage estimate, we decided to test their perceived consensus using a 5-item scale with five-point Likert ratings (1=strongly agree, 5=strongly disagree; e.g., "Generally speaking, my peers and I approach online social media in a similar manner"). The scale had good internal consistency (α=0.77).

Objective consensus

Objective consensus was measured using Kendall's coefficient of concordance (Kendall's W) in relation to Likert scale judgement across a random set of ten relational statements. These relational statements were generated from a set of propositions compiled by the authors in advance of the IM session, and which participants considered during the IM session. A sample item from this set is: "Increased dissatisfaction with one's own life significantly aggravates increased unfair judgements of others". Items were scored by each individual using a 5-point Likert scale (1=strongly agree, 7=strongly disagree). Objective consensus, as measured by Kendall's W, was computed for each group before and after the experimental manipulation (i.e., task-level versus process-level prompts). High values occur when there is greater agreement between raters in the group.

Style of argument

Style of argument was assessed using the Conversational Argument Coding Scheme (Seibold and Meyers 2007). The Conversational Argument Coding Scheme (CACS) was developed to investigate the argumentative micro processes of group interaction (Beck et al. 2012). The CACS includes 5 five argument categories, which contain a total of sixteen argument codes (See Table 1). The five argument categories include: *generative mechanisms* (assertions and arguables), which are "potentially disagreeable statements" and are considered to reflect simple arguments (Meyers and Brashers 1998); *reasoning activities* (elaborations, responses, amplifications, and justifications) which are higher-level argument messages and are most often extensions of generative mechanisms; *convergence-seeking activities* (agreement and acknowledgements), which include recognition and/or agreement with other statements; *disagreement-relevant intrusions*, which consist of statements denying agreement with arguables, or posing further questions; and *delimitors* (frames, forestall/secure and forestall/remove), which consist of messages designed to frame or contextualize the conversation. The remaining codes are termed *nonarguables* (process, unrelated and incompletes) which consist of statements regarding how the group approach the task, side issues and incomplete or unclear ideas and statements. Multiple Episode Protocol Analysis (MEPA; Erkens 2005) was used to facilitate the CACS analysis. MEPA is computer software designed for interaction analysis, in which transcribed data can be coded or labelled on several dimensions or levels.

Complexity of IM problematiques

These complexity scores are based on total activity of the paths of influence in the structure. This involves computing the sum of the antecedent and succedent scores for each element. The antecedent score is the number of elements lying to the left of an element, which influences it. The succedent score is the number of elements lying to the right of an element in the structure, which influences it (Warfield and Cardenas 1994).

Interpretative structural modelling

Interpretive Structural Modelling (ISM) is a computer-mediated, idea-structuring methodology that is designed to facilitate group problem solving (Warfield and Cardenas 1994). The ISM programme was run on a PC by facilitators. The relations which groups were asked to consider and vote on were displayed on a large screen via an overhead projector.

Procedure

During recruitment, prospective participants were presented with information in relation to the nature of the study, including details as to its focus on collaborative inquiry and the personal and social consequences of online social media. Participants were invited to register online via SurveyGizmo, and were required to complete a dispositional trust scale as part of the registration process. Participants were randomly allocated to one of four groups, two in the task-level condition (n=20, n=20) or process-level condition (n=17, n=18).

Interactive management sessions

A total of four IM sessions were carried out, with no more than 20 students in any one session. Each session lasted approximately 180 min. Participants in each of the four sessions were directed to a room in which chairs were arranged in a circle, such that all of the group members could see each other. Before the IM session began, each participant was given a document which contained a participation information sheet, a perceived consensus scale and an objective consensus scale. The participants were asked to read the information sheet, which contained an introductory paragraph about online social media. Participants were then required to complete the aforementioned scales. Once all scales had been completed, participants were given a list of potential negative consequences of social media usage, which were compiled based on a review of the literature. Next, the IM process was explained to participants and then the session began.

The design of the prompting conditions was informed by the work of Hattie and Timperley (2007) and Hattie and Gan (2011). The task-level condition consisted primarily of simple, task-level prompts, while the process-level condition consisted of task-level prompts, with the addition of process-level prompts. In each condition, an independent facilitator was given a specific set of prompts or instructions which could be used as part of the process (see Fig. 2). A second facilitator was present to oversee the process, and assist with the input of ideas into the ISM software. In both conditions, participants were asked to silently generate a set of ideas in addition to the idea set provided which they felt had a significant impact on the problem at hand (i.e., negative consequences of online social media). This is referred to as the *Idea Generation* phase of IM. Specifically, the *nominal group technique* (NGT) was used (Delbeq et al. 1975). The NGT is a method that allows individual ideas to be pooled, and is ideally used when there are high levels of uncertainty during the idea generation phase. NGT involves five steps: (a) presentation of a stimulus question; (b) silent generation of ideas in writing by each participant working alone; (c) presentation of ideas by participants, with recording on flipchart by the facilitator of these ideas and posting of the flipchart paper on walls surrounding the group; (d) serial discussion of the listed ideas by participants for sole purpose of clarifying their meaning; and (e) implementation of a closed voting process in which each participant is asked to select and rank five ideas from the list, with the results compiled and displayed for review by the group.

In the current study, participants began by generating ideas in response to the question: "What are the negative effects of online social media?" Once the initial silent idea generation was complete, and each participant had their own list of ideas to offer, the facilitator went around the room, to each participant asking them to present their idea to the rest of the group. They were asked to explain their idea clearly and succinctly. The facilitator would then open the discussion up to the group, by asking "Does anyone have any other ideas?" While these guidelines were also followed by the facilitator in the process-level prompt condition, there was also the addition of some further prompts. In the process-level prompt condition, the facilitator could, where necessary, ask for further clarification, suggest that some ideas offered may be similar in nature and require further examination, suggest merging of ideas, suggest breaking down of ideas which appear to have multiple-components, suggest considering the relevance of the idea offered in the problem-context, and suggest considering the generalizability of the idea offered (see Fig. 2).

The next phase is the *Idea Structuring* phase. This is the phase during which the primary computer supported collaboration took place, using the ISM software. In an effort to reduce cognitive load, facilitate focus, and build the components of the systems model, the ISM software presents on screen two elements at a time, asking the question "Does A significantly influence B?" As each of these relational statements is presented on the screen, the facilitator would open the discussion to the room, and ask if anyone has a "yes" or "no" preference at this stage. As participants indicated their preference, the facilitator would ask why they had this stated preference, and then request other opinions from the group. The facilitator would then request a show of hands from the

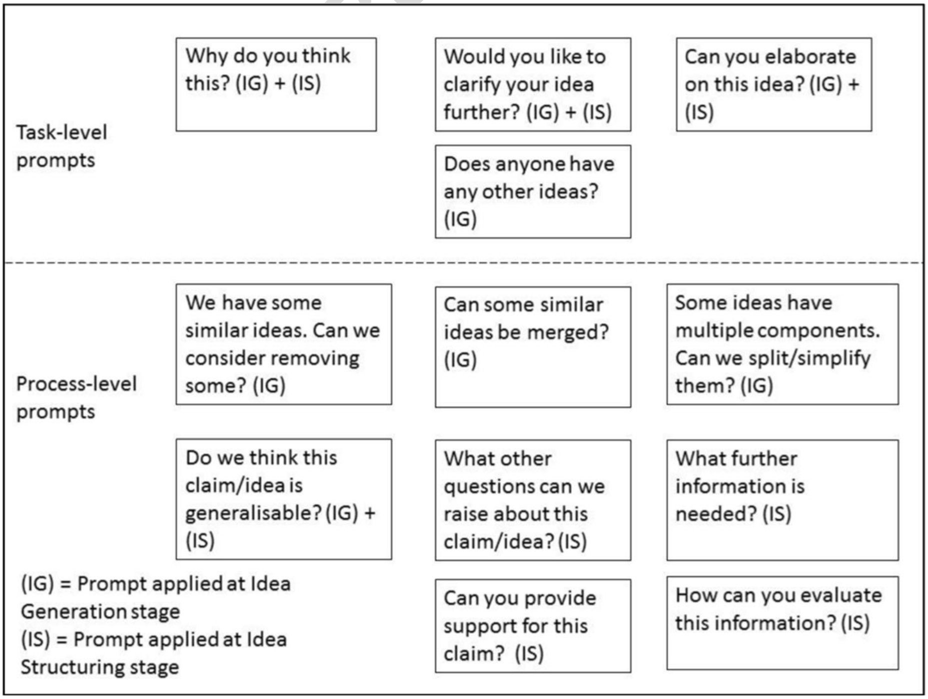


Fig. 2 Task-level and process-level prompts

group, and a vote would be taken and recorded by the ISM software. Again, these guidelines were also followed by the facilitator in the process-level prompt condition, but with the addition of further prompts and instructions. In the process-level condition, the facilitator could, where necessary, ask for contrary opinions, ask for support or evidence, ask the group to further consider the relevance of arguments provided, and suggest considering the generalizability of the reasons and evidence offered (see Fig. 2).

Results

Due to the fact that prompts were delivered at the group level, and perceived efficacy and perceived consensus were measured at the individual level, unconditional models using SAS Proc Mixed were conducted. These models were tested separately for each prompt condition, and each outcome, to determine whether to not there was any significant clustering by group status. These analyses indicated that the intra-class correlations ranged between 0 and 0.0022 (p=0.49). As such, it was deemed that further multi-level analysis was not necessary. The results of ANCOVA testing of perceived efficacy and perceived consensus is presented below.

Perceived efficacy

Perceived efficacy of the IM methodology was assessed at post-test only. A one way ANCOVA was used to assess the effects of prompting style (condition: task-level versus process-level) on perceived efficacy of IM, while controlling for dispositional trust. The ANCOVA revealed a significant main effect of condition, $F(1,72)=38.00$, $p<0.001$, $\eta p^2=0.345$, $d=1.51$, with higher perceived efficacy in the process-level condition ($M=24.38$, $SD=2.71$) than in the task-level condition ($M=22.98$, $SD=2.63$). No other effects were observed.

Perceived consensus

A 2 (condition: task-level versus process-level) x 2 (time: pre-intervention versus post-intervention) mixed ANCOVA was used to assess the effects of task-level versus process-level prompts on perceived consensus, again controlling for dispositional trust. The ANCOVA revealed a significant time x condition interaction, $F(1,72)=8.91$, $p=0.004$, $\eta p^2=0.11$, $d=0.83$, with a significantly greater increase in perceived consensus in the process-level condition from pre ($M=18.06$, $SD=2.22$) to post ($M=20.54$, $SD=2.55$; $t=4.33$, $p<0.01$) than in the task-level condition from pre ($M=17.95$, $SD=2.83$) to post ($M=18.10$, $SD=2.34$; $t=0.18$, $p=0.86$). The results also revealed a significant main effect of the covariate, dispositional trust, on perceived consensus, $F(1,72)=6.48$, $p=0.013$, $\eta p^2=0.083$, $d=0.82$, with higher trust associated with higher levels of perceived consensus.

Objective consensus

Kendall's coefficient of concordance (Kendall's W) was used to measure concordance (i.e., agreement of ratings in relation to specific ISM paths of influence) within groups before and after the experimental manipulation. While there was a trend for objective consensus to increase in all groups, these differences were not statistically significant ($p>0.05$ for all four comparisons; see Table 2).

Table 2 Objective consensus

Condition	Pre	Post
Task-level	0.23	0.25
Process-level	0.21	0.23

Argument style

A series of 2 (condition: task-level versus process-level) x 2 (present versus not present) chi-squared tests were used to assess the statistical significance of differences in argumentation codes (as per the CACS) across prompting conditions. Of the 16 possible CACS argument codes which comprise the five argument categories, 12 were observed in the process-level condition at least once, 8 were observed in the task-level condition at least once, and 4 were not observed in any condition. Significant differences were observed across conditions for 3 argument codes, with higher frequency occurrence in the process-level prompt condition in each case, specifically, for *Amplifications* (x^2 (1)=9.99, p=0.002, V=0.123, d=0.76), *Challenges* (x^2 (1)=7.45, p=0.006, V=0.118, d=0.67), and *Propositions* (x^2 (1)=6.27, p=0.012, V=0.108, d=0.61). In each of the remaining codes, with the exception of *objections*, higher incidence was also observed in the process-level condition than in the task-level condition, however, these differences were not statistically significant. Descriptive data are presented in Fig. 3.

Finally, analysis of the IM-generated problematiques (see Figs. 4, 5, 6 and 7), shows significant differences in complexity of argument structures across conditions. The average complexity score for the problematiques generated by the process-level prompt groups is 25.5. The average complexity score for the problematiques generated by the task-level prompt groups is 14.5.

Discussion

The current study examined the effects of task-level versus process-level prompts, on perceived efficacy of the IM method, perceived consensus, objective consensus, and argumentation style and complexity in the context of an IM session. Results indicated that, compared to

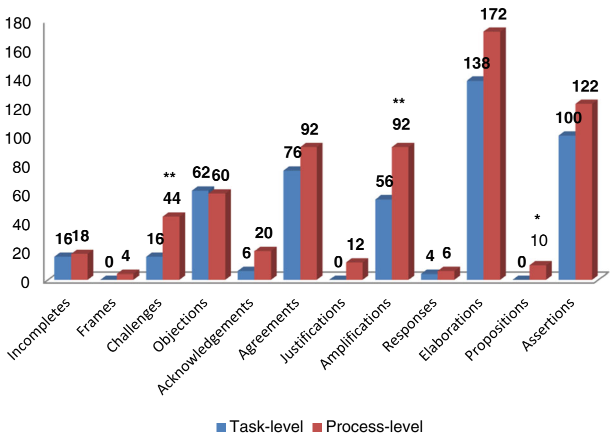


Fig. 3 Incidence of CACS codes across conditions

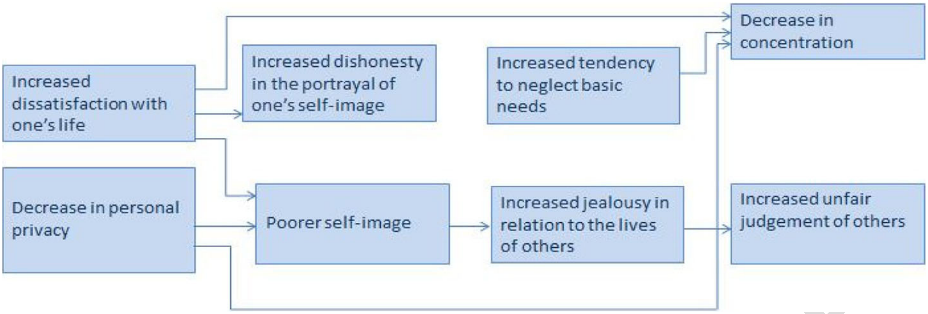


Fig. 4 IM problematique generated in the process-level prompt condition

those in the task-level prompt condition, those in the process-level prompt condition, reported higher levels of perceived consensus in response to the group design problem. Furthermore, those in the process-level prompt condition also reported higher levels of perceived efficacy of the IM process. Finally, analysis of the dialogue from the IM sessions revealed that those in the process-level prompt condition exhibited higher levels of sophistication in their arguments, as revealed by their CACS scores and the complexity of their IM-generated problematiques.

Achieving higher levels of consensus and promoting more coherent collective action was a core objective of John Warfield's when he first developed the IM methodology (Warfield and Cardenas 1994). Importantly, in the current study, while perceived consensus levels increased in both prompting conditions, the increase was significantly greater in the process-level condition. This suggests that while the IM method itself is effective in promoting consensus in a collaborative group, the role of the facilitator and in particular the instructional support provided by the facilitator has a significant impact on the consensus-building process.

Furthermore, the observed link between higher dispositional trust and higher perceived consensus in the current study is consistent with previous research which suggests that trust can influence critical psychosocial processes that may impact on levels of consensus in a

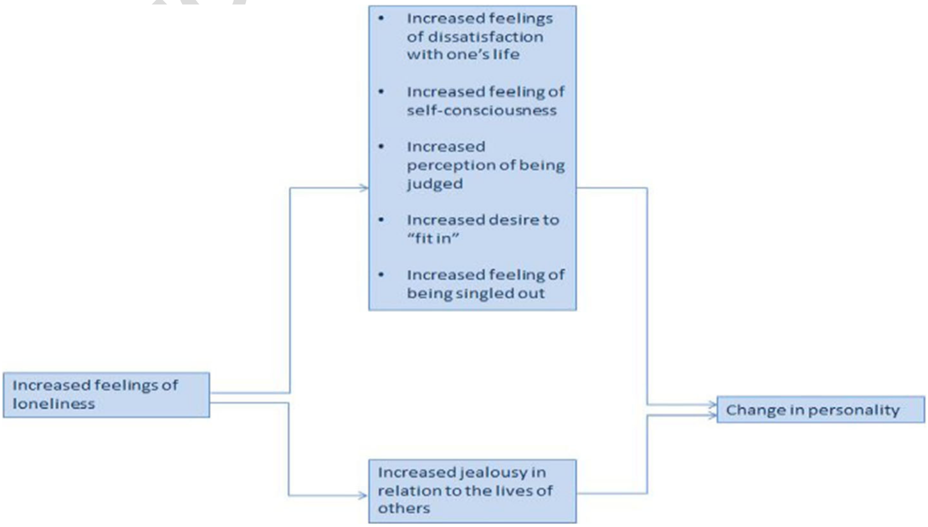


Fig. 5 IM problematique generated in the process-level prompt condition

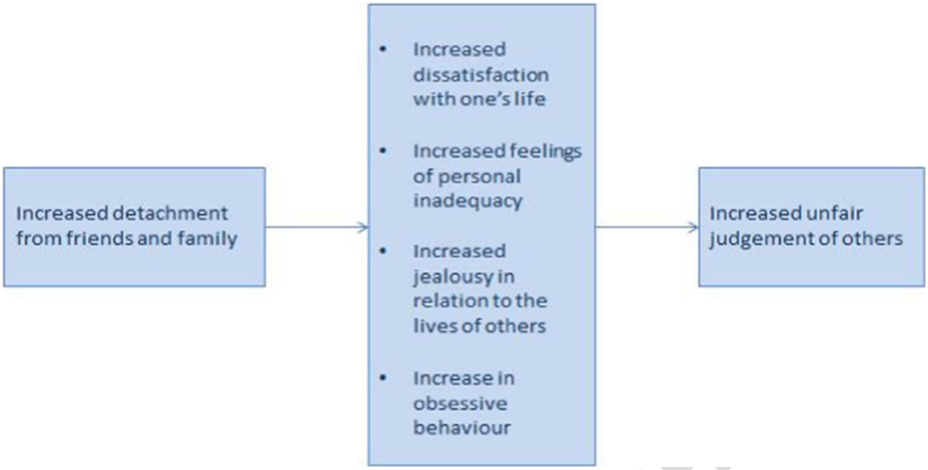
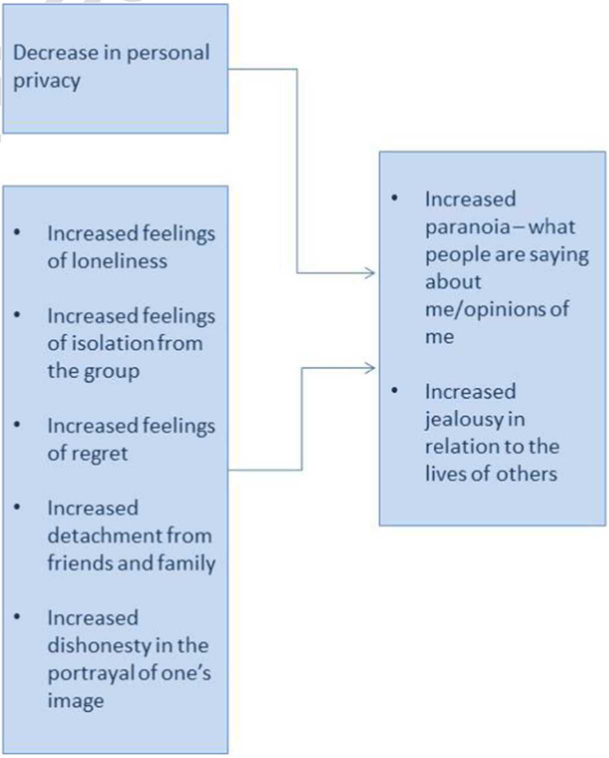


Fig. 6 IM problematique generated in the task-level prompt condition

collaborative group. For example, research suggests that dispositional trust is associated with a 565
preference for social negotiation, critical thinking and solution finding (Kreijns et al. 2002). 566
These factors may have influenced the positive relationship between dispositional trust and 567
perceived consensus in relation to the collaborative efforts of the group in the current study. 568

Fig. 7 IM problematique generated in the task-level prompt condition



It is noteworthy that, while perceived consensus increased significantly in the process-level prompt condition, a significant increase was not seen in objective consensus. This suggests that while the group felt that they were moving towards greater levels of shared understanding and agreement, enhanced by the style of facilitation, their actual level of agreement, in terms of Likert scale agreement/disagreement with IM relational statements, did not increase to the same degree. In practical terms, the implications of the two forms of consensus not coinciding may be different depending on which is higher. If perceived consensus is higher than objective consensus, it would be expected that the group would continue be satisfied with the group process and function effectively, as previous research suggests (e.g., Mohammed and Ringseis 2001). However, if objective consensus is high, but perceived consensus is low, this suggests that although the level of objective agreement in relation to the topic is high, the group is not aware of this level of agreement, or does not feel that their interactions and discussions reflect agreement. This, in turn, might suggest that the group is not functioning optimally, or that other factors may be having a negative impact on consensus-based interactions.

The results here also suggest more time may be required to increase objective consensus in relation to complex issues, whereas increased levels of perceived consensus may be cultivated in a relatively short time frame by the facilitator and by certain qualities of the collaborative discussion (e.g., turn-taking, inclusiveness, democratic decision making). It is also possible that, based on the findings of this study, and consistent with findings from previous research, the positive group behaviours associated with higher perceived consensus (positive expectations and overall satisfaction with the group process), may help a group to achieve high objective consensus over time.

These results represent significant findings in relation to collaborative learning, and CSCL in particular, as higher levels of perceived consensus are likely to lead to higher levels of endorsement and engagement by the group in any action or response to a shared problem. For example, if a group feels strongly that there is a strong level of consensus in relation to the understanding and conception of a problem that they are working on together, they are more likely to be committed to, and satisfied with, any plan which comes from the newly-formed collaborative understanding (Mohammed and Ringseis 2001). The effect of process-level prompts on perceived efficacy has further implications for CSCL. While results showed that, broadly speaking, participants across both prompting conditions found the computer-facilitated group design methodology to be a useful and valid method of mapping and structuring the interdependencies between problem relations (for example, on average, between 80 and 90 % of participants across both conditions agreed or strongly agreed with the statement "*I believe that Interactive Management can be used to help a group achieve consensus about a problem*"), those in the process-level prompt group reported significantly higher levels of perceived efficacy in relation to the IM process. Therefore, the prompts provided by the facilitator may be important for the overall success of the process, and for the level of support for the methodology by the group. This support for, or endorsement of, the methodology may be important in the context of efforts to sustain the ongoing use of a collaborative methodology as part a problem solving strategy adopted by students or other working groups.

With regard to the types of argumentation coded by reference to the CACS coding system, overall, reasoning activities accounted for 37 % of coded utterances, generative mechanisms accounted for 20 %, disagreement-relevant intrusions accounted for 15 %, convergence-seeking activities accounted for 14 % and delimitors accounted for only 0.5 %. The remaining 13.5 % of coded utterances were nonarguables. This suggests that the argumentation across groups was reasonably complex, as the arguments did not rely heavily on generative mechanisms (assertions and propositions) as is typically the case in simple argumentation (Canary et al. 1987). While these figures suggest that, in general, the argumentation was reasonably complex, the results of the CACS analysis in MEPA showed that the process-level prompt condition displayed higher levels of argument sophistication, with higher incidence of CACS codes across all major categories. Furthermore, when compared with those in the task-level prompt group, participants in the process-level prompt condition demonstrated significantly higher levels of propositions, amplifications and challenges. This suggests that the process-level prompt condition was engaging at a higher-level with the claims presented during the IM structuring work, and made more effective moves towards reaching a level of understanding and consensus within the group prior to voting. For example, while elaborations (i.e., statements that support other statements by providing evidence, reasons or other support e.g., "*Because of peer pressure, you know, people trying to get you to do things*") were similarly evident in both groups, amplifications (i.e., statements that explain or expound upon other statements to establish the relevance of an argument through inference e.g., "*I think they are related because change in personality would be more kind self-conscious I suppose, but not perception of being judged,*") were observed more often in the process-level prompt condition. In this way, those in the process-level prompt condition were moving beyond accumulation of evidence and support in their reasoning activity - they were working further to establish how this reasoning relates to the problem at hand, and more specifically the relevance of their reasoning. Similarly, while the frequency of objections (i.e., statements that deny the truth or accuracy of an arguable e.g., "*No, I think it would be the other way around*") were almost identical across the two prompt conditions, challenges (i.e., statements that offer problems or questions that must be solved if agreement is to be secured on an arguable e.g., "*Well it kind of depends, on whether your self-consciousness affects your ability to socialise*") occurred more often in the process-level prompt condition. This suggests that those in the process-level prompt condition engaged more critically with the information at hand, and engaged in more productive argumentation. Finally, of the 16 types of argument codes which comprise the CACS, 12 were observed at least once in the process-level prompt condition, whereas only 8 were observed at least once in the task-level prompt condition, highlighting the greater diversity of argumentation styles demonstrated by the process-level prompt groups.

The IM methodology is well established and has been used successfully in a wide variety of scenarios to accomplish many different goals, including assisting city councils in making budget cuts (Coke and Moore 1981), developing instructional units (Sato, 1979), improving the U.S. Department of Defence acquisition process (Alberts 1992), promoting world peace (Christakis 1987), improving tribal governance processes in Native American communities (Broome 1995a, b; Broome and Christakis 1998; Broome and Cromer 1991), and training facilitators (Broome and Fulbright 1995). However, IM is a facilitated process (Hogan et al. 2014), the success of which is heavily influenced by the support, guidance, and instruction provided by the facilitator. While the importance of good facilitation is often highlighted by expert facilitators (Hmelo-Silver 2002), the current study provides one of the first experimental demonstrations of the effects of prompt style on outcomes in the application of IM.

In the current study, the students were tasked with developing a consensus based model of the negative consequences of online social media usage, a focus of discussion that most students reported as interesting and relevant. The process of model building involved the generation of ideas in relation to the problem, rank-ordering and voting on the most critical ideas, and discussion and decision-making regarding the interdependencies between these ideas. Overall, when examining the relational complexity of the models or structural hypotheses generated by students, the current study revealed that those in the process-level prompt condition arrived at a more complex, consensus-based understanding of the relations between the negative consequences of online social media usage. While each group began with the same initial set of ideas, added an almost equivalent number of additional ideas, and ultimately structured the same number of ideas during the model building process, the results of the groups' collaborative efforts differed in important ways. During this process, the effect of higher dispositional trust and process-level prompts were shown to have positive effects on social psychological variables which are of key importance in collaborative learning settings, that is, consensus and perceived efficacy. Process-level prompts also helped to promote an enhanced style of dialogue and argumentation and increased the overall complexity of consensus-based models generated by the groups.

A closer look at the models or problematiques generated by groups reveals variations in complexity, which are in line with the varying degrees of argument complexity measured by the CACS. For example, while "decrease in personal privacy" appears as a primary driver in two of the problematiques (one in each prompt condition, that is, Figs. 4 and 7), the paths of influence stemming from this idea are more elaborate in the process-level prompt condition (see Fig. 4). In both the task-level prompt and process-level prompt models referred to above, "decrease in personal privacy" had a significant aggravating effect on "increased jealousy in relation to the lives of others". However, in the process-level prompt condition, this path of influence is mediated by poorer self-image. This suggests that the process-level prompt groups, through more complex and varied argumentation and exploration, further developed this relationship, and reached a consensus on a potential mediating factor. The additional complexity in these problematiques, is consistent with, and representative of, the statistically significant differences in prevalence of more complex and varied CACS codes. In other words, the consequence of different patterns of argumentation is reflected in the models generated by the groups. Crucially, when taken alongside the finding that students in the process-level prompt condition reported higher levels of consensus and perceived efficacy, this suggests that the use of effective prompting not only enhances the quality of students interactions with the CSCL tool, but also their motivation to do so in future.

Finally, the finding that process-level prompting resulted in higher levels of perceived consensus has significant implications for learning in the group context. An increase in perceived consensus here reflects changes in attitudes and opinions in relation to the topic, showing that the process level prompting facilitated students' learning from their peers, and the generation of a shared level of understanding. Furthermore, by measuring the student's attitudes in relation to their perception of consensus within the group, the students are given the opportunity to reflect on their learning throughout the CSCL process. This reflection is important, given that, according to Michaelsen and Sweet (2008), students often fail to realise how much they have learned in team-based learning. By taking time to think about their perceived consensus after the group discussion, students become aware of the resulting changes in their attitudes and opinions. During this process, the students may be reflecting on shared mental models. Tjosvold (2008) argues that open-minded discussion of diverse views is a social process which results in increased awareness of the complexity of a problem. By means of such argumentation and discussion, the group approaches a convergence of meaning in order to develop shared mental models (Van den Bossche et al. 2011). The increase in perceived consensus in the process-level prompt condition in the current study may reflect a similar learning process.

Conclusion

The results of this study suggest that adequate facilitation, in particular the use of process-level prompts to support reflection and deliberation, plays a vital role in the outcomes of computer-supported collaborative learning. This study has shown that process-level prompts have a positive effect on the IM collaborative learning process, a process which has both educational and organisational applications. The positive effect of prompting was evidenced by the harnessing of a positive sense of perceived efficacy of the collaborative methodology, by supporting and enhancing levels of consensus, and by supporting productive argumentation. These results are consistent with the views of Pea (2004) and Strijbos et al. (2004), specifically, that in order to cultivate successful collaboration in students, attention must be paid to the design of the collaborative environment, including the provision of scaffolding, leadership, and support by the facilitator. Furthermore, when considered alongside research findings suggesting that teams may not operate at optimum levels on their own, or that they may fail to achieve and sustain quality interactions due to the time-consuming nature of the work (Dickinson and McIntyre 1997; Rummel and Spada 2005), the results of the current study highlight the importance of effective facilitation and instruction in CSCL settings for a variety of outcomes. In order to optimize the power of CSCL, collaborative problem-solving and collective action, it is necessary to both create the optimal working conditions for achieving consensus, and to provide the right supports and framework for effectively harnessing a groups' collective intelligence. Such a framework should address three key factors: the tools, individual talents, and team dynamics that support collaborative learning and collective action (Hogan et al. 2014). By engaging with collaborative tools such as IM, and providing the right support during the IM collaborative process, we believe it is possible to enhance the collective power of teams, by cultivating and harnessing their collaborative, critical and systems thinking skills.

Limitations and future research

There are a number of limitations to the current study which must be noted. First, in relation to argumentation, the IM sessions were conducted in an educational environment, with discussions focused on a problem that may not have been considered critical to students. Despite the fact that many CACS designs have adopted a similar approach (e.g., Beck et al. 2012), the nature of the problem selected may have had an effect on the nature and level of complexity of argumentation in each group. Future research should examine the effects of prompting and facilitation in a variety of real-world problem solving and decision-making contexts with groups that are working to resolve more critical problems that impinge upon their adaptive success as a group. Students in the current study however, did appear to engage with the topic in a way that reflected their interest in the personal and social consequences of social media usage.

Second, the groups in this study consisted of between 17 and 20 participants. These groups may be considered to be quite large relative to other collaborative learning groups. However, the group size is consistent with standard IM procedure, with groups typically consisting of 12 to 20 participants. Also, the size of the group is consistent with tutorial class sizes in our university. As such, we feel that the group size reflects a classic IM systems building session and contributes to the ecological validity of the findings, which demonstrate that students in classic tutorial size groups can work collaboratively to develop systems models in relation to complex problems. We do, however, recognise that variations in group size may influence collaborative dynamics and the effects of prompts and facilitation on group deliberation and decision making. Future research should attempt to replicate these effects using a combination of both smaller groups and larger groups in the same experiment, that is, to test directly for the effects of group size on outcomes.

Third, there was a gender imbalance in the sample of this study with a ratio of approximately 3:2 females to males. This is a common sampling issue in university samples, particularly with regard to psychology-based research (Skinner and Louw 2009). In relation to the results of this study, while some research has found that, in CSCL settings, females are more likely to qualify and justify their assertions (Fahy 2003; Smith et al. 1997) whereas males tend to assert opinions as facts (Fahy 2002), other studies (e.g., Ding and Harskamp 2009), have found that gender differences are diminished when hints (e.g., prompts) are provided.

Future research should also seek to analyse network dynamics in the group to see if process-level prompting is associated with higher levels of coordination in the group, as opposed to higher prevalence of key argument types. Also, research should seek to examine if peer-centered process-level prompting is more effective than facilitator-driven prompting in promoting exploratory talk and higher levels of coordinated and networked activity in collaborative groups.

Appendix

Perceived efficacy of Interactive Management

1) I believe that Interactive Management can be used to solve problems effectively

___Strongly Disagree___Disagree___Neutral___Agree___Strongly Agree

2) I believe that Interactive Management can be used to help a group achieve consensus about a problem

___Strongly Disagree___Disagree___Neutral___Agree___Strongly Agree

3) I would use Interactive Management to structure my thoughts in the future

___Strongly Disagree___Disagree___Neutral___Agree___Strongly Agree

4) I would recommend Interactive Management to others as a problem solving tool

___Strongly Disagree___Disagree___Neutral___Agree___Strongly Agree

5) I think more working groups around the world should use Interactive Management to solve problems

___Strongly Disagree___Disagree___Neutral___Agree___Strongly Agree

6) I think there are some problems that Interactive Management will not help to resolve

___Strongly Disagree___Disagree___Neutral___Agree___Strongly Agree

7) I don't think Interactive Management will help all groups to achieve consensus – there are some problems that are too difficult

___Strongly Disagree___Disagree___Neutral___Agree___Strongly Agree

References

Ackoff, R. L. (1981). *Creating the corporate future: Plan or be planned for*. New York: John Wiley and Sons.

Alberts, H. (1992). *Acquisition: past, present and future*. Paper presented at the meeting of the Institute of Management Sciences and Operations Research Society, Orlando, FL.

Alvero, A., Bucklin, B., & Austin, J. (2001). An objective review of the effectiveness and essential characteristics of performance feedback in organizational settings (1985–1998). *Journal of Organizational Behavior Management, 21*(1), 3–30. doi:10.1300/J075v21n01_02.

Andriessen, J. (2006). Arguing to learn. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 443–460). New York: Cambridge University Press.

Argyris, C. (1982). *Reasoning, learning, and action: Individual and organizational*. San Francisco: Jossey-Bass.

Ashby, W. R. (1958). *An introduction to cybernetics*. New York: Wiley.

Asterhan, C. S., & Schwarz, B. B. (2010). Online moderation of synchronous e-argumentation. *International Journal of Computer-Supported Collaborative Learning, 5*(3), 259–282. doi:10.1007/s11412-010-9088-2.

Baker, M. J. (2003). Computer-mediated argumentative interactions for the co-elaboration of scientific notions. In J. Andriessen, M. J. Baker, & D. D. Suthers (Eds.), *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments* (pp. 47–78). Dordrecht: Kluwer.

Baker, M. J., Quignard, M., Lund, K., and Séjourné, A. (2003). *Computer-supported collaborative learning in the space of debate*. Paper presented at the International Conference on Computer Support for Collaborative Learning: Designing for Change in Networked Learning Environments, Dordrecht, The Netherlands. doi:10.1007/978-94-017-0195-2_4.

Balcazar, F. E., Shupert, M. K., Daniels, A. C., Mawhinney, T. C., & Hopkins, B. O. (1989). An objective review and analysis of 10 years of publication in the journal of organizational behavior management. *Journal of Organizational Behavior Management, 10*(1), 7–38. doi:10.1300/J075v10n01_02.

Barr, S. H., & Conlon, E. J. (1994). Effects of distribution of feedback in work groups. *Academy of Management Journal, 37*(3), 641–655. doi:10.2307/256703.

Barron, B. (2000). Achieving coordination in collaborative problem-solving groups. *The Journal of the Learning Sciences, 9*(4), 403–43. doi:10.1207/S15327809JLS0904_2.

Beck, S. J., Gronewold, K., & Western, K. (2012). Intergroup argumentation in city government decision making: The Wal-Mart dilemma. *Small Group Research, 43*(5), 87–612. doi:10.1177/1046496412455435.

Bell, P. (2004). Promoting students' argument construction and collaborative debate in the science classroom. In M. C. Linn, E. A. Davis, & P. Bell (Eds.), *Internet environment for science education* (pp. 115–143). Mahwah, NJ: Lawrence Erlbaum Associates.

Berthold, K., Nückles, M., & Renkl, A. (2007). Do learning protocols support learning strategies and outcomes? The role of cognitive and metacognitive prompts. *Learning and Instruction, 17*, 564–577. doi:10.1016/j.learninstruc.2007.09.007.

Boulding, K. E. (1966). *The impact of the social sciences*. New Brunswick, NJ: Rutgers University Press.

Broome, B. J. (1995a). Collective design of the future: Structural analysis of tribal vision statements. *American Indian Quarterly, 19*(2), 205–228.

Broome, B. J. (1995b). The role of facilitated group process in community-based planning and design: Promoting greater participation in Comanche tribal governance. In L. R. Frey (Ed.), *Innovations in group facilitation: Applications in natural settings* (pp. 27–52). Cresskill, NJ: Hampton Press.

Broome, B. J. (2006). *Applications of interactive design methodologies in protracted conflict situations. Facilitating group communication in context: Innovations and applications with natural groups*. New York: Hampton Press. Q7

Broome, B. J., & Chen, M. (1992). Guidelines for computer-assisted group problem-solving: Meeting the challenges of complex issues. *Small Group Research, 23*(2), 216–236. doi:10.1177/1046496492232005.

Broome, B. J., & Christakis, A. N. (1998). A culturally-sensitive approach to tribal governance issue management. *International Journal of Intercultural Relations, 12*(2), 107–123. doi:10.1016/0147-1767(88)90043-0.

Broome, B. J., & Cromer, I. L. (1991). Strategic planning for tribal economic development: A culturally appropriate model for consensus building. *International Journal of Conflict Management, 2*(3), 217–234. doi:10.1108/eb022700.

Broome, B. J., & Fulbright, L. (1995). A multi-stage influence model of barriers to group problem solving. *Small Group Research, 26*(1), 25–55. doi:10.1177/1046496495261002.

Brown, A. L., & Palincsar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 393–451). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Canary, D. J., Brossmann, B. G., & Siebold, D. R. (1987). Argument structures in decision-making groups. *Southern Speech Communication Journal, 53*(1), 18–37. doi:10.1080/10417948709372710.

Chi, M. T. H. (2000). Self-explaining expository texts: The dual processes of generating inferences and repairing mental models. In R. Glaser (Ed.), *Advances in instructional psychology* (pp. 161–238). Mahwah, NJ: Lawrence Erlbaum Associates.

Chi, M. T. H., de Leeuw, N., Chiu, M., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science, 18*, 439–477. doi:10.1207/s15516709cog1803_3.

Christakis, A. N. (1987). Systems profile: The club of Rome revisited. *Systems Research, 4*(1), 53–58. doi:10.1002/sres.3850040107.

Coke, J. G., & Moore, C. M. (1981). Coping with a budgetary crisis: Helping a city council decide where expenditure cuts should be made. In S. W. Burks & J. F. Wolf (Eds.), *Building city council leadership skills: A casebook of models and methods* (pp. 72–85). Washington, DC: National League of Cities.

Currall, S. C., & Judge, T. A. (1995). Measuring trust between organizational boundary role persons. *Organizational Behavior and Human Decision Processes, 64*(2), 151–170. doi:10.1006/obhd.1995.1097.

Davis, E. A. (2003). Prompting middle school science students for productive reflection: Generic and directed prompts. *The Journal of the Learning Sciences, 12*(1), 91–142. doi:10.1207/S15327809JLS1201_4.

Deal, T. E., & Kennedy, A. A. (1982). *Corporate cultures: The rites and rituals of corporate life*. Reading, MA: Addison-Wesley.

Delbeq, A. L., Van De Ven, A. H., & Gustafson, D. H. (1975). *Group techniques for program planning: A guide to nominal group and Delphi processes*. Glenview, IL: Scott, Foresman.

Denson, R. W. (1981). *Team training: Literature review and annotated bibliography*. Brooks Air Force Base, TX: Air Force Human Resources Laboratory.

Dewett, T. (2003). Towards an interactionist theory of group-level feedback. *Management Research News, 26*(10–11), 1–21. doi:10.1108/01409170310784041.

Dickinson, T. L., & McIntyre, R. M. (1997). A conceptual framework for teamwork measurement. In M. T. Brannick, E. Salas, & C. Prince (Eds.), *Team performance and measurement: Theory, methods, and applications* (pp. 19–43). Mahwah, NJ: Lawrence Erlbaum Associates.

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches* (pp. 1–19). Oxford: Elsevier.

Ding, N. and Harskamp, E. G. (2009). Gender difference in students' cognitive representations during collaborative problem-solving in physics. *International Journal of Science Education*. Retrieved May 2nd, 2015 from: https://www.rug.nl/research/portal/files/14562479/Chapter%205.

Erkens, G. (2005). Multiple episode protocol analysis. (Version 4.10). [Software] Available from http://edugate.fss.uu.nl/mepa/.

Fahy, P. (2002). Use of linguistic qualifiers and intensifiers in computer conference. *American Journal of Distance Education, 16*(1), 5–22. doi:10.1207/S15389286AJDE1601_2.

Fahy, P. (2003). Indicators of support in online interaction. *International Review of Research in Open and Distance Learning, 4*(1). Retrieved May 2nd, 2015 from: http://www.irrodl.org/index.php/irrodl/article/view/129/600.

Gabelica, C., Bossche, P. V. D., Segers, M., & Gijselaers, W. (2012). Feedback, a powerful lever in teams: A review. *Educational Research Review, 7*(2), 123–144. doi:10.1016/j.edurev.2011.11.003.

Gamlem, S. M., & Munthe, E. (2014). Mapping the quality of feedback to support students' learning in lower secondary classrooms. *Cambridge Journal of Education, 44*(1), 75–92. doi:10.1080/0305764X.2013.855171.

Gan, M. J., & Hattie, J. (2014). Prompting secondary students' use of criteria, feedback specificity and feedback levels during an investigative task. *Instructional Science, 42*(6), 861–878. doi:10.1007/s11251-014-9319-4.

Ge, X., & Land, S. M. (2003). Scaffolding students' problem-solving processes in an ill-structured task using question prompts and peer interactions. *Educational Technology Research and Development, 51*(1), 21–38. doi:10.1007/BF02504515.

Gelmini-Hornsby, G., Ainsworth, S., & O'Malley, C. (2011). Guided reciprocal questioning to support children's collaborative storytelling. *International Journal of Computer-Supported Collaborative Learning, 6*(4), 577–600. doi:10.1007/s11412-011-9129-5.

Graesser, A. C., Person, N. K., & Huber, J. (1993). Question asking during tutoring and in the design of educational software. In M. Rabinowitz (Ed.), *Cognitive foundations of instruction* (pp. 149–172). Hillsdale, NJ: Lawrence Erlbaum.

Guzzo, R. A., Jette, R. D., & Katzell, R. A. (1985). The effects of psychologically based intervention programs on worker productivity: A meta-analysis. *Personnel Psychology, 38*(2), 275–291. doi:10.1111/j.1744-6570.1985.tb00547.x.

Harford, J., & MacRuairc, G. (2008). Engaging student teachers in meaningful reflective practice. *Teaching and Teacher Education, 24*(7), 1884–1892. doi:10.1016/j.tate.2008.02.010.

Harney, O., Hogan, M. J., & Broome, B. (2012). Collaborative learning: The effects of trust and open and closed dynamics on consensus and efficacy. *Social Psychology of Education, 15*(4), 517–532. doi:10.1007/s11218-012-9202-6.

Hattie, J. A. C., & Gan, M. (2011). Instruction based on feedback. In R. Mayer & P. Alexander (Eds.), *Handbook of research on learning and instruction* (pp. 249–271). New York: Routledge.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81–112. doi:10.3102/003465430298487.

Hmelo-Silver, C. E. (2002). Collaborative ways of knowing: Issues in facilitation. *Computer Support for Collaborative Learning: Foundations for a CSCL Community*. Paper presented at the International Conference on Computer Supported Collaborative Learning, Boulder, Colorado. doi:10.1.1.16.9070.

Hogan, K. (1999). Thinking aloud together: A test of an intervention to foster students' collaborative scientific reasoning. *Journal of Research in Science Teaching, 36*, 1085–1109. doi:10.1002/(SICI)1098-2736(199912)36:10<1085::AID-TEA3>3.0.CO;2-D.

Hogan, M. J., Harney, O. M., & Broome, B. (2014). Integrating argument mapping with systems thinking tools - advancing applied systems science. In A. Okada, S. Buckingham Shum, & T. Sherborne (Eds.), *Knowledge cartography: Software tools and mapping techniques* (pp. 401–421). London: Springer.

Hogan, M.J., Harney, O. M., & Broome, B. (2015). Catalyzing Collaborative Learning and Collective Action for Positive Social Change through Systems Science Education. In, R. Wegerif, J. Kaufman, & L. Li (Eds). *The Routledge Handbook of Research on Teaching Thinking*. (In Press). Q8

Hübner, S., Nückles, M., & Renkl, A. (2010). Writing learning journals: Instructional support to overcome learning-strategy deficits. *Learning and Instruction, 20*, 18–29. doi:10.1016/j.learninstruc.2008.12.001.

Ilgen, D. R., Fisher, C. D., & Taylor, M. S. (1979). Consequences of individual feedback on behavior in organizations. *Journal of Applied Psychology, 64*(4), 349–371. doi:10.1037/0021-9010.64.4.349.

Jarvenpaa, S. L., Knoll, K., & Leidner, D. (1998). Is anybody out there? The antecedents of trust in global virtual teams. *Journal of Management Information Systems, 14*(4), 29–64.

Kenny, D. A., Albright, L., Malloy, T. E., & Kashy, D. A. (1994). Consensus in interpersonal perception: Acquaintance and the big five. *Psychological Bulletin, 116*(2), 245–358. doi:10.1037/0033-2909.116.2.245.

Kenworthy, J. B., & Miller, N. (2001). Perceptual asymmetry in consensus estimates of majority and minority members. *Journal of Personality and Social Psychology, 80*(4), 597–612. doi:10.1037/0022-3514.80.4.597.

Ketelaar, E., Den Brok, P., Beijaard, D., & Boshuizen, H. P. (2012). Teachers' perceptions of the coaching role in secondary vocational education. *Journal of Vocational Education and Training, 64*(3), 295–315. doi:10.1080/13636820.2012.691534.

King, A. (1990). Enhancing peer interaction and learning through guided student- generated questioning. *Educational Psychologist, 27*(4), 111–126. doi:10.3102/00028312027004664.

Kirschner, P. A. (2009). Epistemology or pedagogy, that is the question. In S. Tobias & T. M. Duffy (Eds.), *Constructivist theory applied to instruction: Success or failure?* (pp. 144–157). New York: Routledge.

Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance. A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin, 119*(2), 254–284. doi:10.1037/0033-2909.119.2.254.

Kozlowski, S. W. J., & Ilgen, D. R. (2006). Enhancing the effectiveness of work groups and teams. *Psychological Science in the Public Interest, 7*(3), 77–124. doi:10.1111/j.1529-1006.2006.00030.x.

Krause, U. M., Stark, R., & Mandl, H. (2009). The effects of cooperative learning and feedback on e-learning in statistics. *Learning and Instruction, 19*(2), 158–170. doi:10.1016/j.learninstruc.2008.03.003.

Kreijns, K., Kirschner, P. A, & Jochems, W. (2002). The sociability of Computer-Supported Collaborative Learning environments. *Educational Technology and Society, 5*(1), 8–22. doi:10.1.1.95.4422.

Kuhn, D. (1991). *The skills of argument*. Cambridge: Cambridge University Press.

Kuhn, D. (2005). *Education for thinking*. Cambridge, Mass.: Harvard University Press.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *The Academy of Management Review, 20*(3), 709–734. doi:10.5465/AMR.1995.9508080335.

McKnight, D. H., Cummings, L. L., & Chervany, N. L. (1998). Initial trust formation in new organizational relationships. *Academy of Management Review, 23*(3), 513–530. doi:10.5465/AMR.1998.926622.

Mento, A., 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*(1), 52–83. doi:10.1016/0749-5978(87)90045-8.

Meyers, R. A., & Brashers, D. E. (1998). Argument in group decision making: Explicating a process model and investigating the argument-outcome link. *Communication Monographs, 65*(4), 261–281. doi:10.1080/03637759809376454.

Michaelsen, L. K., & Sweet, M. (2008). The essential elements of team-based learning. *New Directions for Teaching and Learning, 116I*, 7–27. doi:10.1002/tl.330.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychology Review, 63*(2), 81–97. doi:10.1037/h0043158.

Mohammed, S., & Ringseis, E. (2001). Cognitive diversity and consensus in group decision making: The role of inputs, processes, and outcomes. *Organizational Behavior and Human Decision Processes, 85*(2), 310–335. doi:10.1006/obhd.2000.2943.

Muller Mirza, N., Tartas, V., Perret-Clermont, A.-N., & de Pietro, J.-F. (2007). Using graphical tools in a phased activity for enhancing dialogical skills: An example with digalo. *International Journal of Computer-Supported Collaborative Learning, 2*(2–3), 247–272. doi:10.1007/s11412-007-9021-5.

Nadler, D. A. (1979). The effects of feedback on task group behavior: A review of the experimental research. *Organisation Behaviour and Human Performance, 23*(3), 309–338. doi:10.1016/0030-5073(79)90001-1.

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*(4), 321–335. doi:10.1207/s15327043hup1104_2.

Paolucci, M., Suthers, D. D., and Weiner, A. (1995, May). *Belvédère: stimulating students' critical discussion.* Paper presented at The Conference on Human Factors in Computing Systems, Denver, Colorado. doi:10.1145/223355.223461.

Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *The Journal of the Learning Sciences, 13*(3), 423–451. doi:10.1207/s15327809jls1303_6.

Pearce, J. L., Sommer, S. M., Morris, A., & Frideger, M. (1992). *A configurational approach to interpersonal relations: Profiles of workplace social relations and task interdependence*. Irvine: Graduate School of Management, University of California.

Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*(2), 155–169. doi:10.1007/BF01405730.

Roberts, K., & O'Reilly, C. (1974). Measuring organizational communication. *Journal of Applied Psychology, 59*(3), 321–326. doi:10.1037/h0036660.

Rummel, N., & Spada, H. (2005). Learning to collaborate: An instructional approach to promoting collaborative problem solving in computer-mediated settings. *The Journal of the Learning Sciences, 14*(2), 201–241. doi:10.1207/s15327809jls1402_2.

Scheuer, O., Loll, F., Pinkwart, N., & McLaren, B. M. (2010). Computer-supported argumentation: A review of the state of the art. *International Journal of Computer-Supported Collaborative Learning, 5*(1), 43–102. doi:10.1007/s11412-009-9080-x.

Schoenfeld, A. H. (1985). *Mathematical problem solving*. New York: Academic.

Schwarz, B. B., & Glassner, A. (2003). The blind and the paralytic: Fostering argumentation in social and scientific issues. In J. Andriessen, M. J. Baker, & D. D. Suthers (Eds.), *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments* (pp. 227–260). Dordrecht: Kluwer.

Seibold, D. R., & Meyers, R. A. (2007). Group argument: A structuration perspective and research program. *Small Group Research, 38*(3), 312–336. doi:10.1177/1046496407301966.

Simmons, M., & Cope, D. (1993). Angle and rotation: Effects of different types of feedbacks on the quality of response. *Educational Studies in Mathematics, 24*(2), 163–176. doi:10.1007/BF01273690.

Simon, H. A. (1960). *The new science of management decisions*. New York: Harper & Row.

Skinner, K., & Louw, J. (2009). The feminization of psychology: Data from South Africa. *International Journal of Psychology, 44*(2), 81–92. doi:10.1080/00207590701436736.

Smith, C., McLaughlin, M., & Osborne, K. (1997). Conduct controls on usenet. *Journal of Computer-Mediated Communication, 2*(4), 0. doi:10.1111/j.1083-6101.1997.tb00197.x.

Stahl, G. (2010). Guiding group cognition in CSCL. *International Journal of Computer-Supported Collaborative Learning, 5*(3), 255–258. doi:10.1007/s11412-010-9091-7.

Stahl, G. (2015). The group as paradigmatic unit of analysis: The contested relationship of CSCL to the learning sciences. In M. Evans, M. Packer, & K. Sawyer (Eds.), *Reflections on the learning sciences: Past, present, and future*. Cambridge, UK: Cambridge University Press.

Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 409–426). Cambridge, UK: Cambridge University Press.

Stark, R., Puhl, T., & Krause, U.-M. (2009). Improving scientific argumentation skills by a problem-based learning environment: Effects of an elaboration tool and relevance of student characteristics. *Evaluation and Research in Education, 22*(1), 51–68. doi:10.1080/09500790903082362.

Stegmann, K., Weinberger, A., & Fischer, F. (2007). Facilitating argumentative knowledge construction with computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning, 2*(4), 421–447. doi:10.1007/s11412-007-9028-y.

Stevenson, C. E., Hickendorff, M., Resing, W. C., Heiser, W. J., & de Boeck, P. A. (2013). Explanatory item response modeling of children's change on a dynamic test of analogical reasoning. *Intelligence, 41*(3), 157–168. doi:10.1016/j.intell.2013.01.003.

Strijbos, J.-W., Kirschner, P. A., & Martens, R. L. (Eds.). (2004). *What we know about CSCL: And implementing it in higher education*. Boston, MA: Springer.

Suthers, D., & Hundhausen, C. (2003). An empirical study of the effects of representational guidance on collaborative learning. *The Journal of the Learning Sciences, 12*(2), 183–219. doi:10.1207/S15327809JLS1202_2.

Tannen, D. (1998). *The argument culture: Moving from debate to dialogue*. New York: Random House Trade.

Tjosvold, D. (2008). The conflict-positive organization: It depends upon us. *Journal of Organizational Behavior, 29*, 19–28.

Van Bruggen, J. M., Boshuizen, H. P., & Kirschner, P. A. (2003). A cognitive framework for cooperative problem solving with argument visualization. In P. A. Kirschner, S. J. Buckingham Shum, & C. S. Carr (Eds.), *Visualizing argumentation: Software tools for collaborative and educational sense-making*. London: Springer.

Van den Bossche, P., Gijselaers, W., Segers, M., Woltjer, G., & Kirschner, P. (2011). Team learning: Building shared mental models. *Instructional Science, 39*(3), 283–301.

Veerman, A. L., Andriessen, J. E. B., & Kanselaar, G. (2000). Learning through synchronous electronic discussion. *Computers & Education, 34*(2–3), 1–22. doi:10.1016/S0360-1315(99)00050-0.

Warfield, J. N. (2006). *An introduction to systems science*. Singapore: World Scientific.

Warfield, J., & Cardenas, R. (1994). *A handbook of interactive management*. Ames: Iowa State University Press.

Webb, N. M. (1995). Group collaboration in assessment: Multiple objectives, processes and outcomes. *Educational Evaluation and Policy Analysis, 17*(2), 239–261. doi:10.3102/01623737017002239.

Wen, Y., Looi, C. K., & Chen, W. (2015). Appropriation of a representational tool in a second-language classroom. *International Journal of Computer-Supported Collaborative Learning, 10*(1), 77–108. doi:10.1007/s11412-015-9208-0.

Woolley, A. W. (2009). Means vs. Ends: Implications of process and outcome focus for team adaptation and performance. *Organization Science, 20*(3), 500–515.